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Quantifying external cost of air pollution and GHG emissions from private road transport in Catalonia using Theory of Planned Behavior and Contingent Valuation

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DOCTORAL THESIS

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تقدیم به آرایه عزیزم و دامون

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Abstract

Internalizing environmental externalities is a market-driven approach to correcting people's private costs and benefits. One way of quantifying these externalities is estimating people's willingness to pay (WTP) to reduce those externalities. To better understand the determinants of this WTP, we use the Theory of Planned Behavior (TPB). This theory is a commonly used approach for predicting behavioral and pro-environmental intentions. Our study focuses on air pollution and greenhouse gas (GHG) emissions from private road transport. We gathered survey data from 406 residents of Catalonia to explore the relationships among the psychological factors determining willingness to pay to quantify the mentioned externalities. We expanded the TPB by adding as antecedent Environmental Concern (EC) prior to the theory's three main factors (Attitude, Subjective Norms and Perceived Behavioral Control). Next, we used Structural Equation Modeling (SEM) to analyze structural relationship between the proposed model constructs. The results of our study show that environmental concern is positively related to the three main factors of TPB. Our model accounts for most of the variation of WTP (R-squared is 94.7%). Moreover, the results also revealed that a majority of the respondents in Catalonia (61.57%) are willing to pay to reduce air pollution and GHG emissions from private road transport. The results of the estimation of the logit model for the overall user sample, revealed that the mean WTP is 64.47€ for implementing plan "L" and 120.17€ for implementing plan "H" regarding the hypothetical scenario of the study.

Resumen

Internalizar las externalidades ambientales de las actividades humanas es un enfoque impulsado por el mercado para corregir los costos y beneficios privados de las personas. Una forma de cuantificar estas externalidades es estimar la voluntad de pago (VDP) de las personas para reducir dichas externalidades. Para entender mejor los determinantes de esta DAP, hemos utilizado la Teoría del Comportamiento Planificado (TCP). Esta teoría es un método que se usa normalmente para predecir el comportamiento y las intenciones pro-ambientales humanas.

Nuestro estudio se centra en la contaminación del aire y las emisiones de gases de efecto invernadero (GEI) del transporte privado por carretera. Hemos recogido datos de una encuesta realizada a 406 residentes de Cataluña para explorar las relaciones entre los factores psicológicos que determinan la voluntad de pago para cuantificar las externalidades mencionadas. Hemos ampliado el TCP añadiendo como antecedente la Preocupación Ambiental (EC) antes de los tres factores principales de la teoría (Actitud, Normas Subjetivas y Control del Comportamiento Percibido). Luego, hemos utilizado el Modelado de Ecuaciones Estructurales (MEE) para analizar la relación estructural entre los constructos del modelo propuesto. Los resultados de nuestro estudio muestran que la preocupación medioambiental está relacionada positivamente con los tres factores principales de la TCP. Nuestro modelo representa la mayor parte de la varianza de la VDP (R^2 es 94,7%). Además, los resultados también han revelado que la mayoría de los encuestados en Cataluña (61,57%) están dispuestos a pagar para reducir la contaminación atmosférica y las emisiones de gases de efecto invernadero del transporte privado por carretera. La estimación del modelo logístico para la muestra global de usuarios ha dado como resultado que la VDP media es 64,47€ para la ejecución del plan "L" y 120,17€ para la ejecución del plan "H" en el escenario hipotético del estudio.

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List of Acronyms

AGFI	Adjusted Goodness-of-Fit Index
AVE	Average Variance Extracted
CDF	Cumulative Distribution Function
CE	Choice Experiment
CFA	Confirmatory Factor Analysis
Chi-square	$\chi 2$
CV	Contingent Valuation
CVM	Contingent Valuation Method
df	degree of freedom
EU	European Union
CFI	Comparative Fit Index
GHG	Greenhouse Gas
GOF	Goodness of Fit
IID	Independently and Identically
Mtoe	Million tonnes of oil equivalent
NOAA	National Oceanic and Atmospheric Administration
OCED	Organization for Economic Co-operation and Development
PGFI	Parsimony Goodness-of-Fit Index
PNFI	Parsimony Normed Fit Index
Pkm	Passenger-Kilometer
RMSEA	Root Mean Square Error of Approximation
PPP	Polluter Pays Principle
RP	Revealed Preference
RUM	Random Utility Model
SP	Stated Preference
SRMS	Standardized Root Mean Square Residual
TFC	Total final consumption
VLYL	Value of Life Years Lost
VSL	Value of Statistical Life
WTA	Willingness to Accept
WTP	Willingness to Pay

Chapter 1

Introduction

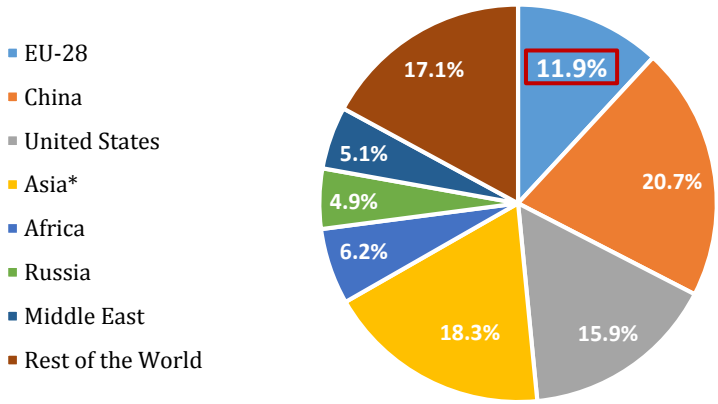
1.1. Overview

1.1.1. Global GHG emissions

Industrialization introduced in the 18th century, changed people's lives. It improved life quality, increased leisure time and boosted productivity compared to the past. However, it had many side effects on health, economy and the environment as well, e.g., (I) high-energy consumption, (II) producing excessive greenhouse gas (GHG) emissions and (III) increasing air pollution. (EEA, 2013a; IEA, 2013; Jeong et al., 2009).

(I) **High-energy consumption:** Not only is the current energy consumption important, but its demand is expected to increase in the future (global energy demand has been estimated to increase about 50% between 2004 and 2030). The major part of this increase is projected to occur in developing countries because of their economic development and population growth. Global final energy consumption has been increasing for decades, it was 4674 Mtoe[1] in 1973, and increased to 9555 Mtoe in 2016 (European Commission, 2018a; IEA, 2013). In figure 1.1 we see that the biggest energy consumers in the world are China and United States. EU-28 uses 11.9% of world total energy.

Figure 1.1. World final energy consumption by region in 2016 (%)



*Excluding China and Middle East countries
Source: (European Commission, 2018a)

In 2016, 31.7% of world total energy is consumed by industry, 31.6% by the transportation sector and the rest by the agriculture, residential and commercial sectors (IEA, 2018). In EU-28,

[1] Million tonnes of oil equivalent

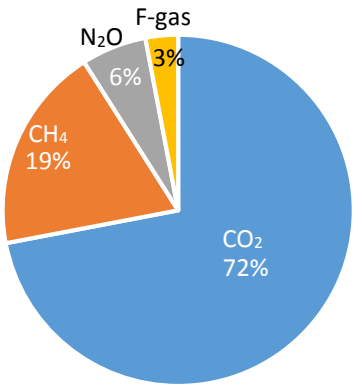
the situation is a little bit different. In 2016, transport was the first user with 33.2%. Residential energy use and the industry sector followed with respectively 25.7% and 25.0% of total energy consumption of EU-28 (European Commission, 2018a).

Spain generally is not an exception compared with EU-28. It consumed 82.5 Mtoe in 2016, around 7.5% of EU-28 total energy. In Spain, more energy is consumed by the transportation sector (34.97%) than by industry (18.97%), residential sector (15.06%) and services (10.63%) (European Commission, 2018a).

Catalonia has a significant role in the economy of Spain (in 2018 it represented around 19% of the country's GDP) and in its energy consumption (16.4% of Spain energy in 2014). It is the second largest region in Spain with 2,949,700 households and a population around 7,500,000 inhabitants in 2017 (almost 16% of Spanish population). Its energy consumption by sectors is similar to Spain (IDESCAT, 2015; INE, 2018).

(II) Producing GHG emissions: The other problem of industrialization is the production of GHG emissions. GHG emissions has become one of the main humans' problems in recent decades and will be one of the main problems in the early future. Gases that trap heat in the atmosphere are called greenhouse gases. GHG emissions are carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4). Moreover, there are a number of entirely human-made greenhouse gases named as F-gases such as Sulphur hexafluoride (SF_6), hydro fluorocarbons (HFCs) and per fluorocarbons (PFCs) (IPCC, 2001; UN, 1998). As it shown in figure 1.2, CO_2, is the main culprit of GHG emissions. Because of its share in GHG emissions, CO_2 emissions frequently symbolize GHG emissions in the scientific and non-scientific literature.

Figure 1.2. Global GHG emissions in 2017



Source: Adapted from Oliver et al. (2017)

In EU-28, energy industries with 26.9% and transport with 24.3% were the two biggest producers of GHGs emissions in 2016. As expected, CO_2 emissions with 3,637 million ton were the biggest component of GHG emissions in 2016 (Table 1.1). Transport produced 29.3% of total CO_2 emissions of EU-28 in the same year (European Commission, 2013a). Table 1.1 shows the amount of GHG and CO_2 emissions from 1995 to 2016 in EU-28. GHG and CO_2 emissions are

decreasing after 2005, but regarding the Kyoto protocol and Europe 2020 objectives, EU countries are still producing too many emissions.

Table 1.1, EU-28 GHG and CO_2 emissions from 1995 to 2016

Year	1995	2000	2005	2010	2016
CO_2 *	4301	4294	4434	4071	3637
Index 1995	100	99.8	103.1	94.6	84.6
GHG *	5386	5277	5351	4909	4440
Index 1995	100	98	99,3	91.1	82.4

* Million ton of CO_2 or equivalent
Source: (European Commission, 2018a)

According to the Kyoto Protocol in 1997, Spain committed itself to limit its GHG emissions to no more than 115% of the benchmark emissions levels in 1990. This meant that Spain had to keep its share of world GHG emissions between 6.12% and 7.04%. In 2009, Spain reached 8.34% of world GHG emissions (37% more than the emissions in 1990). Spanish government planned to keep, for the period of 2008-2012, GHG emissions level beneath the level of 2009 (Fuenmayor, 2012). To comply with this objective, Catalonia had to reduce CO_2 emissions (in 2009, its emissions were 42% higher than in the base year) (Generalitat de Catalunya, 2013).

(III) Increasing air pollution: As we mentioned, air pollution is becoming an important issue for the public health and the environment (EEA, 2013a). The most prominent air pollutants are Sulphur dioxide (SO_2), Nitrogen oxides (NOx), Particulate matter (PM), Ozone (O_3), Ammonia (NH_3), Non methane volatile organic compounds (NMVOCs), Carbon monoxide (CO), and Methane (CH_4). These pollutants mostly are coming from energy use and supply, different types of transport (especially road transport), industrial processes, agriculture, and waste (EEA, 2013b).

1.1.2. Road transport and emissions

At the world level, the share of transport in total energy consumption is increasing over time (from 25% in 1990 to 31.6% in 2016). Over the same period, transport energy consumption increased by 75% (from 1570.5 to 2747.94 Mtoe.) (IEA, 2018). In EU-27 countries, transport's share of energy consumption grew from 22.8% to 33.2% (from 259 to 367.3 Mtoe.) during the period of 1990- 2016 (European Commission, 2018a; IEA, 2018).

Regarding GHG emissions, transport was the only sector, which had an increasing trend in EU-27 (from 775 to 931 million ton CO_2 or equiv.) between 1990 and 2010 (European Commission, 2018a, 2014). Table 1.2 shows the shares of air pollutants and GHG emissions from transport in EU-27 and Spain.

Table 1.2, Share of transport in air pollutants and GHG emissions (EU-27 and Spain)*

	Pollutant/Emissions	NO_x	CO	$PM_{2.5}$[2]	$NMVOC_s$	NH_3	SO_2	CH_4	GHGs
EU-27 **	by Transport (all modes include road transport)	46%	28%	19%	16%	2%	4%	0%	24.3%
Spain ***	by Transport (all modes include road transport)	42%	13%	36%	7%	1%	15%	0%	41.7%

Source: (EEA, 2013b; European Commission, 2018b)
* The data for air pollution is related to 2011 and for GHG emissions is related to 2016.
** Percentage of each pollutant regarding the total amount in EU-27.
*** Percentage of each pollutant regarding the total amount in Spain.

In 2016, road transport was responsible for 72% of GHG emissions of transport in EU-27. In Spain and in the same year, 64.2% of GHG emissions of the transport sector come from road transport. On the other hand in both EU and Spain, road transport is responsible for a considerable share of air pollutants (see table 1.3) (EEA, 2013b; European Commission, 2014). Regarding the case of Catalonia, this region is ranked as the second autonomous community in Spain with most vehicles: around 16% of the country's vehicles are circulating in this region. At the end of 2016, there were 5,093,500 vehicles; of these, 3,436,271 were private road vehicles (IDESCAT, 2016). Table 1.3 shows the percentage of the air pollutants and GHG emissions by road transport in EU-27 and Spain transport sector.

Table 1.3. Share of road transport in air pollutants and GHG emissions in the transport sector (EU-27 and Spain)*

	Pollutant/Emissions	NO_x	CO	$PM_{2.5}$[3]	$NMVOC_s$	NH_3	SO_2	CH_4	GHGs
EU-27 **	by Road Transport	40%	26%	16%	14%	2%	0%	0%	72%
Spain ***	by Road Transport	33%	13%	22%	6%	1%	0%	0%	64.2%

Source: (EEA, 2013b; European Commission, 2018b)
* The data for air pollution is related to 2011 and for GHG emissions is related to 2016.
** Percentage of each pollutant/emissions regarding the amount from sector in EU-27.
*** Percentage of each pollutant regarding/emissions the amount from sector in Spain.

The overall road network in Catalonia is large: it represents more than 12,000 Km. Private road transport is the second most commonly used mode of transport with 40.6% of total transport after non-motorized mode with 45.1%. Despite the presence of public transport, the use of private vehicles is high (Generalitat de Catalunya, 2010). Transport and especially road transport, have notable effects on air pollution and GHG emissions of Catalonia. Table 1.4 considers the situation of Catalonia according to different air pollutants and GHG emission from transport.

2. PM2.5 is fine particulate matter (particles measuring 2.5 µm or less)

3. PM2.5 is fine particulate matter (particles measuring 2.5 µm or less)

Table 1.4, Share of transport and road transport in total air pollutants and GHG emissions in Catalonia (2016)

Pollutant/Emission	NO_x	CO	PM_{10}	$NMVOC_s$	NH_3	SO_2	CH_4	GHG
by Transport (all modes include road transport)	55%	76.11%	60%	19.97%	n/a	8.38%	0%	28%
by Road Transport	40%	72.83%	52%	18.81%	n/a	2.5%	0%	n/a

Source: (Generalitat de Catalunya, 2017; Marti Valls et al., 2010; Parra Narváez, 2004)

Road transport is expected to maintain its dominant role in passenger transport by 2050. Projections show passenger cars alone would be responsible for 67% of total passenger transport activities in 2050 (European Commission, 2013b).

1.1.3. Road transport externalities

Undoubtedly, on the one hand transport supports the well-functioning of the economy and adds value to the welfare of society. On the other hand, transport activities have a cost for society. Besides costs of time and resource consumption, a set of unseen and mostly unpaid costs are determined, such as safety and environmental damages (Knockaert, 2010).

When individuals impose costs on or provide benefits for others, but do not have an economic incentive to take those costs or benefits into account, economists say that externalities -negative and positive- are generated (Krugman et al., 2010). In transport, negative externalities include environmental and road damage, accidents, congestion etc. (Santos et al., 2010). Microeconomic theory states that the internalization of the external costs (negative externalities[4]) produced by different transport modes is needed to maximize social welfare. In other words, whenever externalities are found, economists look after procedures to internalize the externalities[5] (Elvik, 1994). In the EU White Paper on Transport, the internalization of external costs plays prominent role and is included as one of the ten goals for a competitive and resource efficient transport system (van Essen et al., 2012).

Transport is thus important for the control of future energy consumption, greenhouse gas (GHG) emissions and is therefore a target for active policy intervention. There are two main policy instruments for addressing transport externalities: command-and control and incentive-based policies. The first one refers to regulations (e.g. fuel standards, parking and driving restrictions). The second one refers to using market-based instruments to internalize externalities (e.g. fiscal instruments –such as taxes and charges-, tradable emissions permits and subsidies) (Muthukrishnan, 2010; Santos et al., 2010). In the last decades, there is a growing interest in using these incentive-based policies for the different transport modes (Maibach et al., 2008).

[4] In this study, we will use indistinctly the terms of negative externality and external cost.

[5] It is related to the idea of the polluter pays principle (PPP) which was adopted by the OECD in 1972 (Belhaj and Fridell, 2008).

Social preferences for any kind of environmental policy intervention play an important role. To design tools and implement plans to mitigate negative externalities, behavioral changes are required. The cost of these changes should be estimated in order to assess the difficulty of implementing a corrective policy in terms of social acceptance of the policy, cost of technological change implied by the policy, and the like. For example, initially the public may approve a mitigation policy, but it is necessary to evaluate the degree of support for this policy as it will imply concrete changes that the public may not have been aware of (Bamberg et al., 2011; Layton and Brown, 2000). To address this, different surveying techniques can assess the public benefits of air pollution reduction and climate change mitigation. Nevertheless, the stated preferences methods are the only techniques capable of estimating total economic value of these benefits in monetary terms (Bateman et al., 2004).

In case of evaluating individual preferences and estimating the price of non-marketed goods such as air quality (by reducing pollution), one of the most popular, practical and recommended tools is the willingness-to-pay (WTP) approach (Bateman et al., 2002; Maibach et al., 2008; U.S. Environmental Protection Agency, 2011). Eliciting WTP from hypothetical situations can be done by different methods one of which is the Contingent Valuation (CV) methods (Bateman et al., 2004).

Furthermore, there is a growing interest in understanding public perceptions about environmental problems and how these perceptions influence the public's behavior regarding the environment (Dunlap et al., 2000). Analysis of psychological factors is needed to understand the behavioral intentions of individuals, such as their intention to pay or stated WTP (Ajzen, 1991; Ajzen et al., 1996; Ajzen and Madden, 1986; Gifford, 2011; Pouta and Rekola, 2001; Spash et al., 2009). In this thesis we use the Theory of Planned Behavior (TPB), one of the most commonly used approaches in the area of predicting behavioral intentions, to estimate the value of non-marketed goods (e.g. Armitage and Conner, 2001; Bamberg et al., 2003; Bamberg and Schmidt, 2001; Collins and Carey, 2007; Fielding et al., 2008; Oreg and Katz-Gerro, 2006). We use this theory to estimate individuals' willingness to pay to reduce air pollution and GHG emissions. Subsequently, we employ Structural Equation Modelling (SEM) to verify that the data fits the Theory of Planned Behavior.

The rest of this chapter is organized as followed. First, we present the objectives and research questions. Second, we introduce the motivations of this study and the research gap it aims to bridge. Third, we describe the theoretical framework of the thesis and the research hypothesizes made. Fourth, we point out the contributions of our study and, fifth, we present the structure of the thesis.

1.2. Objectives and research questions

The general objective of this study is to estimate the monetary value of air pollution and GHG emissions from private road transport in Catalonia. For this purpose, first we develop an extended model of TPB by using Structural Equation Modelling (SEM). We expect this model to have a higher explanatory power to predict future pro-environmental behavior of a given population than the non-extended TPB model.

We consider the following specific objectives:

1) To analyze attitudinal factors which influence the respondents' decision-making processes when they estimate the value of environmental goods.

2) To include behavioral theory variables in a CV questionnaire for evaluating the respondents' estimates.

3) To define an extended version of TPB in order to better explain respondents' intention to realize a pro-environmental behavior.

4) To use this extended version of TPB to quantify respondents' willingness to pay (WTP) to reduce air pollution and GHG emissions from private road transport in Catalonia.

The research questions of this study can be defined as follow:

Q1. Does the TPB model fit the data of our survey?

Q2. Does the proposed extended TPB model fit the data of our survey?

Q3. How much are the respondents willing to pay to reduce air pollution and GHG emissions in the hypothetical scenario of our survey?

1.3. Motivations and research gap

Regarding the Kyoto Protocol in 1997, Europe 2020 objectives, and local objectives of Spain, Catalonia has to decrease its CO_2 and GHG emissions level. Now, the question is not only how Spain and Catalonia can reach mentioned targets (What kind of local policies would have to be made? How could these policies be implemented?), but also how will people react to these policies?

We believe that attitude-based monetary valuation methods facilitate policymaking. To obtain this valuation, we use an extended model of the TPB because the latter may improve the explained variation of the original model. In addition, it will help us to estimate a monetary value based on proposed scenarios for the externalities under study by using contingent valuation method.

As we discussed before, one of the main sources of GHG emissions and air pollution that can be targeted is transport (Loureiro et al., 2013). Moreover, road transport has a substantial pollution share among the different transport modes. Previous research has studied road transport along with other modes, although it did not concentrate only on road transport. For this reason, we choose road transport, with a special focus on private road transport.

Since almost all the policies trying to reduce GHG emissions and air pollution from transport, need citizen's participation and approval, we need to take into account behavioral factors to be able to answer the following questions:

- On which elements does a pro-environmental behavior of the people depend?
- Which type of socio-economic profile will pay for policies that try to reduce GHG emissions and air pollution?
- How much are they willing to pay for these policies?
- How can we encourage people to support these pro-environmental policies?

In this study, we try to answer these questions by considering different socio-economic and behavioral factors and using structural equation modelling and monetary valuation methods.

1.4. Theoretical framework and research hypotheses

1.4.1. TPB and pro-environmental behaviors

Environmental social psychology has developed a variety of theoretical approaches to study pro-environmental behaviors such as the New Environmental Paradigm by Dunlap et al., (2000), the Value-belief-norms theory by Stern et al., (1999) and the Theory of Planned behavior by Ajzen, (1991). In our study we use the latter, which is one of the most commonly used approaches in the area of predicting behavioral intentions to estimate the value of non-marketed goods (e.g. Armitage and Conner, 2001; Bamberg et al., 2003; Bamberg and Schmidt, 2001; Collins and Carey, 2007; Fielding et al., 2008; Oreg and Katz-Gerro, 2006).

Nevertheless, the TPB has received many criticisms because it neglected complementary variables and left a considerable unexplained percentage of variance of the analyzed behavior (Ajzen, 1991; Han and Hansen, 2012; Kaiser, 2006). For this reason, and in order to enhance the original TPB's explanatory power, various authors have tried to propose an extended model of TPB by adding new variables (Bamberg et al., 2007; Han and Hansen, 2012; Heath and Gifford, 2002; Kaiser, 2006; Peters et al., 2011). They suggested that the theory could improve by taking into account additional factors. Especially, two groups of factors (categories) being addressed. First, moral related constructs such as perceived moral obligation, perceived moral control and personal norm, and, secondly, environmental values such as environmental concern and awareness of consequences (Abrahamse et al., 2009; Ajzen, 1991; Bamberg, 2003; Han and Hansen, 2012; Heath and Gifford, 2002; Kaiser, 2006; Peters et al., 2011). For example, Wang et al. (2016) use an extended model of TPB to predict the customers' intention to adopt Hybrid electric vehicles (HEVs). The empirical results show that the attitude toward HEVs, subjective norm, perceived behavioral control (the three main constructs of the TPB model) and personal moral norm partially mediate the effect of consumers' environmental concern on their intention

to adopt HEVs. Consumers' environmental concern affects the adoption intention indirectly, positively and significantly.

In our study, we use the second category, environmental concern, to extend the TPB by means of the structural equation modelling analysis.

For the economic valuation, this study employs the contingent valuation (CV) method of the willingness to pay (WTP) approach. With this valuation of WTP, we discuss the usefulness of the TPB. We demonstrate that combining attitude-behavior framework (TPB) with contingent valuation can increase our understanding of how citizens' preferences are shaped in the field of air pollution and GHG emissions.

Ajzen's (1991) TPB theorizes that individuals make rational choices to engage (or not engage) in the behavior of interest. The choices made are influenced by individuals' own beliefs about the outcome and the evaluation of the favorableness (or unfavorableness) of the outcomes from engaging in the target behavior. As Bamberg and Möser (2007) argued, according to this model, individual decision-making is guided by a rational evaluation of the consequences of his behavior. The sum of perceived positive and negative consequences determines the global attitude toward a behavioral option. Attitude does not directly determine behavior but only indirectly via behavioural intention.

The TPB also stresses the importance of situational constraints. When forming their behavioural intention, people do not only take into account their attitudes toward this behavior but also estimate their ability to perform the behavior. This is what we call perceived behavioural control (PBC). The TPB assumes that when PBC is a reliable predictor of objective behavioural control it also predicts behavior directly.

Social norms are the third factor influencing decision-making. In the TPB framework, a social norm corresponds to perceived social pressure, by which we mean the expectations of significant reference persons for the individual to perform or not perform a given behavior. Fear of social exclusion is viewed as a primary motive why people tend to fulfil social norms. Like attitude and PBC, social norms are thought to determine behavior not directly but only indirectly via its impact on intention (Armitage and Conner, 2001).

Studies have validated the TPB in wide-ranging behaviors such as exercise (Ajzen and Driver, 1991); recycling (Taylor and Todd, 1995); alcohol misuse (Marcoux and Shope, 1997); weight loss (Sparks et al., 1995); and speeding (Conner et al., 2007).

Many studies also investigated pro-environmental behaviors through TPB. For instance, Bernath and Roschewitz (2008) examine the potential of TPB to explain how much respondents would be willing to pay for the recreational benefits of the Zurich city forests. The results revealed that the inclusion of the three main TPB factors (attitude, PBC and social norms) significantly improved the explanations of protest votes. However, the results indicate that the interpretation

of bid levels as behavioral intention may not be appropriate. Therefore, in this case the ability of these factors to improve the performance of the model to explain bid levels was limited.

Han et al. (2010) tested TPB to explain the formation of hotel customers' intentions to visit a green (eco-friendly) hotel. The findings were consistent with TPB. The results of a structural equation analysis revealed that attitude, subjective norm, and perceived behavioral control positively affected intention to stay at a green hotel. Smart (2012) modified and extended the original TPB model with the inclusion of a number of economic and noneconomic constructs to demonstrate the wide applicability of TPB. The results of this study suggest that noneconomic constructs, such as beliefs and attitudes, are good predictors of tax compliance behavior. Consistent with the majority of other studies, the most influential factor explaining tax compliance behavior (through the mediating effects of behavioral intention) is attitude. Social norms are also a significant predictor of tax compliance behavior. Finally, perceived behavioural control is only significant for the taxpayers but not for the tax agents[6].

There are few studies, which are using TPB in a contingent valuation context to quantify air pollution and GHGs emissions. van Birgelen et al. (2011) used the TPB constructs to examine the behavior of passengers with respect to their preparedness to compensate for CO_2 emissions. They assessed the influence of consumer-related factors on the willingness of air travelers to compensate for CO_2 emissions, and the likelihood of them actually compensating. Among respondents willing-to-pay, the average reported CO_2 compensation amount was €24 for a short-haul flight and €55 for a long-haul flight.

In another study, Bazrbachi et al. (2017) aims to determine how the respondents' behavior intentions towards public transportation will affect their decision regarding whether to maintain the current level of welfare by continuing to use their own private cars or to shift to a more environmentally friendly alternative: public transport. They estimate how much current private passenger vehicle users are willing to pay to continue using their private vehicles. They report two different willingness to pay value equal to RM[7] 7.89 (USD 2.46) and RM 4.99 (USD 1.55) per trip to avoid using the public transport system based on basic and extended TPB models.

To sum up, given the research we have found, the use of TPB to estimate the public's willingness to pay to reduce air pollution and greenhouse gas emissions from private road transport has room for development.

Hereunder, we present the basic and extended models of TPB and the related hypotheses.

[6] In this study, three distinct sub-groups of New Zealand taxpayers were considered: general taxpayers, tax agents (accountants), and tax lawyers.
[7] Malaysian Ringgit

1.4.2. Basic model of TPB

According to previous studies on TPB, we expect greater intention to pay to reduce pollution and GHG emissions from individuals who (1) have a positive evaluation of the proposed payment (attitude), (2) feel the support from family and friends to do this payment (subjective norms), and (3) rely on their own strength to perform this payment (perceived behavioral control). When we do a survey, the intention to pay (where the amount of the payment is not mentioned to the respondents) should lead to higher stated WTP (where the amount of the payment is mentioned to the respondents) and, finally, higher payment (behavior) (see Figure 1.3). To better document the relationship between behavioral motivation (the four mentioned TPB constructs) and WTP to reduce air pollution and GHG emissions from private road transport, this study makes the following hypotheses:

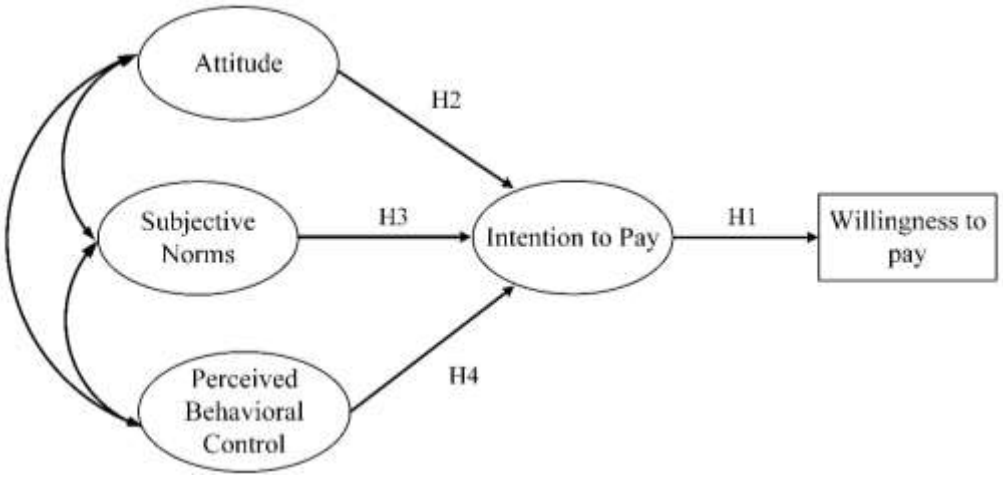
H1*:* There is a significant and positive relationship between a person's intention to pay and his/her stated willingness to pay to reduce air pollution and GHG emissions.

H2*:* There is a significant and positive relationship between a person's attitude toward payment to reduce air pollution and GHG emissions and intention to pay for these reductions.

H3*:* There is a significant and positive relationship between a person's subjective norms toward payment to reduce air pollution and GHG emissions and intention to pay for these reductions.

H4*:* There is a significant and positive relationship between a person's perceived behavioral control toward payment to reduce air pollution and GHG emissions and intention to pay for these reductions.

Figure 1.3, Original components of TPB to explain WTP



Note: Circles denote latent constructs; squares denote observed variables.

1.4.3. The extended model of TPB

As we discussed before, TPB has received many criticisms because it neglected complementary variables and left a considerable unexplained percentage of variance of the analyzed behavior (Ajzen, 1991; Han and Hansen, 2012; Kaiser, 2006).

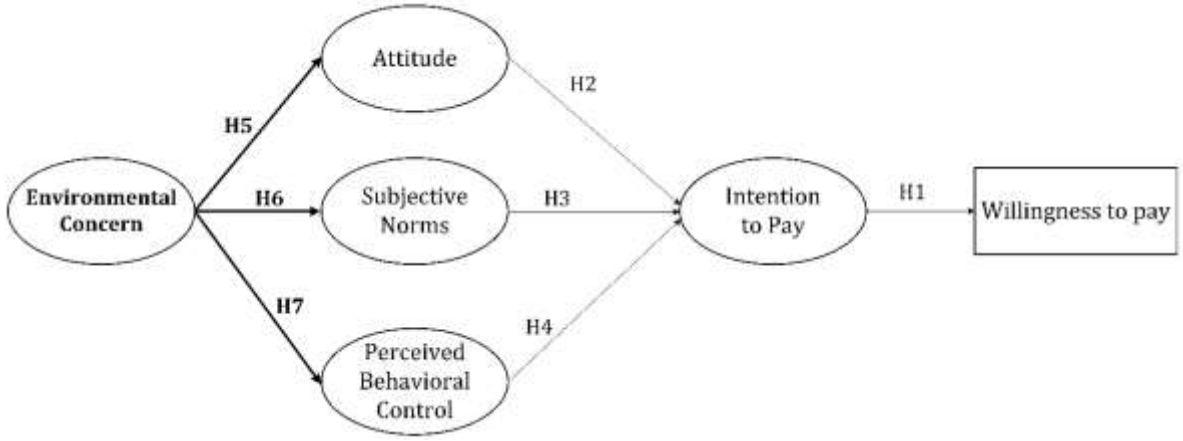
In our study, we propose entering environmental concern as the antecedents of the constructs of the basic TPB model (see Figure 1.4) and formulate the following hypotheses:

H5*:* There is a significant and positive relationship between individuals' environmental concern and attitude toward paying to reduce air pollution and GHG emissions.

H6*:* There is a significant and positive relationship between individuals' environmental concern and subjective norms toward paying to reduce air pollution and GHG emissions.

H7*:* The relationship between a person's environmental concern and his/her perceived behavioral control toward paying to reduce air pollution and GHG emissions is significant and positive.

Figure 1.4, Extended model of TPB by adding Environmental Concern



Note: Circles denote latent constructs; squares denote observed variables.

1.5. Contributions of the study

This study aims to contribute to existing knowledge in the environmental economics literature by investigating how people feel and think about pollution reduction and how these factors can explain their intentions to engage in pro-environmental behavior. For this purpose, by using an extended model of TPB integrating environmental concern, we attempt to distinguish more clearly the psychosocial factors that play a role in determining individuals' WTP to reduce environmental externalities from private road transport.

In our study, we try to quantify air pollution and GHG emissions related to private car use according to the assessment of people in Catalonia (Spain). This study, in comparison with previous studies, has two elements, which differentiate it from them. The first one refers to the model that is used. We extended the TPB model by adding environmental concern prior to the

factors of the original model. The second one is that we use this extended model to examine the intention to pay to reduce air pollution and GHG emissions in case of private road transport. Extended versions of TPB have been used in the literature to explain different types of pro-environmental intentions, such as willingness to pay for abatement of forest regeneration (Pouta and Rekola, 2001), willingness to reduce personal car use (Nordlund and Garvill, 2003), willingness to pay for improving biodiversity (Spash et al., 2009) or for conserving a suburban park (López-Mosquera and Sánchez, 2012). However, to the best of our knowledge, there have been no studies that use the proposed extended model of TPB to examine WTP to reduce air pollution and GHG emissions in case of private road transport.

1.6. Structure of the thesis

As previously stated, the purpose of this study is to quantify external cost of road transport in case of air pollution and GHG emission in Catalonia by using an extended TPB model. To this end, the thesis is structured as follows.

In Chapter 2, we carry out a literature review and an in-depth study of the field of research to identify the research gap and to choose the model, the possible variables to extend the model and the monetary valuation method.

In Chapter 3, first we discuss the willingness to pay approach. Second, we compare the characteristics of the two main methods within the stated preferences approach (choice experiment and contingent valuation). We study the pros and cons of these two methods to justify why we use the Contingent Valuation Method (CVM) for our study. Third, we explain how we use our extended TPB model to quantify a group of externalities of private road transport (air pollutions and GHG emissions). Finally, we present the survey and the methodology employed to analyze the data.

In Chapter 4, we present the results of the study. We analyze the validity of the constructs using Confirmatory Factor Analysis (CFA). We estimate the willingness to pay of the respondents of the survey.

Finally, in Chapter 5, conclusions are drawn and suggestions made for further work. In addition, we mention the article and the conference participations derived from this thesis.

Chapter 2

State-of-the-art

2.1. Transport externalities

2.1.1. Typology

As it discussed previously, an externality can be associated with positive (benefits) or negative (costs) effects. Due to improvements in the transport sector, positive externalities (desirable side effects) such as increased accessibilities, increased land values, emergency services, agglomeration benefits, etc., become apparent. There exist negative externalities, which the society has imposed by their costs. Some of the major externalities are:

I) Accident costs: With the introduction of additional cars on the streets, the accident externalities could result (Newbery, 1988):

a) Higher accident risks for other vehicles and unprotected road users

b) Many accidents that may effects on the rest of the society in terms of ambulance transport, hospital treatment, etc.

External accident costs are the accident costs not covered by risk oriented insurance premiums. They include damage, insurance administration costs, police and fire services costs, medical costs, production losses and the so called risk-value as a proxy to estimate pain, grief and suffering triggered by traffic accidents in monetary value (Maibach et al., 2008, p. 36)

II) Road damage costs: It includes repair costs of the damages from vehicles circulation in the roads, traffic jam, weather and the road's age. Heavy vehicles by loading the fourth power of the axle increase the damage (Maibach et al., 2008).

III) Congestion costs: Generally, the decision about making a (private vehicle) trip has governed by the private costs of making trip against expected benefits of the trip. Travelers ignore the additional congestion that they cause to others due to the presence of their vehicles.

IV) Noise pollution costs: Similar to emissions, noise pollution also affects health adversely (e.g., hearing problems, sleeping disorders, cardio-vascular disease, stress related heart problems, etc.). This could arise due to continuous honking, acceleration/deceleration of powerful engines, tire/road contact, etc.

V) Climate and air pollutants: Exhaust emissions from the motorized vehicles is a major source of air pollution releasing a variety of emissions. These are categorized as follows:

a) Green House Gases (GHG): Combustion of the fossil fuels emits Carbon Dioxide (CO_2), which does not impair human health directly but exacerbate global warming (GHG trap the heat in the atmosphere and consequently elevate global warming).

b) Air pollution: Nitrogen Oxides (NOx), Nitrogen Dioxide (NO2), Particular Matter (PM), Non-Methane Hydrocarbons (NMHC), Sulfur Dioxide (SO2), etc., are other major pollutants which affect the human health adversely such as, irritation in the respiratory system and in the lungs, coughing, choking, etc., which are proven to yield long-term health damages. In contrast to other externalities, emission costs imposed on a larger group of persons and for a longer period.

Here onwards, the term externality refers to negative externality or external costs unless otherwise stated. This thesis mainly focuses on externalities related to GHG emissions and air pollution. Considering the problem under study, in the next parts of this chapter we will review studies related to the theoretical framework of the study.

In the first part of this chapter, a concise study is carried out on researches related to external costs of transport at the EU level. The second part is related to studies on quantifying mentioned externalities. In the third part, we focus on air pollution and GHG emissions. In the fourth part, we will report our review on the literature of the stated preferences methods, especially the Contingent Valuation method by focusing on the willingness-to-pay approach. The penultimate part of this chapter will be dedicated to review of the previous studies related to the behavioral theories. In this part, we will review Theory of Planned Behavior as one of the most commonly used approaches in the area of predicting behavioral intentions to estimate the value of non-marketed goods.

As we discussed, transport use causes different categories of externalities: congestion, accidents, environmental costs (including air pollution, global warming and noise) and road damage externalities (Mayeres, 2002). As it mentioned before, EU has many projects in order to calculating transport external effects and internalizing them. With respect to Maibach et al. (2008) and van Essen et al. (2011), available studies regards to their output categorized into 3 different types as *pricing information*, *information for cost benefit analysis* and *total cost figures*.

A. Pricing information based on marginal costs is the most important topic that has been developed at EU-level. The CAPRI project (1999) and High Level Group on transport infrastructure charging (1999a-c) are the first ones. These have been further developed and used within the two research projects UNITE (2003) and GRACE (2007), in order to provide cost figures for different modes, mainly based on representative case studies. The IMPACT project commissioned by EU DG TREN (CE/INFRAS/ISI, 2008a/b) has produced a Handbook on estimation of external costs in the transport sector (Deliverable 1). In addition, the study provided an overview of road infrastructure cost data (Deliverable 2) and an assessment of policy instruments for internalizing the various external costs, an assessment of the impacts of various

pricing scenarios and a policy analysis and recommendation on internalization strategies (Deliverable 3). The results of IMPACT have been used as the basis for the 2008 Commission proposal for amending the Euro vignette Directive.

B. As regards information for cost benefit analysis, there are attempts at EU and at national level. In this group, we have HEATCO (2006), CAFÉ CBA (2005), UBA (2006) and NEEDS (2009).

C. Total cost figures and transport accounts for different countries. Here we can see UNITE (2003) as the most important study at EU-level containing transport accounts and total external cost estimates for most Western European countries. Also the UIC studies (INFRAS/IWW study (2004a), CE/INFRAS/ISI, 2011), Allianz pro Schiene (INFRAS/ISI/IER, 2007), ILFD (INFRAS/ISI, 2010) and several national studies have estimated costs for different transport modes (Maibach et al., 2008; van Essen et al., 2011).

The studies differ in several aspects, such as focus, transport modes covered, cost categories etc. Table 2.1; show the main scope and differences of the studies. Also an emerging literature is producing marginal and total estimates in developing countries like India, China and Mexico (Cravioto et al., 2013; Guo et al., 2010; Kumar Sen et al., 2010) but research there remains in its infancy.

2.1.2. Approaches to estimate externalities in transport

To estimate transport externalities, there are two main approaches. They are usually described as 'top-down' and 'bottom-up', although the labels "macro" and "micro" might be more descriptive (European Commission, 1995; Maibach et al., 2008).

A top-down (macro) analysis is typically highly aggregated; being carried out at a regional or national level, using estimates of the total quantities of pollutants emitted or present an estimate of the total damage that they cause. As estimation of health effects due to the exposure of air pollutants and valuation with specific costs per additional case of mortality or morbidity, would be an example. On the other hand, the estimation approaches are costly and difficult to aggregate. This approach was applied in the previous studies such as UIC update study (CE/INFRAS/ISI, 2011), UIC update study (CE/IWW, 2004, 2000) and was based on the tri-national study for Austria, Switzerland and France (WHO 1999a-d).

The bottom-up (micro) is calculation of damage costs based on an impact pathway approach, which requires the following methodological steps: emissions – transmission – concentration (dose) – impact/damage (humans, ecosystems, buildings) – monetization – costs. Bottom-up methodology allows the use of technology-specific emissions data for individual locations. This approach is in line with the social marginal cost approach and efficient pricing and has been applied in a variety of European studies such as NEEDS (2006, 2007, 2008); HEATCO (2006a, b);

CAFE CBA (2005a, b); ExternE (2005); UNITE (2003a, b) (European Commission, 1995; Maibach et al., 2008; van Essen et al., 2011).

Table 2.1, Main European studies in quantifying transport externality.

EU projects and Programs	Year or Period of calculations	Scope			Output category
		Countries covered	Cost categories covered	Transport modes covered	
UNITE	1996-2005	EU-15, Hungary, Estonia, Switzerland	Infrastructure, Congestion, Accident, Noise, Air pollution	All modes (Rail, road, water, air)	A and C
UIC Update Study 2004 (INFRAS/IWW, 2004)	1995-2000	EU-15, Switzerland and Norway	Infrastructure, Congestion, Accident, Noise, Air pollution and Climate Change	All modes	C
OSD	2000	Switzerland	All categories	Road and Rail Transport	C
TREMOVE	2000 (2000-2020)	EU-25	All categories	All modes	B (policy assessment)
CE Delft	2002	Netherlands	All categories	All modes	A
CAFE CBA	2002 (2002-2020)	EU-25 (Excluding Cyprus)	Air pollution	All modes	B
HEATCO	2002-2006	EU-25 + Switzerland	Infrastructure, Congestion, Accident, Noise, Air pollution	Road and Rail Transport	B
GRACE	2005-2008	EU-25	All categories	All modes	A
ExternE	2005	EU	Accident, Air pollution, Water pollution and Climate change	All modes (Based on energy)	A
Allianz pro Schiene Study (INFRAS/ISI/IER, 2007)	2005	Germany	All categories	All modes	C
NEEDS	2004-2009	EU-25 + Switzerland	Air pollution, Water pollution, Climate change	-	A
COMPETE	2006	EU-25, USA, Switzerland	Congestion	All modes	C
iTREN-2030	2007 (2007-2030)	EU-25	All categories	All modes	C
UBA	2008	Germany	All categories	All modes	B
ILFD Study (INFRAS/ISI, 2010)	2008	Germany	All categories	Road, rail, air	C
UIC Update Study 2011 (CE/INFRAS/ISI, 2011)	2008 (2000-2008)	EU-25 + Norway and Switzerland	All categories	All modes	C
HEIMTSA	2011	EU-27	Noise and air pollution	Road, rail and air	A and B
EEA 2013	2013	EU-27	Air pollution	Road	C

Source: Based on (Korzhenevych et al., 2014; Maibach et al., 2008; Proost et al., 2009; van Essen et al., 2011)

In addition, there are some studies such as COMPETE that used results of other studies. Another study, which is named TREMOVE, is a policy assessment model to study the effects of different transport and environment policies on the emissions of the transport sector. Therefore, we could put these studies neither in macros nor in micros. Moreover, total, average and marginal external costs are calculated for the five core cost categories of transport externality (Accident, Air pollution, Climate change, Noise and Congestion) with different methods in European and other studies. Table 2.2 is summarizing the best practice approaches and methods for different cost categories pointing out the sensitive issues.

Table 2.2, Best practice valuation approaches and methods for most important transport externalities.

Cost Components	Best practice approach
Accident costs	Resource costs for health improvement. Willingness To Pay (WTP) for the estimation of Value of Statistical Life (VSL)/ Value of Life Years Lost (VLYL) based on Stated Preference (SP) for the reduction of traffic risks. Alternatively: Willingness To Accept (WTA).
Air pollution costs (human health)	Impact pathway approach using resource cost. WTP for human life (Life years lost) base. Alternatively: WTA.
Climate change	Avoidance cost approach based on reduction scenarios of GHG emissions. Damage cost approach; shadow prices of an emission trading system.
Noise	WTP based on hedonic pricing (loss of rents – this reflects WTA) or SP for noise reduction. Impact pathway approach for human health using WTP for human life.
Congestion	WTP, Deadweight loss, Delay costs and Revenues to compensate deadweight loss

Source: (Maibach et al., 2008; van Essen et al., 2011)

2.2. How can we quantify an externality? The willingness to pay approach.

One of the most popular, practical and recommended tools for evaluating individual preferences and estimating the price of non-marketed goods such as air quality is the willingness-to-pay (WTP) approach (Bateman et al., 2002; Maibach et al., 2008; U.S. Environmental Protection Agency, 2011). Eliciting WTP from

hypothetical situations can be done by any of several varieties of methods such as the Stated Preference (SP) and Revealed Preference (RP) methods (Bateman et al., 2004).

In many situations, the analyst would wish to look to the revealed trends in market behavior though this is not always feasible. Therefore, a significant literature has been developed around survey methods for estimating individuals' willingness-to-pay (WTP) in the absence of revealed market alternatives. These methods are now widely used for developing optimal pricing strategies and forecasting the responses to price changes and for modeling demand functions. Generally WTP defines as a potential buyer or user maximum price at which he or she would buy a good or service (Krugman et al., 2010). That is to say, the starting point for measuring costs or benefits is willingness to pay; that amount of money which individuals or firms could pay after a proposed change and still be equally well off (by his or her own evaluation). This concept incorporates consumer power: i.e., the belief that individuals are the best judge of the value to them of their consumption decisions. The willingness-to-pay principle allows one to assess how much people care about relieving the externality (Small and Verhoef, 2007). The literature classified the different methods for estimating willingness of people to pay for the abolishment, reduction or reception of a particular matter into revealed and stated preference.

2.2.1. Revealed preference methods

Revealed preference methods (RP) refer to the observation of preferences revealed by actual market behavior and represents real-world evidence on the choices that individuals exercise (Accent, 2010). In fact RP methods, use information from markets that are associated with the good or service that is being evaluated. There is a strong case for using RP techniques whenever the relevant WTP information can be inferred from individuals' actual decisions (Bateman et al., 2002). Revealed preference techniques typically cannot be applied directly to the

valuation of environmental goods because of the lack of an observable market price. One solution is to investigate a substitute market (Bateman et al., 2003). For example, in the presence of water pollution, a household may install a filter on the primary tap in the house to remove or reduce the pollutant. This involves a capital expenditure by the household and changes in behavior because potable water can now be safely obtained only from the primary tap, not from other taps in the house. If the filter could solve the water quality in the first tap, we would say the capital expenditure and maybe the maintenance cost is equal to the value of potable water from one tap for this family.

Hedonic pricing and Travel cost methods are introduced as the main methods in this group (Bateman et al., 2002; Bockstael and McConnell, 2007; Kjær, 2005). Hedonic pricing method is used in some European studies such as UNITE, RECORDIT, INFRAS/IWW, CE DELFT and etc. for valuating costs of noise (Maibach et al., 2008).

The travel cost method is based on the simple idea that it ought to be possible to infer the values placed by visitors on environmental amenity services from the costs that they incurred in order to experience the services (Perman et al., 2003). Here the costs of a recreation site visit are calculated. These costs would be a combination of any entry charge (typically zero for UK forests), travel expenditure (e.g. petrol costs) and the opportunity cost of travel time (i.e. the value of the time devoted to travelling to the site; this might be wages forgone or the lost opportunity to enjoy some other activity during that time) (Bateman et al., 2003). The travel cost method seeks to place a value on non-market goods by using consumption behavior in a related market. The rationale behind the travel cost method is that as the price of access (i.e. cost of travel) increases, the visit rate tends to fall (Kjær, 2005).

The hedonic pricing method follows Lancaster's theory of characteristics of a good, which regards a good (or service) as a set of attributes and considers the value of a good as a function of each attribute of that good (Lancaster, 1966). The

hedonic pricing focuses on valuing the separate characteristics of a public good (Brown Jr. and Mendelsohn, 1984). This method is a variant of the travel cost method which seeks to use data on the attributes of recreational sites together with data on visitation rates and travel costs to value site attributes (Perman et al., 2003). The hedonic approach is implying that the method regards a good as a set of attributes and considers the value of a good as a function of each attribute of that good. The value of an attribute is called an implicit price (a hedonic price) of the attribute, because it cannot be observed in a real market. (Kjær, 2005). Hedonic pricing method is used in some European studies such as UNITE, RECORDIT, INFRAS/IWW, CE DELFT and etc. for valuating costs of noise (Maibach et al., 2008).

2.2.2. Stated preference methods

The Stated preference (SP) methods are used to refer to any questionnaire-based technique, which seeks to discover individuals' preferences. Stated preference techniques elicit willingness to pay for a marginal improvement or for avoiding a marginal loss directly by asking questions of the form 'What are you willing to pay?' or 'Are you willing to pay $x, or by asking respondents to express preferences across some set of alternatives (Bateman et al., 2002; Tietenberg and Lewis, 2011).

The principal difference between revealed preference and stated preference methods is that the latter draw their data from people's responses to hypothetical questions, when the WTP information that is needed cannot be inferred from markets, rather than from observations of real-world choices (Bateman et al., 2002; Bockstael and Freeman III, 2005). Stated preference is the only valuation technique capable of measuring non-use values, i.e., the value that people place on certain goods or natural resources even if they do not use them nor plan to do so in the future. The other advantage is that it covers all costs and benefits which are relevant for peoples' WTP. This is especially important for goods that are not traded on markets, e.g. the preservation of specific ecosystems or species. Though the

values are based on, what people say and not on their observed market behavior, these techniques are well-accepted methods for valuing non-market goods and services. Contingent valuation and Choice modeling (Choice experiment) are known as the main techniques in stated preference (Bateman et al., 2002; Bockstael and McConnell, 2007; Kjær, 2005).

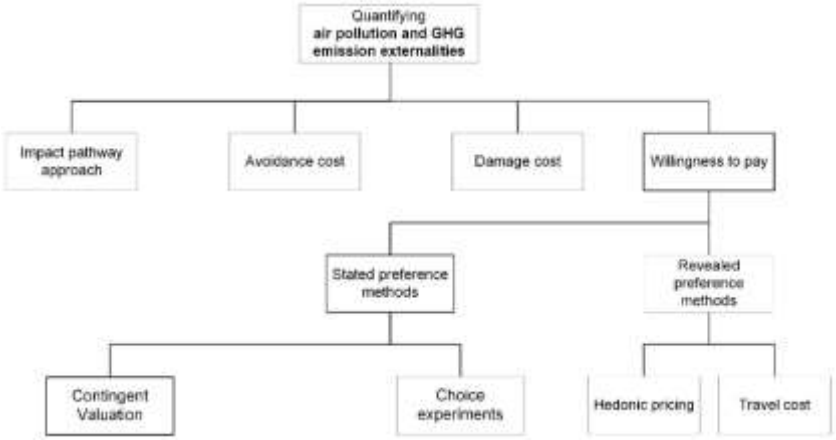
As it explained earlier, Stated Preferences methods are the only valuation technique capable of measuring total value (use and non-use value of a good). Modern welfare economic models specify that individuals will choose options that maximize utility subject to their preferences, knowledge of alternatives and budget. Consumers are assumed rational decision-makers with well-defined preferences. Preferences for environmental goods and services, which are not usually traded within the market mechanism, can be inferred by revealed preference and stated preference (Roche et al., 2010). In this section, we will review the characteristics of its two main group of methods and studies related to the environmental goods.

The Choice Experiment (CE) approach was initially developed by Louviere and Hensher (1983) and Louviere and Woodworth (1983). It has a common theoretical framework with dichotomous choice contingent valuation in Random Utility Theory (RUT), which assumes that individuals will make choices based on the attributes (i.e., transport mode travel time is an attribute) and attribute levels (very slow, slow and fast would be the travel time levels) along with some degree of randomness (a random, unobservable component) (Hoyos, 2010; Snowball, 2008). As it mentioned, in principle, all choice modeling techniques assume that goods or services can be described in terms of their attributes or characteristics and the levels that these take. The focus is on the value placed on these attributes. In stated choice experiments, respondents evaluate and decide which mutually exclusive and multi-attribute alternative they prefer. Each alternative is described by a number of attributes, which are offered at different levels across a series of options (Accent, 2010).

Choice experiment methods are widely used for environmental valuation. Issues such as environmental improvement (Campbell et al., 2008; Zhai and Suzuki, 2008), environmental quality objectives (Carlsson et al., 2010), water quality (Del Saz-Salazar et al., 2009), wildlife management (Hanley et al., 2010), coastal development (Hoyos et al., 2012), valuing climate change impacts on plant cover (Riera et al., 2012) and many other concerns. In addition, there are many studies related to transport and transport externalities that they used choice experiment method as their valuation method. Different topics are considered such as fuel tax acceptance (Sælen and Kallbekken, 2011), households demand for clean vehicle (Potoglou and Kanaroglou, 2007), policy objectives to reduce CO_2 from transport (Hensher, 2008), the social acceptance of Carbon Capture and Storage (CCS) (Kraeusel and Möst, 2012), benefits of a reduction of traffic noise, air pollution and electromagnetic pollution (Banfi et al., 2012).

Contingent valuation (CV) is a scenario-based method, meaning individuals make their valuation contingent on a specific scenario. Often, the scenario is hypothetical in character, which may threaten the reliability of the method (Armbrecht, 2012). Contingent valuation is widely used in environmental valuation studies. In figure 2.1 we summarized the most commonly methods for quantifying transport externalities.

Figure 2.1, Methods for quantifying GHG emission and air pollution externalities



Many studies have focused on environmental issues related to the energy. Environmental improvement in power generation (Soliño et al., 2009a), estimating preferences for electricity generated by conventional energy sources (Soliño et al., 2009b) and profiling potential adopters of green electricity tariffs (Diaz-rainey and Ashton, 2011) are some examples of measuring respondents' willingness to pay for an energy related environmental concerns or improvement. In other researches, problems such as improving air quality and climate, water quality, natural resources protection have been addressed by using CV method. Mitigating global climate change through its willingness to pay for biomass (Solomon and Johnson, 2009), evaluating protected areas in the developing world (Adams et al., 2008), estimating the willingness to pay to maintain environmental conditions of a specific natural park (Álvarez Díaz et al., 2010) and estimating the willingness to pay to avoid infection of tsutsugamushi disease (a kind of infection of climate change diseases) (Rhee, 2013) are some cases in this category. Nevertheless, the most important category for the current study is the studies related to the transport externalities.

In this section, we discuss in detail some studies that are related to the transport externalities. The study of Svensson and Vredin Johansson (2010) estimates the willingness to pay for a mortality risk reduction in Sweden. They argued that WTP for a private risk reduction is three times higher compared to a public risk reduction and a significant part of the difference can be explained by respondents' attitudes towards privately and publicly provided goods in general. D'Haultfœuille et al. (2011) investigate whether French consumers have modified their preferences towards environmentally friendly vehicles between 2003 and 2008. Their results show that there has been a shift in preferences towards low emitting cars, with an average increase of 536 euros of the willingness to pay for a reduction of 10 grams of carbon dioxide per kilometer. They suggest that such policies may be efficient tools to shift consumers' utility towards environmentally friendly goods. Lera-López et al. (2012) examines the willingness-to-pay of people living in

a number of villages in Navarre, in the Spanish Pyrenees to reduce noise and air pollution. Their estimation based on contingent valuation, remarks that those living near roads are willing to pay more to reduce air and noise pollution. In other study, Loureiro et al. (2013) find a positive willingness to pay (in the form of higher car fuel prices) for a policy to reduce GHG emissions through biofuels. In Korea, Lim and Yoo (2014) attempt to apply contingent valuation to measure the publics willingness to pay for voluntary carbon offsets from railway travel.

As it shown, wide ranges of topics are targeted to quantify by contingent valuation method. An extra payment for internalizing transport externalities are among these topics. Meanwhile, researchers believe that willingness to pay an extra amount to solve an environmental problem is a pro-environmental behavior. On the other hand, based on the findings in social psychology, attitude is the most commonly used predictor of economic value of a good (Ajzen and Peterson, 1988). As it mentioned before, WTP as an environmental attitude can be evaluated by using psychological concepts of behavioral theories (Ajzen, 1991; Ajzen and Madden, 1986; Gifford et al., 2011; Pouta and Rekola, 2001).

2.3. What does the willingness to pay depend?

2.3.1. Environmental psychology and behavioral theories

Environmental psychology, which developed in the US in the 1960s, looks at the range of complex interactions between humans and the environment. It is therefore a very broad field with many branches. The branch that looks at the psychological roots of environmental degradation and the connections between environmental attitudes and pro-environmental behaviors is part of environmental psychology (Kollmuss and Agyeman, 2002). Attitudes are a central concept to social psychology, and hence to environmental psychology. They are defined as ‘‘a psychological tendency that is expressed by evaluating a particular entity [or attitude object] with some degree of favor or disfavor’’ (Eagly and Chaiken, 1993).

There are numerous theories regarding how the ‘‘evaluation’’ occurs, giving rise to attitude formation and attitude change. In this section, we considered some of the most commonly used ones. These theories include the Theory of Reasoned Action (TRA) developed by Fishbein and Ajzen (1975), the Norm-Activation Model (NAM) developed by Schwartz (1977), the Theory of Reasoned Action (TRA) developed by Fishbein and Ajzen (1975), the Value-Belief-Norm Theory developed by Stern et al. (1999) and the Theory of planned behavior (TPB) developed by Ajzen (1991).

The Reasoned Action Theory assumes that human behavior is grounded in rational thought, and the model uses the Principle of Compatibility, offers insight into when attitudes should be most strongly associated with behavior. This principle states that measuring the attitude and the behavior at the same level of specificity can maximize the predictive power of attitudes. Fischbein and Ajzen maintain that people are essentially rational, in that they ‘make systematic use of information available to them’ and are not ‘controlled by unconscious motives or overpowering desires’, neither is their behavior ‘capricious or thoughtless’ (Ajzen and Fishbein, 1980, introduction; see also Fishbein and Ajzen, 1975, p. 15). Attitudes do not determine behavior directly; rather they influence behavioral intentions, which in turn shape our actions. Intentions are not influenced only by attitudes but also by social (‘normative’) pressures. Thus, ‘the ultimate determinants of any behavior are the behavioral beliefs concerning its consequences and normative beliefs concerning the prescriptions of others’ (Ajzen and Fishbein, 1980, p. 239).

The Norm-Activation Model (NAM) originally developed by Schwartz (1977). It was developed to explain pro-social behaviors or environmental significant behavior. Consequently, researches using this model conceptualize car use reduction as a behavior primarily driven by pro-social motives (Eriksson et al., 2006). This concept is based on the assumption that a ‘personal norm’ is the most important determinant of travel mode choice. A ‘personal norm’ is defined as the felt moral obligation for bringing own behavior in line with personal standards.

This model assumes that the information as well as activation of personal norm is the result of interplay of cognitive, emotional and social factors. The 'problem awareness and perceived responsibility' are important cognitive preconditions for the development of personal norm (Ashraf et al., 2013; Schwartz, 1977).

The Value Belief Norm Theory was proposed by (Stern et al., 1999). According to the theory, pro-environmental behaviors arising from acceptance of particular personal values, from beliefs that things important to those values are under threat, and from beliefs that actions initiated by the individual can help alleviate the threat and restore the values. This theory is a broadened version of the norm activation model that better accounts for pro-environmental intention and behavior in that it is particularly designed to examine pro- environmental behavior and includes several essential concepts (i.e., values and ecological worldview) in environmentalism (Oreg and Katz-Gerro, 2006; Stern, 2000).

The Theory of Planned Behavior (TPB) is essentially an extension of the Theory of Reasoned Action that includes measures of control belief and perceived behavioural control (Armitage and Conner, 2001). Intention is itself an outcome of the combination of attitudes towards a behavior. That is the positive or negative evaluation of the behavior and its expected outcomes, and subjective norms, which are the social pressures exerted on an individual resulting from their perceptions of what others think they should do and their inclination to comply with these. The TPB added a third set of factors as affecting intention (and behavior); perceived behavioural control. This is the perceived ease or difficulty with which the individual will be able to perform or carry out the behavior, and is very similar to notions of self-efficacy. The dominating trend in environmental psychology for the study of the relationship between attitudes and intended behavior is the use of the Theory of Planned Behavior by Ajzen (1991). The TPB is one of the most influential theories in social and health psychology (Armitage and Conner, 2001) and has also been validated in the context of pro-environmental behavior (Pouta and Rekola, 2001; van Birgelen et al., 2011). This model may have some better explanation

power that relates to the concept of attitude. The theory of planned behavior have been widely recognized for predicting behavior and have been supported in many studies.

2.3.2. Theory of Planned Behavior (TPB)

Behavior is conceptualized and defined in several ways. The largest number of studies (primarily from within psychology) focus squarely on the individual as the locus of behavior. The Theory of Planned Behavior has been held to be a sufficient and powerful model in explaining or predicting behavior (Ajzen, 1991). It has successfully attracted wide application and empirical support to several pro-environmental behaviors.

The Theory of Planned Behavior (Figure 4), which is an extension of the Theory of Reasoned Action, theorizes that behavior is a function of intention, which itself is a function of attitudes, subjective norms and perceived behavioural controls. TPB assumes that attitudes, subjective norms and perceived behavioral control help us to better understand environment-related behaviors, such as "the behavior of paying money for a good" (Ajzen, 1991; Ajzen et al., 1996; Kaiser et al., 2005). The inclusion of PBC provides information about the potential constraints on action as perceived by the actor, and is held to explain why intentions do not always predict behavior. (Armitage and Conner, 2001), These are the key elements in determining a person's intentions to engage in a target behavior, and ultimately influences the performance of the behavior (Ajzen, 1991; Fishbein and Ajzen, 1975). The TPB expands the applicability of the Theory of Reasoned Action also to behaviors that cannot be assumed to be dependent only on volitional[8] control (Ajzen, 1991; Ajzen and Madden, 1986).

Attitude refers to individuals' positive or negative evaluation of performing a behavior. Subjective norms represent the social pressure from the members of a

[8] Volition or will is the cognitive process by which an individual decides on and commits to a particular course of action.

reference group to act out a given behavior. Perceived behavioral control concerns the perceived ease or difficulty of performing a behavior. The majority of the studies using TPB have revealed that the individual's intention to engage in the behavior under investigation should be enhanced by a positive attitude, stronger subjective norms and higher perceived behavioral control (Ajzen, 1991; Liebe et al., 2011).

Therefore, as shown in Figure 2.2 behavioral intention is formed as a weighted combination of attitudes, subjective norms and perceived behavioral control,

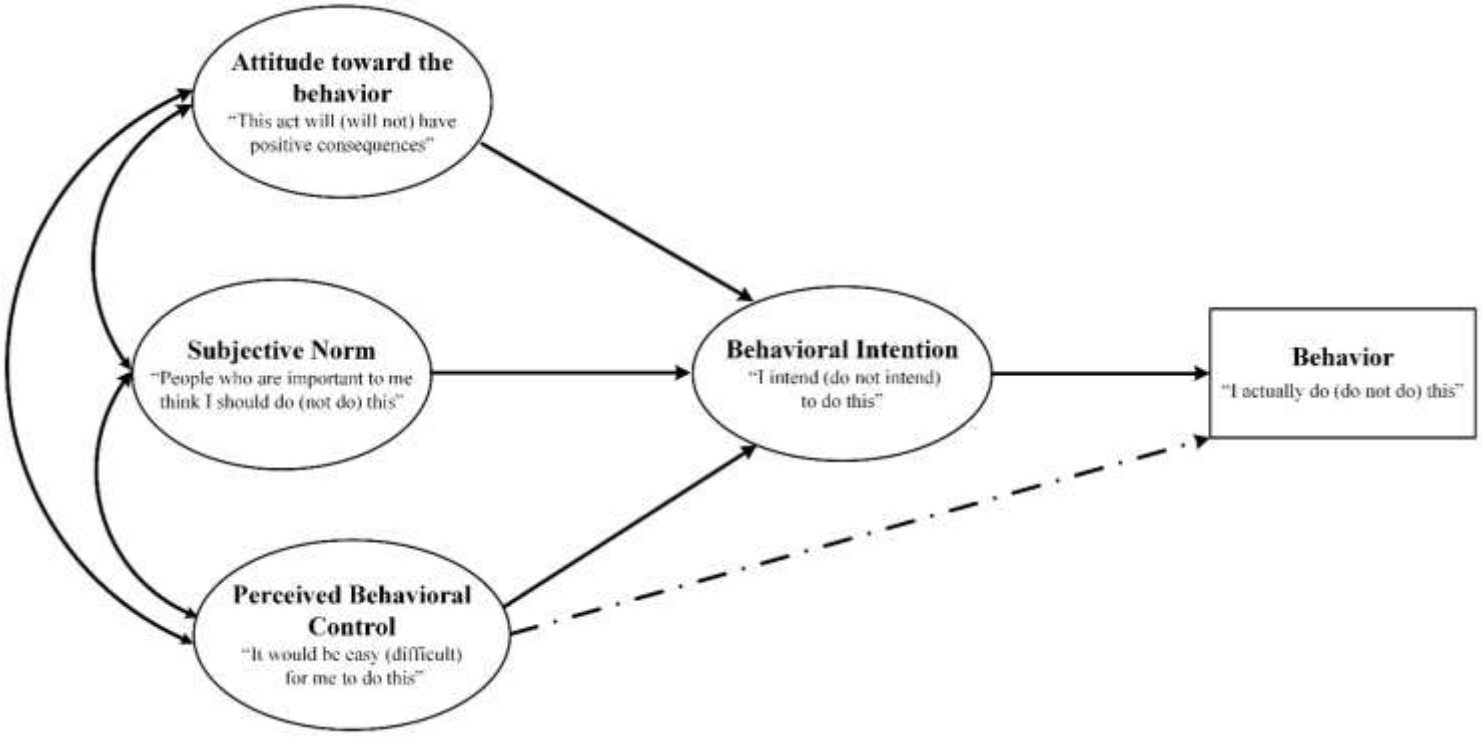
$$BI = f(AT, SN, PBC)^{9}$$

The TPB has been used as a framework in a very wide range of studies examining intention including pro-environmental behaviors (e.g., Bamberg and Möser, 2007), safe sex practices (Fisher et al., 2002; Sutton et al., 1999), exercise behaviors (Ickes & Sharma, 2011), sleeping patterns and intentions (Knowlden et al., 2012), dangerous driving behaviors (Elliot et al., 2003), choosing transport mode (Donald et al., 2014), hotel customers' intentions to visit a green hotel (Han et al., 2010) and conservation behavior (Kaiser et al., 2005). In applications to a variety of domains, good empirical studies have supported TPB (for more reviews, see Ajzen, 2001; Armitage and Conner, 2001).

As an example, Armitage and Conner's (2001) meta-analytic review using a database of 185 independent studies revealed that TPB accounted for 27 percent of the variance in behavior and 39 percent of the variance in intention. Perceived behavioral control accounted for large amounts of variance in intention and behavior. In studies where the behavior was based on self-reported measures, intentions and perceived behavioral control accounted for 31 percent of the variance in behavior (across 44 tests), whereas intentions and perceived behavioral control only accounted for 20 percent of the variance in behavior (across 19 tests).

[9] BI=Behavioral intention, AT=Attitude, SN=Subjective norm, PBC=Perceived behavioral control

Figure 2.2, Theory of Planned Behavior by Ajzen (1991)



The authors attribute the differences between self- reported and objectively assessed behavior to a number of factors, including self- presentation biases. Subjective norms were found to be weak predictors of intention. The authors attribute this outcome to a combination of poor measurement and the way normative pressures were conceptualized. The authors further note that the results are consistent with past meta-analytic reviews, thus providing evidence that the TPB is a useful framework for predicting a wide range of behavioural intentions and behaviors.

In transport related studies, TPB is used to measure different kinds of intentions and behaviors. Bamberg et al. (2011) propose a theoretical grounding of soft transport policy measures, based on TPB, that aim at promoting voluntary reduction of car use. First, they presented a conceptual framework to clarify how hard and soft transport policy measures influence car-use reduction. Then, two different behavioural theories, TBP and the Theory of Reasoned Action, which have been used to account for car use and car-use reduction, are then integrated in a self-regulation theory that identifies four stages of the process of voluntarily changing car use. As they reported, there were indirect effects of goal intention via attitude, of goal feasibility via perceived behavioural control, and of personal norm via attitude and perceived behavioural control, so the results were consistent with the self-regulation theory.

In other study which has been done by Bamberg et al. (2003), relying on the theory of planned behavior, a longitudinal study investigated the effects of an intervention—introduction of a prepaid bus ticket—on increased bus use among college students. In this context, the logic of the proposition that past behavior is the best predictor of later behavior was also examined. The intervention was found to influence attitudes toward bus use, subjective norms, and perceptions of behavioral control and, consistent with the theory, to affect intentions and behavior in the desired direction. Furthermore, the theory

afforded accurate prediction of intention and behavior both before and after the intervention.

2.3.3. Extension of the Theory of Planned Behavior (TPB) by different authors

The TPB has targeted for many criticisms in case of neglecting complementary components and leaving a considerable unexplained percentage of variance in behavior and its antecedents (Ajzen, 1991; Han and Hansen, 2012; Kaiser, 2006). Despite considerable supports for the TPB constructs in predicting intention and behavior, it is also apparent that the TPB still leaves a substantial proportion of unexplained variance in intention and behavior. So other conceptual factors besides the TPB constructs should be considered (Han and Hansen, 2012). Even though Ajzen (1991) argued that any other variable external to the TPB model could have only an indirect effect on intention mediated by attitude, subjective norm, or perceived behavioral control, several studies on pro-environmental behavior have extended the TPB and successfully improved the explanatory power of the model.

For this reason and in order to enhance the original TPB's explanatory power, various authors have tried to propose an expanded model of TPB by adding new variables (Bamberg et al., 2007; Han and Hansen, 2012; Heath and Gifford, 2002; Kaiser, 2006; Peters et al., 2011). Among different variables, a number of previous studies have emphasized the importance of Environmental Concern and Moral Norm in predicting pro-environmental attitude, intentions and behavior (Alló and Loureiro, 2014; Hansla et al., 2008; Hartmann and Apaolaza-Ibáñez, 2012; Liebe et al., 2011; Thøgersen and Ölander, 2006).

As Manstead (2000) defined, the factor, which has been called personal norm[10], is one of the most widely used determinants for demonstrating a person's pro-

[10] In different studies, personal norm also labeled differently. Such as moral norm or moral obligation with the same application and meaning.

environmental behavior. Many authors have figured out that personal norm is a good predictor to determine environmentally oriented behaviors (Han and Hansen, 2012; López-Mosquera et al., 2014; Peters et al., 2011). Personal norm component which would reflect the perception of the individual about the moral correctness or incorrectness of a particular behavior (Ajzen, 1991).

Social norms are known as the origin of the personal norms. Social norms imply that (certain) people should manifest a prescribed behavior or not manifest a proscribed behavior. Furthermore, social norms are often guiding behavior in specific contexts, and many times, they need to be activated. Violation of social norms is met by sanctions (Biel and Thøgersen, 2007). Social norms may become internalized, in which case sanctions (in the form of guilt feelings or pride) are administered by the individual him or herself. Internalized social norms are called personal norms (Schwartz, 1977). Thorgersen (1996) has argued that pro-environmental behaviors should be classed in the moral rather than in the economic sphere, given that people evaluate these environmentally relevant behaviors in terms of whether they are correct or not, rather than by balancing personal costs and benefits. Continuing in this line of study, various authors have determined that moral norms determine pro-environmental intentions and behavior and that they improve the prediction of it (Han and Hansen, 2012; Peters et al., 2011; Thøgersen and Ölander, 2006). Other authors, by contrast, have been uncertain of the inclusion of personal norms as a proximal or independent determiner of intention in the environmental area (Kaiser et al., 2005; Kaiser and Scheuthle, 2003).

Regarding the other factor, Schultz (2000) proposed that concern for environmental problems is fundamentally linked to the degree to which people view themselves as part of the natural environment. As suggested by Bamberg (2003) an individual's environmental concern is a general attitude and indirect determinant of specific behaviors. That is to say, an individual's environmental concern would have impacts on specific behaviors through situation-specific

beliefs and attitude. He explained, in many daily situations, where people have to made quick decisions, they may use general attitudes like environmental concern as an easy accessible heuristic, which guides the 'definition of the situation' that is how to frame the decisional problem, the relevant alternatives and the personally salient decision criterion. Since environmental concern is an important antecedent determining an individual's pro-environmental behaviors, such as consumers' intentions to visit green hotels, their environmental concern will also be considered as an antecedent of the components of the extended TPB model (Chen and Tung, 2014).

Heath and Gifford (2002) examines environmental concern, moral norms and some other factors in an expanded version of the theory of planned behavior (TPB) to predict and explain public transportation use. Regarding their findings, moral and descriptive norms, significantly explained additional variance in bus use. They added a further 2.2% of the variance in intention to use the bus. However, environmental concern, which was added in the last step of their study, did not add a significant amount of variance. The result were consistent with previous studies (e.g., Schultz and Oskamp, 1996) which indicates that the effort to perform a specific behavior moderates the relation between environmental concern and pro-environmental behavior.

Chen and Tung (2014) aim to develop an extended TPB model, which includes environmental concern and perceived moral obligation to predict consumers' intention to visit green hotels. The results of this empirical study indicate that the consumer's environmental concern is positively related to his/her attitude toward visiting green hotels. Moreover, the consumer's perceived moral obligation also has a positive impact on his/her intention to visit green hotels.

Personal norms and environmental concern are known as the most widely used constructs to expand TPB. Mentioned studies are potent proofs to show it would be possible to expand the TPB with complementary components and cover some unexplained percentage of variance in behavior or other constructs. Although, in

the current study we will only use environmental concern to expand the TPB model.

2.4. Theory of Planned Behavior and Contingent Valuation

2.4.1. TPB, Contingent Valuation and environmental issues

As it discussed before, willingness to pay as an environmental attitude can be evaluated by using psychological concepts of behavioral theories (Ajzen, 1991; Ajzen and Madden, 1986; Gifford et al., 2011; Pouta and Rekola, 2001). In other words, analysis of psychological factors is needed to understand the behavioral intentions of individuals, such as their intention to pay or stated willingness to pay (e.g. Ajzen et al., 1996; Spash et al., 2009). There are plenty of studies that have analyzed intentions and attitudes by estimating people's WTP regarding an environmental issue.

Pouta and Rekola (2001) in their study, examine willingness to pay responses obtained through contingent valuation in the context of the theory of planned behavior. According to the theory of planned behavior, attitudes, subjective norms, and perceived behavioral control predict behavioral intention. Considering WTP as a behavioral intention, the article explains willingness to pay for abatement of forest regeneration using data from a community-level case study in southern Finland. Attitudes toward forest regeneration and toward supporting forest regeneration abatement policy were measured and used to predict willingness to pay. Attitudes and perceived behavioral control predicted contingent valuation results significantly.

Bernath and Roschewitz (2008) examine the potential of the theory of planned behavior to explain willingness to pay in a contingent valuation survey of the recreational benefits of the Zurich city forests. Models with and without the psychological predictors proposed by the theory of planned behavior were compared. Whereas the inclusion of the psychological predictors significantly improved explanations of protest votes, their ability to improve the performance

of the model explaining bid levels was limited. The results indicate that the interpretation of bid levels as behavioral intention may not be appropriate and that the potential of the theory of planned behavior to improve contingent valuation models depends on which aspect of willingness to pay responses is examined.

Spash et al. (2009) report on empirical work extending the standard economic approach to valuation by including psychological and philosophical factors. More specifically a contingent valuation method survey was applied to biodiversity improvement while simultaneously assessing rights based beliefs, consequentialism and the theory of planned behavior. This study extends previous work on the motives behind economic valuations under the contingent valuation method by adopting an approach to explaining intended behavior from social psychology, namely the theory of planned behavior. Clearly, the theory of planned behavior is highly relevant to the willingness to pay results and this has strong implications for their interpretation.

López-Mosquera et al. (2014) used the concept of moral obligation and the components of the Theory of Planned Behavior to determine their influence on the willingness to pay of visitors for park conservation. The mean willingness to pay estimated was 12.67€ per year. The results also indicated that moral norm was the major factor in predicting behavioral intention, followed by attitudes. The new relations established between the components of the Theory of Planned Behavior show that social norms significantly determine the attitudes, moral norms and perceived behavioral control of individuals.

2.4.2. Willingness to pay to reduce GHG emissions and air pollution

Several economic reviews demonstrate the substantial costs related to climate change and consequently call for early action. These reviews, however, have been limited to measuring 'objective' risks and expected material damage related to climate change. The 'subjective' perceived risk of climate change and society's willingness to pay to avoid these risks are expected to provide an important

additional motivation for direct action (Brouwer et al., 2008). There are many studies on WTP estimation for air pollution and GHG emissions reduction.

Adaman et al. (2011) explores Turkish urban households' WTP for CO_2 emission reductions expected to result from improvements in power production. The determinants of WTP were identified by considering not only the impact of standard socio-economic factors but also the effects of environmental knowledge, attitudes and behavior, the relevance of the identity of the collection agent (national versus international institutions), and the degree of perceived participation of others in the realization of the project. Their study confirms the existing literature in demonstrating that WTP figures reported by young and educated people that are active on environmental issues, and who possess material security and environmental knowledge, are more likely to be high.

Yang et al. (2014) explored the factors that influence respondents' willingness to pay (WTP) for CO_2 mitigation under climate change. Respondents' traditional demographic attributes, risk perception of greenhouse gas (GHG), and attitude toward the government's risk management practices were established to analyze the determinants. Important factors influencing WTP include people's feeling of dread of GHGs, confidence in policy, the timeliness of governmental information disclosure, age, education and income level.

Carlsson and Johansson-Stenman (2000) tried to quantify individual willingness-to-pay measures of improved air quality in Sweden by using the Contingent Valuation Method. WTP was increasing in income, wealth and education; it was larger for men, members of environmental organizations, people living in big cities (which are on average more polluted), and people who own their house or apartment. It was lower for retired people.

In another study, Carlsson et al. (2012) conducted a Contingent Valuation study in China, Sweden, and the United States. They investigate citizens' willingness to pay (WTP) for reducing CO_2 emissions. We find that a majority of the respondents in all three countries believe that the mean global temperature has increased over

the last 100 years and that humans are responsible for the increase. The share of Americans that believes these statements is smaller, and a relatively larger share of Americans believes that nothing can be done to stop climate change. Sweden has the highest WTP, while China has the lowest.

In the context of the CO_2 emission compensation, van Birgelen et al. (2011) examine the behavior of passengers with respect to their preparedness to do this compensation. For this purpose, they assessed the influence of consumer-related factors on the willingness of air travelers to compensate for CO_2 emissions, and the likelihood of them actually compensating.

Brouwer et al. (2008) investigate whether and why air travel passengers—an increasingly important source of greenhouse gas emissions—are supportive of measures that increase the cost of their travel based on the polluter pays principle and compensate the damage caused by their flight. The study confirms that passenger belief in the effectiveness of the tax significantly influences WTP and that introducing a voluntary tax is expected to result in a high degree of non-participation.

Achtnicht (2011) focuses on the demand side. It examines whether CO_2 emissions per kilometer is a relevant attribute in car choices. Based on a choice experiment among potential car buyers from Germany, a mixed logit specification is estimated. In addition, distributions of willingness-to-pay measures for an abatement of CO_2 emissions are obtained. The results suggest that the emissions performance of a car matters substantially, but its consideration varies heavily across the sampled population. In particular, some evidence on gender, age and education effects on climate concerns is provided.

Assessing the WTP of the general public for climate change mitigation programs enables governments to understand how much taxpayers are willing to support the implementation of such programs. The study of Longo et al. (2012) contributes to the literature on the WTP for climate change mitigation programs by investigating, in addition to global benefits, the ancillary benefits of climate change mitigation. It

does so by considering local and personal benefits arising from climate change policies. The Contingent Valuation Method is used to elicit the WTP for ancillary and global benefits of climate mitigation policies in the Basque Country, Spain. Results show that WTP estimates are 53–73% higher when ancillary benefits are considered.

In Spain, Lera-López et al. (2012) examine the willingness-to-pay of people living in a number of villages in Navarre, in the Spanish Pyrenees to reduce noise and air pollution. Several models are used for estimation based on contingent valuation, noting that those living near roads are willing to pay more to reduce air and noise pollution. In addition, the result shows younger people, the better educated, and the more environmentally aware individuals are willing to pay more to reduce those externalities.

To summarize, it is worth it to define what we are going to do in this study once again. The main problem, which this study is going to address, is external costs of GHG emission and air pollution from road transport. To do so, we will use WTP method to quantify mentioned pollutions costs. Since the WTP is known as a behavioral intention, we will use the TPB, which is the most widely used psychological theory in the context of environmental and pro-environmental behavior assessment.

Chapter 3

Methodology

In the previous chapters, we discussed about different transport externalities. Then we considered the air pollution and GHG emission as one of the most important environmental externalities that may affect human and nay human creature health. In continue we argued the importance of the transport as one of their causes of the air pollution and GHG emissions. Subsequently, the importance of quantifying these externalities in order to make new policies or change current ones was raised. In addition, we reviewed the appropriate solutions and approaches. As previously described, one of the most commonly used, practical and recommended tools for evaluating individual preferences and estimating the price of non-marketed goods[11] such as air quality is the willingness-to-pay (WTP) approach. Contingent Valuation method has selected among different methods of WTP. This chapter presents the research hypotheses of the current study and the methodology to test those hypotheses. The key objective of this research is to examine the influence of the attitudinal elements of the Theory of Planned Behavior on intention to pay (willingness to pay) more to reduce air pollution and GHGs emission from private road transport in Catalonia. Further, a selected number of other constructs incorporated into the research model were also examined, and their effects on intention to pay for the targeted transport externalities were tested trough a Structural Equation Modelling (SEM) method.

In this chapter, in section 3.1 we discuss the measurement of the willingness to pay. In this section, we will compare the characteristics of the two main

[11] Environmental goods, e.g., clean air or wetlands are not sold in the common market place. For valuing non-marketed environmental values more efforts are required due to the absence of well-defined markets like other goods and services, where prices are revealed openly (Ahmed and Gotoh, 2006).

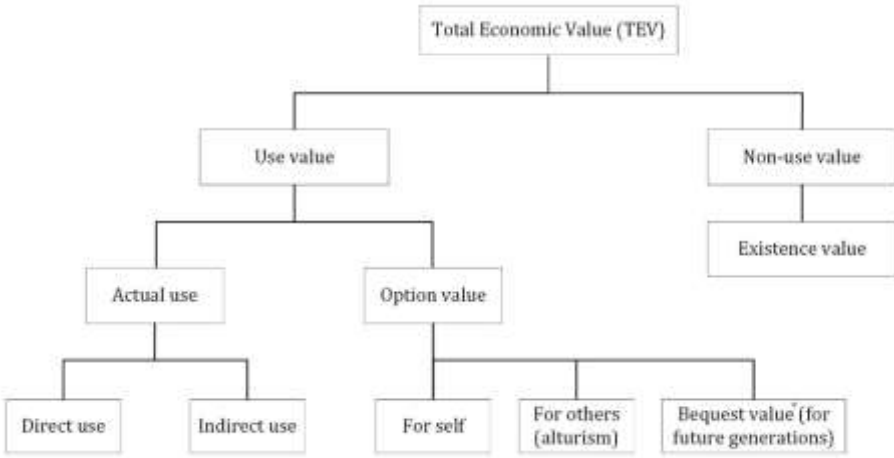
approaches of the stated preferences method. Here we argue pros and cons of the two methods to see the reasons of selecting the contingent valuation method for the current study. In section 3.2 we will explain the theoretical framework once more, to see what exactly we are going to do in this study based on TPB. Then, in the section 3.3, we go to the survey including sampling area, data collection and sampling techniques and questionnaire development. Section 3.4 presents the method, which has been applied to analyze the survey data. Finally, in the last section, the econometric model for estimating mean willingness to pay is presented.

3.1. Measurement of Willingness to Pay

As it mentioned before, the starting point for measuring costs or benefits is willingness to pay: "that amount of money that an individual or firm could pay after a proposed change and still be equally well off (by his or her own evaluation)" (Small and Verhoef, 2007). In other words, the willingness-to-pay is the highest price an individual is willing to accept to pay for some good or service. In the current case as there is no market for the good under study, we need to do the economic valuation by means of methods that are capable to measure the total economic valuation. In fact, it was shown that WTP estimates, more over use values, could include potentially important non-use values (Hoyos and Mariel, 2010). Between two main methods of measuring WTP, we selected stated preference method because it is the only method capable of measuring total value[12] (use and non-use value) of the good under study (Figure 3.1).

[12] Total value or total economic value of something can be regarded as the extent to which people would be prepared to sacrifice something else in order to obtain or safeguard a quantity of it. Total economic value comprises the sum of use and non-use values. Use values may be direct (e.g. by consuming the good, visiting a site) or indirect (e.g. by securing some benefit from the good). A forest, for example, serves both direct and indirect use functions. Visitors to the forest make direct use of it. The role of the forest in protecting the regional watershed would be an example of an indirect use, as would the role of the forest in sequestering carbon dioxide. In addition to current use values, individuals may be willing to pay to conserve the option of future use. If the option relates to their own use, this WTP reflects option value. If the future use which individuals are willing to pay for is for others (e.g., children or future generations), it is termed a bequest value. Non-use values, also known

Figure 3.1, Total Economic Value



* Different authors classify the components differently. Thus, bequest value is often classified as a non-use value because the person expressing the value makes no use of the asset in question. Nevertheless, the bequest is effectively for potential future use and hence is classified under option value here.

Source: (Pearce and Ozdemiroglu, 2002)

Next, we will see pros and cons of different stated preferences methods and the motives behind choosing the Contingent Valuation method for this study.

3.1.1. Choice Experiment versus Contingent Valuation

Several approaches and methods are capable to approximate resource costs directly. They can be measured by market price of a certain effect (losses, compensation). If resource costs are not available, hypothetical market situations have to be constructed (Maibach et al., 2008). This research is going to use hypothetical situation in which we assume a future increase in vehicle tax. This increase would help to internalize externalities under study. Therefore, we need to choose appropriate method. The available methods, regarding the subject, are choice modeling and contingent valuation.

In practice, the analyst has to balance between the difficulties of the method and scarcity of time and budget to conduct a valuation study. As it mentioned before

as passive use values, arise in contexts where an individual is willing to pay for a good even though he or she makes no direct use of it, may not benefit even indirectly from it, and may not plan any future use for themselves or others. This is also referred to as existence value (Pearce and Ozdemiroglu, 2002).

stated preferences methods are used to refer to any questionnaire-based technique which seeks to discover individuals' preferences working with hypothetical situations. It has two main methods: Contingent valuation and Choice modeling which were briefly explained previously in sections 2.2.1. This study with respect to each method attributes and requirements will use contingent valuation in order to reach its objectives.

Differences between choice modeling and contingent valuation methods are presented in table 3.1 With respect to these differences and our limitations and resources, contingent valuation is selected for this study. The main reasons of this selection are cost and time in conceptual step, high stability of preferences and as the important one it is fitted with the study objectives in case of measuring a specific welfare change. This specific welfare change will be the payment vehicle of method that is related to the vehicle taxes.

Table 3.1, Contingent valuation methods versus Choice experiment methods

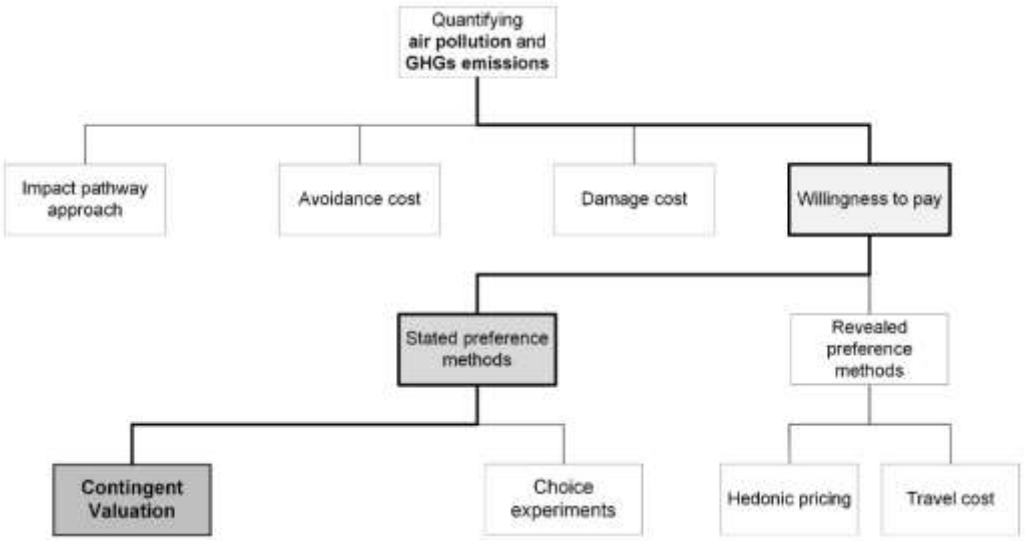
Stage	Step	Contingent Valuation	Choice Experiment
Conceptual	Cost	Low-medium	High
	Timing of the valuation exercise	Short (1-2 months)	Medium-long (3- 6 months)
Design of the valuation task	Valuation of the total good or individual attributes	Total Good	Individual attributes
	Complexity for designing the valuation scenario	Low - medium	High
	Specialized software and analysts	Low	High
Preference Elicitation	Task complexity (time required in explaining the task to respondents)	Low-Medium	High
	Avoids yea-saying (compliance bias)	No	Yes
	Stability of preferences	High	Medium
Analysis and Results	Modeling expertise and software requirements	Low	Medium-high
	Estimation of marginal effects and attribute values simultaneously	No	Yes
Research Objective	Measure a specific welfare change	Yes	No
	Measure a range of welfare changes	No	Yes

Source: (Accent, 2010)

3.1.2. Contingent Valuation, in more details

As we discussed before, we will use Contingent valuation method as the economic valuation method for the current study. Figure 3.2 is demonstrating a general perspective of the method for quantifying external costs of transport in case of air pollution and GHGs emissions. In addition, it shows the path we traversed among these different methods to choose CV as the method for the economic valuation part of this study.

Figure 3.2, The current study path for choosing quantification method



3.1.2.1. Economic theory of contingent valuation

Contingent valuation (CV) has become one of the most widely used non-market valuation techniques (Carson et al., 2001). CV is a direct method which is asking a sample of the relevant population questions about their WTP or Willingness to Accept (WTA) (Perman et al., 2003). The goal of a CV study is to measure an individual's monetary value for some item. We denote the item being valued by q; for now we will treat this as a single item whether a single commodity or a single program involving some mix of commodities treated as a fixed group – and

therefore q is a scalar[13]. Assuming the individual is a consumer and we assume the individual has a utility function defined over the quantities of various market commodities, denoted by the vector x, and q, $u(x, q)$ as direct utility function. Also regardign the direct utility function, indirect utility function can be written, $v(p, q, y)$, where p is the vector of the prices of the market commodities and y is the person's income. We make the conventional assumption that $u(x, q)$ is increasing and quasi-concave in x, which implies that $v(p, q, y)$ satisfies the standard properties with respect to p and y; but we make no assumptions regarding q. If the agent regards q as a "good," $u(x, q)$ and $v(p, q, y)$ will both be increasing in q; if she regards it as a "bad," $u(x, q)$ and $v(p, q, y)$ will both be decreasing in q; and if she is indifferent to q, $u(x, q)$ and $v(p, q, y)$ will both be independent of q.

The act of valuation implies a contrast between two situations – a situation with the item, and one without it. We interpret what is being valued as a change in q. Specifically, suppose that q changes from q^0 to q^1; the person's utility thus changes from $u^0 \equiv v(p, q^0, y)$ to $u^1 \equiv v(p, q^1, y)$. If she regards this change as an improvement, $u^1 > u^0$; if she regards it as a change for the worse, $u^1 < u^0$; and if she is indifferent, $u^1 = u^0$. The value of the change to her in monetary terms is represented by the two Hicksian measures, the compensating variation C that satisfies

$$v(p, q^1, y - C) = v(p, q^0, y), \qquad (1)$$

And the equivalent variation E which satisfies

$$v(p, q^1, y) = v(p, q^0, y + E). \qquad (2)$$

Observe that

$$sign(C) = sign\ (E) = sign(u^1 - u^0). \qquad (3)$$

[13] Scalar uses to call any real number or any quantity that can be measured using a single real number. Temperature, length, and mass are all scalars. A scalar is said to have magnitude but no direction.

If the change is regarded as an improvement, $C > 0$ and $E > 0$; in this case, C measures the individuals' maximum WTP to secure the change, while E measures her minimum WTA to forego it. If the change is regarded as being for the worse, $C > 0$ and $E < 0$; in this case, C measures the individuals' WTA to endure the change, while E measures her WTP to avoid it. If she is indifferent to the change, $C = E = 0$ (Carson and Hanemann, 2005).

From a welfare economics perspective, public intervention may be justified under the notion of a potential Pareto improvement: that is, if the overall benefits of public intervention exceed its costs[14] (Hoyos and Mariel, 2010). The utility theoretical model provides the basic framework for interpreting the responses to a CV study. Given that these responses are usually treated as random variables, the economic model needs to incorporate a stochastic component and the WTP distributions need to be linked to the survey response probability under the assumption that an individual maximizes her utility (Carson and Hanemann, 2005). The cumulative distribution function of WTP, $G_C(x)$, for a given individual, it specifies the probability that the individual's WTP for item in question is less than x

$$G_C(x) \equiv Pr(C \leq x)\,. \qquad (4)$$

and the corresponding probability density function, $g_c(x)$, depend on the form of the survey question (Carson and Hanemann, 2005; Hoyos and Mariel, 2010).

[14] A Pareto improvement in a macro sense is an action that leads to an economic benefit without making someone worse off. Given an initial allocation of goods or resources for a set of individuals, if a change in resources benefits at least one person while harming no one else, a Pareto improvement has been made.

3.1.2.2. Different types of contingent valuation question

Bateman et al. (2002) categorized contingent valuation surveys as follow, also in the table 3.2; an example question of each method is demonstrated:

- *The Open-ended*: is a straightforward way of uncovering values. An individual is asked to state his/her maximum willingness-to-pay and no amounts are given beforehand.
- The Bidding game (Iterative bidding): here respondents are faced with several rounds of discrete choice questions, with the final question being an open-ended WTP question. The bidding game is continued until the respondent expresses unwillingness to pay the given amount.

Table 3.2, Contingent valuation (CV) methods question example.

<table>
<tr><th>CV Method</th><th>Question</th></tr>
<tr><td>Open-ended elicitation</td><td>What is the maximum amount that you would be prepared to pay on top of your annual water bill to improve the quality of drinking water that comes to your home?</td></tr>
<tr><td>Bidding game (Iterative bidding)</td><td>Would you pay an additional 5€ every year through your annual water bill to improve the quality of drinking water that comes to your home?
If Yes: Interviewer keeps increasing the bid until the respondent answers "No". (The maximum WTP is elicited)
If No: Interviewer keeps decreasing the bid until respondent answers "Yes". (The maximum WTP is elicited)</td></tr>
<tr><td>Payment card</td><td>Which of the amounts listed below best describes your maximum willingness to pay on top of your annual water bill to improve the quality of drinking water that comes to your home? (in €)
<table>
<tr><td>0</td><td>0.5</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>7.5</td><td>10</td><td>12.5</td><td>15</td><td>20</td><td>40</td><td>>40</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table></td></tr>
<tr><td>Single-bounded dichotomous choice</td><td>Would you pay 5 € every year on top of your annual water bill to improve the drinking water quality that comes to your home? (The price is varied randomly across the sample). Yes / No</td></tr>
<tr><td>Double-bounded dichotomous choice</td><td>Would you pay 5€ every year on top of your annual water bill to improve the drinking water quality that comes to your home? (The price is varied randomly across the sample).
If Yes: Would you pay 10€? If No: Would you pay 1€?</td></tr>
</table>

Based on: (Accent, 2010; Bateman et al., 2002)

- *Payment Card:* or ladder approach was developed as improved alternative to the open-ended and bidding game formats. The individual is confronted with a given set of amounts and has to identify the most preferred amount.

- *Single-bounded dichotomous choice* (close-ended or referendum methods): An individual is confronted with an amount and has the opportunity to accept or reject to pay the given amount. It means respondents only have to make a judgment about a given price, in the same way as they decide whether to buy a supermarket good at a certain price.
- *Double-bounded dichotomous choice:* The dichotomous choice question is followed up by another dichotomous choice question depending on the prior answer (Bateman et al., 2002; Kjær, 2005).

Regarding advantages and disadvantages of different CV methods (see Table 3.3) Single-bounded dichotomous choice has chosen as the proper one. This method is one of the most efficient methods of CV and it received endorsement from NOAA[15]. In addition, it minimizes non-response and avoids outliers. Although the problem of starting point bias is possible but the bids' design would help to minimize it.

[15] See Arrow et al. (1993)

Table 3.3, CV methods advantages and disadvantages

CV Method	Advantages	Disadvantages
Open-ended elicitation	Straightforward	Large rate of : - Non-response - Protest answers - Zero answers (which can be protest responses), - Outliers (i.e. unrealistically large bids) Difficult for some respondent to come up with their true WTP for a change they are unfamiliar with and have never thought about valuing before.
	No anchoring bias.	
	Very informative and maximum WTP can be identified for each respondent	
	Requires comparatively straightforward statistical techniques	
Bidding game (Iterative bidding)	This may facilitate respondents' thought processes and encourage them to consider their preferences carefully.	Anchoring bias may exist.
		Problem of large number of outliers and 'yea-saying'.
		Cannot be used in mail surveys and other self-completed questionnaires.
Payment card	Provides a context to the bids and avoiding starting point bias at the same time	Probable to biases relating to the range of the numbers used in the card and the location of the benchmarks.
	Less outliers in comparison to the open-ended and iterative bidding	It cannot be used in telephone interviews.
	Use benchmarks in some versions of the payment card.	
Single-bounded dichotomous choice	Respondents have to make a judgment only about a given price	Values obtained from this method are significantly larger than those resulting from comparable open-ended questions.
	Minimizes non-response and avoids outliers	Some degree of yea-saying is also possible
	The approach received the endorsement of the NOAA[16] panel.	In subjects which we have lack of information, it is inefficient
		Dichotomous choice formats are relatively inefficient in that less information is available for each respondent.
		There may also be starting point bias
Double-bounded dichotomous choice	More efficient than single-bounded dichotomous choice as more information is elicited about each respondent WTP.	All the limitations of the single-bounded procedure still apply. Two added problems: - Possible loss of incentive compatibility (truth telling) due to the fact that the second question may not be viewed by respondents - Possibility of anchoring and yea-saying biases.

Based on: (Bateman et al., 2002; Pearce and Ozdemiroglu, 2002)

[16] NOAA: National Oceanic and Atmospheric Administration

3.1.2.3. Potential problems of Contingent Valuation

Different CV approaches are discussed to formulating questions in order to get the most accurate responses and to avoid the problems of unrealistic, biased or strategic answers (Pearce and Ozdemiroglu, 2002). A number of potential 'biases' have been identified in the Contingent Valuation Method literature, and survey design is seen as an exercise in eliminating and reducing bias as much as possible (Özbafli, 2011; Pearce and Ozdemiroglu, 2002; Tietenberg and Lewis, 2011).

I. Disparity between WTP and WTA

WTA values have been found to be always greater than WTP values when used for the same good. There are a number of possible reasons causing this disparity, some of which are the income and substitution effects, transaction costs, and existence of loss aversion. The large disparity found between the two measures leads to the conclusion that WTA is not a proper measure of consumer surplus, and WTP should be used in the Contingent Valuation studies.

II. Embedding effect

The embedding effect is also called part-whole bias, disaggregation bias, sub-additivity effect, or the scope effect. This is the variation observed in the WTP measure for the same good when valued by itself or as part of a package. There is a small difference in the WTP for a commodity irrespective of its size. The studies that are reported to suffer from the scope bias have been mostly criticized for the flaws in their survey design, improper implementation of the surveys and the sampling procedures, and the clarity of the survey questions. To minimize this bias some of the recommendations made to the researchers are to use various visual aids in describing the scenario to improve the respondents' understanding of the questions, and after describing the different commodity sizes, to ask the respondents to concentrate on the smaller size.

III. Sequencing effect

The sequencing effect, also called the question order bias, occurs in studies that attempt to measure the WTP for more than one good. The WTP for a particular good depends on the order in which it is asked in the survey. Some of the factors that give rise to this error are substitution and income effects, as well as the design and administration of the survey. To minimize the sequencing effect, the respondents need to be informed about the complete WTP questions that will be asked, before asking the first one, and be given the opportunity to revise their bids once they are finished with all the valuation questions.

IV. Information bias

The information effect happens when the level of information provided affects the WTP results. Respondents when reminded of substitutes and their income constraints tend to state lower WTP amounts. The effect of the information provided on the respondents' stated WTP depends on their existing level of information about the subject. Additional information provided to the respondents on the quality of their electricity supply, for example, will affect their stated WTP if they possess different levels of information on the quality of the service.

V. Elicitation effects

The elicitation effect arises when different elicitation formats end in different WTP values. The major elicitation techniques used in CV surveys are previously introduce in part 3.1.2.2. Biases related to these elicitation techniques can be as below:

- Open-ended elicitation technique: strategic bias
- Payment card: range bias (preference imprecision effect)[17]
- Bidding game: starting point bias
- Single-bounded dichotomous choice: starting point bias

[17] Respondent unable to cite precise WTP. In fact the method procedure allow for uncertainty in respondents' preferences.

- Double-bounded dichotomous choice: starting point bias and yea-saying bias[18]

VI. Hypothetical Bias

The hypothetical bias is the divergence between the true WTP and the stated WTP of the respondent. Most studies find the hypothetical WTP to be higher than the actual WTP. This has been attributed to the level of familiarity of the respondent with the good in question. The hypothetical bias will not be a major problem when the respondents are familiar with the good for which the WTP value is elicited.

VII. Strategic Bias

The strategic bias is the case when respondents act strategically and do not state their true WTP. Their strategic behavior can be seen in two ways: If they are led to believe that, a certain change has already been decided upon, and the survey is to determine the amount they will pay because of the change, then they understate their true WTP hoping to pay less for the good in question. On the other hand, if they believe that their stated WTP value will have a positive effect on the acceptance of the proposed change, and they do not see the prospect of them having to pay that amount, then they tend to overstate their true WTP. The strategic bias is minimized by not giving any hints to the respondents in the questionnaires to engage them in strategic behavior and by choosing incentive compatible elicitation formats like the dichotomous-choice techniques.

VIII. Payment Vehicle Bias

The payment vehicle is the element of the Contingent Valuation survey, which provides the context in which the respondent will make payment. Some of the different payment vehicles are income taxes, entry fees, changes in utility bills, trust fund payments, and reallocation of taxation funds. Since respondents value the good/service as a package where the payment vehicle is one of the elements, different WTP estimates are expected to result from different payment vehicles. Therefore, the payment vehicle bias arises when the payment vehicle is not

[18] Respondent tries to please the interviewer.

understood by the respondent or not used as the researcher intended it. In order to avoid bias the payment vehicle should be realistic and appropriate. The payment vehicles can be classified into two categories: voluntary vehicles; and obligatory vehicles (e.g. taxes, prices, fees, etc.). With voluntary contributions, the respondents are more likely to engage in free-riding behavior, and have an incentive to overstate their WTP figures to make sure the good/service is provided. Obligatory payment vehicles on the other hand are more incentive compatible, but still disposed to the payment vehicle bias if not found realistic or appropriate by the respondents. Many Contingent Valuation Method practitioners argue that with good survey instrument design strategic bias is not a major problem nowadays (Perman et al., 2003, p. 424).

Good survey instrument design now has seen as involving extensive pre-testing, the use of focus groups and one-to-one interviews. These are small groups of individuals, up to a dozen or so, who are led by a facilitator through a loosely structured discussion of the issues raised by the scenario and payment vehicle. The purpose of this exercise is to avoid biases concerning the scenario itself, and of the regarding the payment vehicle and related matters. This is in line with the guidelines recommended by the National Oceanic and Atmospheric Administration panels in 1993 (Arrow et al., 1993).

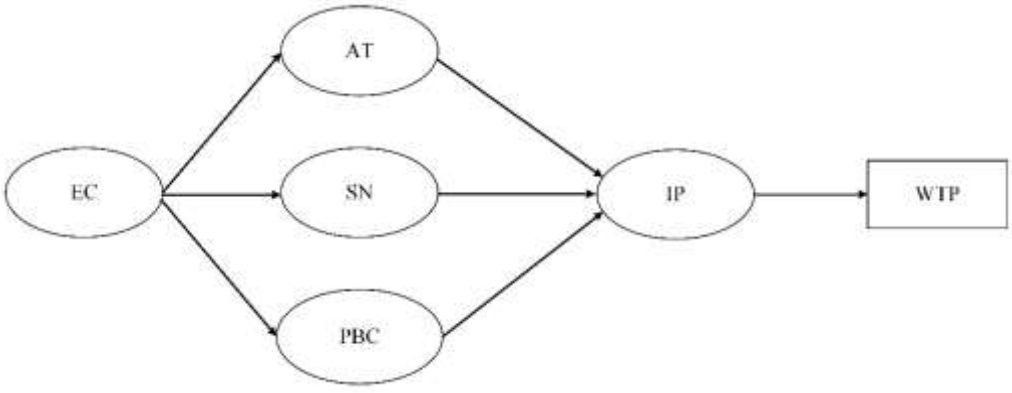
3.2. Theoretical framework

As it mentioned in chapter 1, Theory of Planned Behavior (TPB) is one of the most commonly used approaches in the area of predicting behavioral intentions to estimate the value of non-marketed goods (e.g. Armitage and Conner, 2001; Bamberg et al., 2003; Bamberg and Schmidt, 2001; Collins and Carey, 2007; Fielding et al., 2008; Oreg and Katz-Gerro, 2006). In this study, TPB will use to estimate mean willingness to pay to reduce GHG emissions and air pollution from road transport in Catalonia.

Moreover, in this study, we propose adding a new variable to the model to decrease unexplained percentage of variance of the analyzed behavior previously and other variables of the model. As we discussed in section 1.4 the new variable will be the environmental concern. Environmental concern will enter the model as the antecedent of attitude, perceived behavioral control and subjective norms. In the extended TPB model, we expect greater intention to pay to reduce pollution and GHG emissions from individuals who have a positive attitude to do the payment. Who think his/her family and friends will support his decision to do this payment (subjective norms), and who think that he will do the payment based on his own strength (perceived behavioral control).

Furthermore, in the extended model, we divided a person's behavioral intention into two variables. A latent variable that is called intention to pay and an observed variable, which is WTP. Intention to pay measured by three indicators that are asked in the questionnaire. WTP considered as a dichotomous variable, because the answers will categorize to yes and no regarding the question about the respondents' willingness to pay to reduce externalities. We assumed that intention to pay (where the amount of the payment is not mentioned to the respondents) should lead to higher stated WTP (where the amount of the payment is mentioned to the respondents) and, finally, higher payment (behavior) (see Figure 3.3).

Figure 3.3. Extended TPB model proposed in this study



3.3. Survey

3.3.1. Sampling area

Catalonia is ranked as the second autonomous community in Spain with the most vehicles: around 16% of the country's vehicles are circulating in Catalonia. At the end of 2016, there were 5,093,500 vehicles; of these, 3,436,271 were private road vehicles. Catalonia comprised 2,949,700 households and its population was 7,448,332 inhabitants (almost 16% of Spain's population). This means that, on average, each household had more than one private vehicle (IDESCAT, 2016; INE, 2016). Transport is responsible for more than 34% of CO_2 emissions and more than 50% of main air pollutants in Catalonia (Generalitat de Catalunya, 2010; Marti Valls et al., 2010; Parra Narváez, 2004).

3.3.2. Sampling techniques

Once the sampling area is determined, then the sampling strategy (the method with which the individuals included in the sample will be chosen from the population) needs to be selected (Özbafli, 2011). The main sampling techniques are Probabilistic and Non-probabilistic as they shown in table 3.4 The former is a sampling procedure in which each element of the population has a fixed propabilistic chance of being selected for the sample, while in the latter the sampling procedure relies on the personal judgment of the researcher (Bateman et al., 2002).

Table 3.4, Taxonomy of sampling designs

Non-probabilistic designs	Convenience samples
	Judgment samples
	Purposive sampling
	Snowball sampling
	Quota samples
Probabilistic designs	Simple random-sampling
	Systematic sampling
	Stratifies sampling
	Cluster sampling

Source: (Bateman et al., 2002; Given, 2008)

In this study, we used a Non-probability sampling technique. In this category of sampling techniques, the researcher does not know the chances of a unit's selection if non-probability sampling techniques are employed. Therefore, the ability to generalize about a population, using the laws of probability, is much reduced and it is not possible to calculate the degree of confidence in the results. The sample is chosen at the convenience of the consultant or to fulfil the demands of some predetermined purpose (Baker, 2003). This category is includes Convenience sampling, Judgement sampling, Purposive sampling, Snowball sampling and Quota sampling. The latter is the technique we used for the current study.

Quota sampling attempts to reflect the characteristics of the population in the chosen sample, and in the same proportions. From national statistics, researchers gather the percentages for such 'stratifies' as age groupings, income levels etc. and use them to construct 'cells'. This results in statements such as '23 per cent of the population is female, aged between 30 and 40 and earning €12,000–15,000 per annum'. Then the sample would be collected, and 23 percent of it would have to fulfil those demands. Quota controls must be available, easy to use and current. Quota 'stratifies' shouldn't be used merely because they are available – they must be relevant to the project. This method may be cheaper to operate than a probability-based method, it is quick to use and relatively simple to administrate – it does not require a sampling frame. However, there is the possibility that the interviewer shows bias in the way the individual units are selected and in the difficulty that may arise in uncovering relevant and available quota controls.

To finish, recommendations in the literature on the sample size for using Structural Equation Modelling (SEM) analysis are mixed. There is, however, general census that the minimum recommended samples for SEM analysis should be (>120) in order to test multiple hypotheses in a model of interacting variables (Byrne, 2009; Kline, 2011). SEM analysis with a sample of fewer than 100 subjects may be flawed and may encounter technical problem unless a simple model is evaluated (Kline, 2011). Hoelter (1983) and Hair et al., (2014) recommended that

a sample size of ≥200 is typically sufficient to yield an adequate model fit for the chi-square (χ^2) test.

3.3.3. Data collection

Data were collected through an online survey in May and June 2015 in Catalonia. Questionnaires were sent to a sample of Catalan residents. We received 525 answers, of which 406 were valid. Quota sampling was employed in this study by controlling for gender (female, male), age (over 18 years old) and geographical location of the respondents.

The reliability of the results from any research depends on the methodology adopted to collect the data. Sandford (1995) emphasized the basic requirements of an appropriate methodology as one, which has a good representative sample, relevant questions, and sufficient response rate.

Environmental economists have long used surveys to gather information about people's preferences. This is particularly true in the field of non-market valuation, where techniques such as the travel cost method, contingent valuation and choice modelling invariably employ some form of survey instrument. Conventional survey administration modes include mail, in-person, telephone and central site. More recently, the use of e-mail and web-based surveys has emerged as another option (Fleming and Bowden, 2009). In this study, we are going to use an internet-based questionnaire. The internet-based has some advantages and disadvantages (see table 3.5). It is one of the low price methods. With this method researcher would avoid interviewer bias. In addition, sensitive questions can be asked. The distance to the respondents will not be a problem. Besides its advantages, it should be mentioned that the online samples has the self-selection bias, which means respondents are allowed to decide entirely for themselves whether or not they want to participate. In addition, internet samples not fully representative of overall population because a part of the society are less likely to have internet access or to have basic skills to respond to online questionnaire. That may cause the sample will not well represent the whole target population.

The increasing popularity of web-based or internet-based surveys is evident by the number of researchers using this survey technique in a variety of research areas (Shih and Fan, 2008). As the current study targets the whole population of the Catalonia a web-based survey regarding the internet penetration rate in this region, make the access to the targeted population much easier. Catalonia has the second highest penetration rate for internet use in Spain, at 82%, compared with a countrywide rate of 79.4% (AIMC, 2017).

Table 3.5, Advantages and Disadvantages of Internet-based survey;

Internet-based questionnaire	
Advantages	**Disadvantages**
Low cost	Internet samples not fully representative of overall population (quotas needed)
Lack of interviewer bias	Self-selection bias
Can ask sensitive questions	Limited control over who completes questionnaire
Can be completed in respondent's own time	Limited probing possible[19]
Very short elapsed time	Respondent can change earlier responses before submission the questionnaire
Wide geographic spread easy to achieve	
Long and complex questionnaires can be administered	
Computer applied questionnaire can be used	

Source: (Accent, 2010)

There were limitations in order to gather the data. We contacted dozens of public and private institutes to get permissions of distributing our questionnaire. We did not succeed in any of them. No one was able to help us in this case mostly because of the information privacy law and the general data protection regulation.

[19] Probing is a common technique that researchers use in interviewer-administered surveys when respondents initially refuse to answer a question or say they "don't know." Interviewers are trained to use neutral probing techniques -- such as "Would you lean more toward [answer] or [answer]?" or "Just your best guess is fine" -- to encourage valid responses. Probing can be particularly effective when respondents initially hesitate to provide an answer, and it can increase the number of valid responses. However, some researchers have suggested that probing can lead to poor data quality because respondents may guess at an answer when they are asked a knowledge-based question for which there is a verifiably right or wrong answer. In addition, it may cause interviewer bias.

Institutes were worried about leaking information from their database. Even UPC did not facilitate sending the questionnaire by its email service to its staff, students and faculty members. Finally, we contracted a market research company-Toluna-, which has a vast network of people from different social and economic level in Spain and Catalonia. They send our questionnaire to their network based on two main assumption:

- General population with 18 or more years old in Catalonia
- Based on census (age and sex) information of Catalonia

We used the Survey Monkey[20], which is an online survey platform to design the questionnaire and send to the Toluna[21] network.

3.3.4. Questionnaire development

The questionnaire that was developed to obtain the needed data for this study is composed of five parts. The survey starts with a concise introduction, which presents the topic of the survey: "Policy against climate change and air pollution". Respondents are offered a brief introduction: definitions of GHG emissions and air pollution and their possible harms and hazards to the environment.

In the second part, questions related to the citizens' behavioral profile are asked. This part focuses on the extended TPB model, asking respondents about their environmental concern, attitudes, subjective norms, perceived behavioral control and intentions in relation to air pollution and GHG emissions. In order to be consistent with prior research, the constructs are measured through indicators adapted from the literature (see table 3.6).

Part 3 contains the scenario and related monetary valuation question using the Contingent Valuation Method to elicit individuals' WTP (Mitchell and Carson, 1989). Prior to asking the valuation questions, a hypothetical valuation scenario

[20] Survey Monkey is an online survey development cloud-based software.
[21] Toluna is a market research company with an online community around Spain.

was presented to respondents in as clear and simple a manner as possible (see appendix A).

Respondents were reminded of the main benefits and services the hypothetical policy offers to citizens (i.e. less polluted air and GHG emissions through, for example, support to biofuel production, investment in public transport development and encouragement of the use of electric cars); also it reminded them of the main disadvantages of GHG emissions and air pollution. Respondents were then asked to indicate their willingness to make a financial contribution of a specific amount (i.e. a compulsory annual vehicle tax or transport tax[22] for 5 years that would be managed by the government of Catalonia[23]) to fund a policy that would reduce air pollution and GHG emissions.

[22] Tax is a means of payment which is completely known for most of Spanish people and they are familiar with the process and time of money collection, therefore they can plan for it in household budget; accordingly, tax is selected as the payment vehicle for this study. Based on Wiser (2007), this payment method facilitates acceptance and understanding of the Contingent Valuation Method scenario from respondents' point of view. Also, after comparing different payment vehicles, Bateman et al. (2003) have found stated WTP which is obtained via taxes is significantly higher than the stated amount obtained through voluntary donations. This tax can be defined as "earmarked tax" which is raised and allocated to specific expenditure programs (IMF, 2007).

[23] As we proposed a compulsory annual vehicle tax as the payment vehicle in our Contingent Valuation method, there will be two main options as the organizations to collect it. First, the central government or one of organizations in its span of control. Next, a local public administration organization such as the Generalitat de Cataluña (Catalonia government). The actual relationship between more than 45% of population of the Catalonia and the central government is unstable and not good. Among the rest of the population, mainly there is a lack of trust in the central government decisions and actions. Therefore, in the focus group we decided to use the Catalonia government as the responsible of collecting and spending the proposed tax in the hypothetical scenario of the survey.

Table 3.6, Constructs and indicators of the extended TPB model.

Constructs	Indicators	Response scale (1-5)	References used
Environmental Concern (EC)	Think about climate change and air pollution. How much concern do you have about the effects of these environmental issues on your personal health or well-being? (EC1)	No concern – Very high concern	(Fujii, 2006; Wang et al., 2016)
	I think climate change and air pollution problems are becoming more and more serious in recent years. (EC2)	Strongly disagree - Strongly agree	
	The problem of climate change and air pollution is ... for my family and me. (EC3)	Not serious at all - Extremely serious	
Attitude (AT)	I think the idea of paying to reduce emissions is very responsible. (AT1)	Strongly disagree - Strongly agree	(Chen and Tung, 2014; Han et al., 2010; López-Mosquera et al., 2014)
	For me, in general, paying to reduce emissions is … (AT2)	Extremely negative - Extremely positive	
	Generally speaking, I think the idea of paying to reduce emissions is very intelligent. (AT3)	Strongly disagree - Strongly agree	
Subjective Norms (SN)	People whose opinions I value would prefer that I pay for reducing emissions. (SN1) The people who are important to me expect that, in general, I will pay for reducing emissions. (SN2) Most people who are important to me think that one should pay for reducing emissions. (SN3)	Strongly disagree - Strongly agree	(Chen and Tung, 2014; Han et al., 2010; Han and Kim, 2010; López-Mosquera et al., 2014; Wang et al., 2016)
Perceived Behavioral Control (PBC)	Whether or not I pay for reducing emissions is completely up to me. (PBC1)	Extremely disagree - Extremely agree	(Chen and Tung, 2014; Han et al., 2010; Han and Kim, 2010; López-Mosquera et al., 2014)
	I am confident that if I want, I can pay for reducing emissions. (PBC2)		
	I have resources, time, and opportunities to pay to help reduce emissions. (PBC3)		
Intention to Pay (IP)	I will make an effort to pay for reducing CO_2 emissions and air pollution. (IP1)	Extremely disagree - Extremely agree	(Chen and Tung, 2014; Franzen and Vogl, 2013; Han et al., 2010; Han and Kim, 2010; López-Mosquera et al., 2014)
	I am willing to pay for reducing air pollution and CO_2 emissions. (IP2)		
	How willing would you be to pay for reducing air pollution and CO_2 emissions? (IP3)	Very Unwilling-Very Willing	

Here some notes should be considered. First, the payment vehicle is proposed as an annual tax. It will be more reasonable if this tax will, design based on the mean of stated willingness to pay of the sample respondents. In addition, more studies, in different aspects, are needed to reach a much more generalizable monetary value. At last, the tax should assign to vehicles based on further calculations.

The fourth part covers socio-economic characteristics of the respondents (age, gender, income, etc.). The final part of the questionnaire serves to profile the characteristics of the car owner's vehicle(s).

The purpose of the hypothetical policy choice was to reinforce the credibility of the proposed scenario and to minimize misunderstandings and misconceptions that can pose a problem for contingent valuation analysis. In the questionnaire, respondents face two dichotomous choices (single-bounded WTP questions) to carry out proposed policy to reduce GHG emissions and air pollution in Catalonia:

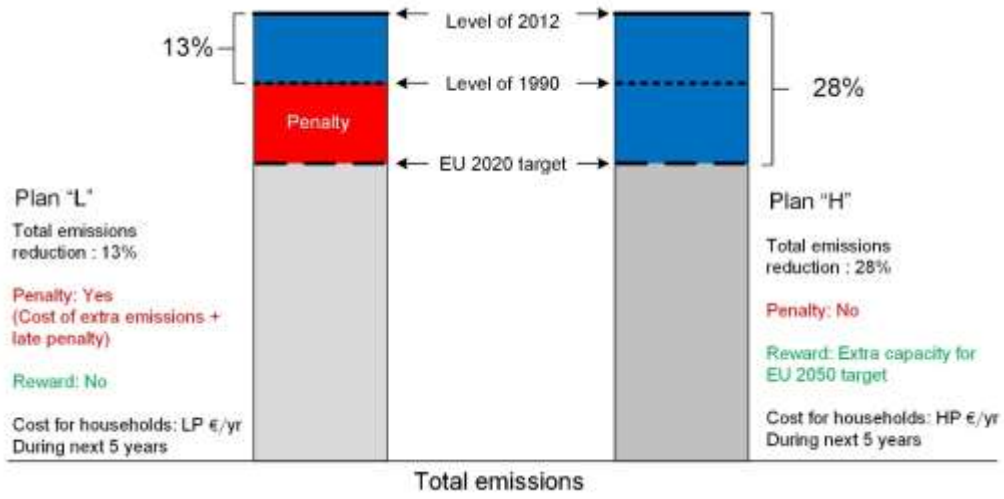
(1) By 13% compared to the level of 2012 (back to 1990 level) and pay a penalty to the EU (Plan "L");

(2) By 28% compared to the 2012 level (meet EU 2020 target) without paying a penalty and enjoying an extra capacity of emissions for the next phase of EU 2050 plan as a reward (Plan "H").

Figure 3.4 provides the graphical representation of the emission reduction and the penalties and rewards according to EU and Kyoto targets, which was shown to the respondents.

According to the multiple CV questions literature, single-bounded dichotomous-choice question was used as elicitation question format for this study. Therefore, in order to minimize ordering effects, WTP for the two plans was randomly distributed among respondents (Hoehn and Loomis, 1993; Longo et al., 2012; Payne et al., 2000). This approach allowed us to gather higher quality data and to minimize protest answers (Poe et al., 1997).

Figure 3.4, Graphical representation of advantages and disadvantages of each scenario.



Using standard form of dichotomous choice CV questions, five different bid amounts for the proposed tax were randomly presented to five different groups of respondents. Each group had to indicate whether they agreed to pay a specific tax for plan "L" and a specific tax for plan "H". For plan "L", these amounts varied between €13 and €96 (13, 32, 54, 69 and 96) to finance the policy reducing GHG emissions and air pollution by 13% compared to the level of 2012. For plan "H", these amounts varied from €24 to €185 (24, 61, 102, 134 and 185) to finance the policy reducing emissions and pollution by 28% compared to the level of 2012. Respondents were randomly assigned to one of these possible groups.

The bid amounts for both Plans ("L" and "H") are hypothetically proposed in this study. They are calculated based on national and regional information in Spain and Catalonia provided by Marti Valls et al. (2010); Parra Narváez (2004) and Generalitat de Catalunya (2010); also based on previous studies at the EU level and at the country level reported in Korzhenevych et al., (2014); Maibach et al. (2008); van Essen et al. (2011); European Commission (2013a) and EEA (2015). For example, as van Essen et al. (2011) reported, air pollution and GHGs emissions are estimated as representing 40% of total external costs of transport in EU-27. The

total external costs of transport in EU-27 estimated around 641€/inhabitant—excluding congestion—in 2008 (van Essen et al., 2011).

Here we made some assumptions. First, we assumed that everyone in EU-27 should pay his share for the air pollution and GHGs emissions from private road transport. Second, all people has an equal share of these externalities, even those they do not have any car. Third, the hypothetical plans to reduce emissions are only related to the road transport sector. Based on the mentioned assumptions, each inhabitant, on average, should pay around 256€ as his share for internalizing air pollution and GHGs emissions from private road transport in 2008. Nevertheless, we did more calculations based on the international, EU-27 and local trends and plans on reducing mentioned externalities. Finally, we reached the numbers above that we introduced as bid amounts.

The valuation question was asked in two steps. In the first step, respondents had to state whether they are "in favor" or "against" each of the two plans. In the next step, they had to confirm their choice and select one of the following three options: plan "L", plan "H" or "neither one".

Following the examples of Jorgensen et al. (2001) and Bateman et al. (2002), we introduced a control question to determine the reasons why the respondents were unwilling to pay the proposed tax. Using Longo et al. (2012) and our focus group observations, we offered the following motives for not wanting to pay the proposed tax: (1) The proposed tax is a fixed tax and I am in favor of a variable tax (e.g. tax per km driven); (2) Companies are the major causes of climate change and air pollution, and therefore they should pay for it; (3) The proposed policies are unrealistic; (4) The government should pay for climate change and air pollution, not the citizens; (5) I am not concerned about climate change and air pollution; (6) I do not feel responsible for climate change and air pollution; therefore, I should not pay for it; (7) I feel that climate change is a global problem and people in Catalonia should not be the ones to pay for it; or (8) I already pay high taxes and face high transport costs.

3.3.5. Pilot testing of the questionnaire

In order to ensure the user-friendliness and validity of the survey, prior to implementing the main questionnaire two jobs have done. First, all the questions and their translations were check with a focus group, which was made up of a linguistic expert, a university professor and a person who has PhD in electronics. We tried to minimize the translation errors and misunderstanding among the group. Finally, all the members agreed on a translation, which could be the best translation of the questions. Then, a pilot survey was realized on a sample of 40 respondents. This pilot or pre-test survey, with the help of comments and recommendations of experts of the focus group, allowed us to make the necessary adjustments. In fact, an open-ended feedback provided valuable information. This exercise allowed for refinement of the instrument with respect to salience, variance, phraseology, ordering, and ambiguity of items, as well as possible subject burden. Item responses were evaluated for variability, and discriminant value.

3.4. Analytical methods

This section presents the quantitative technique employed to analyze the data obtained from the surveys. The first part includes a description of the procedure taken to screen and prepare data, in order to ensure the quality of the data collected. The second part provides an introduction and a discussion on the Structural Equation Modelling (SEM) methodology used and the methods to test the validity and reliability of the data and the hypotheses established in the previous chapters.

3.4.1. Data Screening

One of the most noticeable issues to consider before using the data collected from a survey is to ensure that the data accurately reflects the responses made. Moreover to make sure that the data has been correctly coded and entered, patterns in missing data points are discovered, unusual or extreme responses are

identified, and to certify that the data meets statistical assumptions that underlie the methods used to analyze the data (Meyers et al., 2006).

The data from the web-based surveys was received electronically from respondents by the online platform (Survey Monkey), and was transferred into a spreadsheet and forwarded to the author. As such, it was expected that the data would be free of coding errors. Data from the mail survey was entered into a spreadsheet and each entry was manually checked against the survey instrument in an attempt to minimize any coding errors made during the transfer.

3.4.2. Structural Equation Model (SEM)

SEM is a multivariate regression model in which the response variable in one regression equation may appear as a predictor in another equation. In SEM, variables can be modeled to influence one another reciprocally, either directly or indirectly through other variables. The structural equations represent causal relationships (paths) among the variables in the model.

The advantages of using SEM include: (1) it can handle complex relationships among variables, where some variables can be hypothetical or unobserved (latent variables); (2) It estimates all coefficients in the model simultaneously and thus, one is able to assess the significance and strength of a particular relationship in the context of the complete model, (3) multicollinearity can be accounted for, (4) when using latent variables in SEM, measurement error is eliminated and thus more valid coefficients are obtained (Dion, 2008). Therefore, SEM is an adequate tool to model the complex relationships such as those that are being modeled in this study.

The structural model specified in Figure 1.4 in chapter 1, will estimate by using Maximum Likelihood. Following the two-stage approach proposed by Anderson and Gerbing (1988), we first tested the measurement model by means of Confirmatory Factor Analysis (CFA) and then estimated the Structural Model. At the beginning, in an attempt to ensure convergent and discriminant validity as well as the reliability of the measures, a confirmatory factor analysis (CFA) was

conducted to test the measurement quality of the model (Anderson and Gerbing, 1988). Second, we tested the structural relationship among the latent variables of the model in Figure 1.4 Sequentially, SPSS 22.0 and LISREL 8.80 were used to assess the hypotheses presented in this study.

3.4.3. Reliability and validity

Then reliability was assessed using Cronbach's (1951) α, which requires that the items be tau-equivalent. When this assumption was not fulfilled alpha is biased (Raykov, 1997), we then used instead the simplest alternative, Heise and Bohrnstedt's Ω (Heise and Bohrnstedt, 1970), which only requires a unidimensional factor analysis model fitted to the indicators of each factor.

Next, the convergent validity was assessed by the Average Variance Extracted (AVE; i.e., the average communalities per competency) for each factor, which should exceed 0.5 (Hair et al., 1998) for all reflective constructs. Finally, discriminant validity was measured by comparing the square root of the AVE of each reflective construct with the correlations between the constructs.

According to the principle of convergent validity, measures of theoretically similar constructs should be substantially intercorrelated. Convergent validity is the measure of how much an observed variable shares variance in common with different observed variables on a different latent variable (Hair et al., 2014).

According to the principle of discriminant validity, measures of theoretically different but related constructs should not correlate highly with each other. Toward this end, the inter-factor correlations (observed and corrected) were examined as well as the extent of "simple structure". In addition, a more rigorous test of discriminant validity based on the average variance extracted (AVE) for each construct, was applied. Fornell and Larcker (1981) recommended that in order to demonstrate discriminant validity, the AVE for each construct (within construct variance) should be greater than the squared correlation (variance) between that construct and another.

3.4.4. Goodness of fit (GOF)

GOF indices (See table 3.7) indicate the degree to which the sample variance–covariance data fit the structural equation model (Hair et al., 2014). There are three different kinds of GOF measures used in the present study including absolute fit indices (χ2, χ2 /df, RMSEA, AGFI), incremental fit indices (SRMR, CFI, TLI) and parsimony measures (PGFI, PNFI). Absolute measure of fit presumes that the best fitting model has a fit of zero and the associated GOFs (χ2, χ2 /df, RMSEA, AGFI) determine how far the model is from perfect fit. Absolute fit indices determine how well *a-priori* model fits the sample data (McDonald and Ho, 2002). Incremental fit indices are a group of indices that do not use the chi-square in its raw form but compare the chi square value to a baseline model (Hair et al., 2014). For the mentioned models the null hypothesis is that, all variables are uncorrelated (McDonald and Ho, 2002). Parsimony indices refer to the number of estimated parameters required to achieve a specific level of model fit. Essentially, an over-identified model is compared with a restricted model. Collectively, the GOF measures will summarize the discrepancy between observed values and values expected.

Table 3.7, Goodness of Fit Measures

GOF Measure	Abbreviation	Acceptable thresholds (>250) (Hair et al., 2014)
Absolute fit indices		
Chi-square	χ2	*(P>.05)*
Chi-square/df	χ2/df	≤3
Root Mean Square Error of Approximation	RMSEA	≤.08
Adjusted Goodness-of-Fit Index	AGFI	≥.80
Incremental fit indices		
Standardized Root Mean Square Residual	SRMS	≤.09
Comparative Fit Index	CFI	≥.95
Parsimony Goodness-of-Fit Index	PGFI	^
Parsimony Normed Fit Index	PNFI	^

^=No specific recommendations: Score ranges between: 0=poor fit-1=very good fit (Mulaik et al 1989)

Source: (Cooper, 2016)

3.5. Econometric model of WTP

According to Gujarati 2004, there are three main approaches to developing a probability model for a binary response variable[24]: The linear probability model (LPM), the logit model and the Probit model

For although all cumulative distribution functions (CDF) are S shaped, for each random variable there is a unique CDF. For historical as well as practical reasons, the CDFs commonly chosen to represent the 0–1 response (dichotomous variable) models are (1) the logistic and (2) the normal, the former giving rise to the logit model and the latter to the Probit (or Normit) model (Gujarati, 2004).

In addition, parametric estimation of the parameters of the change in the utility requires some assumptions about the nature of the random term. The general assumption that ε_j are independently and identically (IID) distributed with mean zero facilitates the wide use of two symmetric distributions: the normal and logistic distributions. In the former, when the error term is thought to be a standard normal random variable, the response function becomes a Probit model; in the latter, when the error term is thought to be a logistic random variable, the response function becomes a Logit model. The advantage of the Logit model is that it has a closed-form solution, which facilitates its calculation (Hoyos and Mariel, 2010).

The utility that the decision maker (from n decision makers) obtains from alternative j (between J alternatives) is decomposed into (1) a part labeled V_{nj} that is known by the researcher up to some parameters, and (2) an unknown part ε_{nj} that is treated by the researcher as random: $U_{nj} = V_{nj} + \varepsilon_{nj} \ \forall j$. The logit model is obtained by assuming that each ε_{nj} is distributed independently, identically extreme value (Train, 2002).

Logistic distribution function (cumulative) is presented in equation (5).

[24] The willingness to pay question accounts as a binary response variable, because the answers will categorize to yes and no.

$$P_i = \frac{1}{1+e^{-z_i}} = \frac{e^z}{1+e^z} \quad (5)$$

If P_i, the probability of positive answer, is given by (5), then$(1 - P_i)$, the probability of negative answer, is

$$1 - P_i = \frac{1}{1+e^{z_i}} \quad (6)$$

Therefore, we can write

$$\frac{P_i}{1-P_i} = \frac{1+e^{z_i}}{1+e^{-z_i}} = e^{z_i} \quad (7)$$

Now $P_i/(1 - P_i)$ is simply the odds ratio in favor of positive answer; the ratio of the probability that an individual will pay to the probability that she will not to pay.

Now if we take the natural log of (5), we obtain a very interesting result, namely,

$$L_i = ln\left(\frac{P_i}{1-P_i}\right) = Z_i \quad (8)$$

$$= \beta_1 + \beta_2 X_i$$

that is, L, the log of the odds ratio, is not only linear in X, but also (from estimation perspective) linear in the parameters (Gujarati, 2004).

The mean WTP is calculated by means of the contingent valuation method (Mitchell and Carson, 1989). Mean WTP was calculated by integrating under a logit function where price was truncated at 96€ and 185€ for plan "L" and "H" and bounded to be positive based on the work of Bateman et al. (2002) and Hanley et al. (2007).

The mean WTP is calculated by:

$$Mean\ WTP = \int_0^T [1 - G_{wtp}]dW \quad (9)$$

Where G_{wtp} is the distribution function of the true WTP. T is infinite for the true intention to pay and is truncated at some value (96€ and 185€ for plan "L" and "H") for the purpose of estimation.

Chapter 4

Results

Structural Equation Modelling (SEM) has become one of the techniques of choice for researchers across disciplines and increasingly is necessary for researchers in the social sciences. However, the issue of how the model that best represents the data reflects underlying theory, known as model fit, is by no means agreed. With the abundance of fit indices available to the researcher and the wide disparity in agreement on not only which indices to report but also what the cut-offs for various indices actually are, it is possible that researchers can become overwhelmed by the conflicting information available.

The structural model specified in Figure 1.4 is estimated by using Maximum Likelihood. Following the two-stage approach proposed by Anderson and Gerbing (1988), we first tested the measurement model by means of Confirmatory Factor Analysis (CFA) and then estimated the Structural Model. At the beginning, in an attempt to ensure convergent and discriminant validity as well as the reliability of the measures, a confirmatory factor analysis (CFA) was conducted to test the measurement quality of the model (Anderson and Gerbing, 1988). Second, we tested the structural relationship among the latent variables of the model in Figure 3 and Figure 4. Sequentially, SPSS 22.0 and LISREL 8.80 were used to assess the hypotheses presented in this study. Once we had assessed the unidimensionality of each reflective construct, we checked whether all loadings (λ in Table 4.3) of the reflective indicators per factor were above 0.65. Then reliability was assessed using Cronbach's (1951) α, which requires that the items be tau-equivalent. When this assumption was not fulfilled alpha is biased (Raykov, 1997), we then used instead the simplest alternative, Heise and Bohrnstedt's Ω (Heise and Bohrnstedt, 1970), which only requires a unidimensional factor analysis model fitted to the indicators of each factor.

Next, the convergent validity was assessed by the Average Variance Extracted (AVE; i.e., the average communalities per competency) for each factor, which should exceed 0.5 (Hair et al., 1998) for all reflective constructs. Finally, discriminant validity was measured by comparing the square root of the AVE (Table 18) of each reflective construct with the correlations between the constructs (Table 19).

As far as the goodness of global fit is concerned, the following fit indices were considered to determine how the model fitted the data: Satorra-Bentler χ^2 (chi-square); χ^2/df ratio; CFI (Comparative Fit Index), GFI (Goodness Fit Index) and NFI (Normed Fit Index) indices should be close to 0.9 or 1.0 and the RMSEA (Root Mean Squared Error Approximation) should ideally lie between 0.05 and 0.08 (Hooper et al., 2008; Hu and Bentler, 1999).

It should be noted that mentioned indexes based only on statistical significance could lead to inaccurate conclusions (Saris et al., 2009). Accordingly, rather than only focusing on overall model fit in the diagnostic stage, we considered more detailed diagnosis indicators such as: 1) reasonable estimated values in the expected direction, 2) addition of justified correlated specificities and 3) the assessment of modification indexes and their expected parameter changes, which led to plausible estimates. This process, in line with the proposal of Saris et al. (2009), considers significance as well as the power of the test, paying more attention to identifying misspecification errors than just looking for the global fit.

4.1. Data Screening

In order to ensure that the data in the data matrix accurately reflects the respondents‟ views, it was necessary to screen all data before proceeding with the analysis. As set out in Chapter 5, the screening of data included checking for coding errors, patterns in the missing data, unusual or extreme responses and ensuring that the data satisfied the required statistical assumptions (Meyers et al., 2006).

A superficial analysis of the data revealed that it was of a reasonably high quality. The responses of each sample population were first examined for completeness and consistencies in the individual responses. The consistency checks were completed by comparing and cross-checking the responses to similar questions. This examination revealed that very few items were overlooked or disregarded and consistencies in responses were apparent.

4.2. Response rate

The level of response rate is always of interest in any survey research. Mostly for the surveys that depends on the generalizability of the results of the survey. In our study from 406 valid responses, 61.57% stated that they are willing to pay more to reduce air pollution and GHG emissions according the scenarios they faced. We were curios if respondents, who stated that they are willing to pay, will state that they are willing to pay even more to reduce pollutions. So, we asked them “Are you able to pay 15% more than L (H) €/year for plan "L" (“H”)?”. The answers were interesting. A 65.2% of those respondents that confirmed their willingness to pay were willing to pay an additional 15% more over “L” or “H” euros they selected before. That means 40.14% of the whole sample were willing to pay even more than the proposed bids to reduce pollutions.

Table 4.1 summarized the demographic characteristics of the respondents. The sample consisted of 63.7% women and 36.3% men; 72.4% in the age range of 30 to 64; 45.8% with only primary or secondary education or less; and 51.35% with a monthly disposable income between 1,125€ and 3,000€. The composition of our sample corresponds to that of the Catalan population, at least in terms of age range (64% of people over 18 are between 30 and 64 years of age) and income (46% with middle class disposable income). In addition, figure 4.1 is showing the geographical scope of the sample. However, in terms of gender our sample is not representative of the actual population (IDESCAT, 2015). In addition, 79.8% of the respondents

stated that they have at least one vehicle in their household. Only 20.2 % indicated that they do not have any vehicle in their household.

Figure 4.1, Geographical scope of the sample (Made with Google Maps: Google (2019))

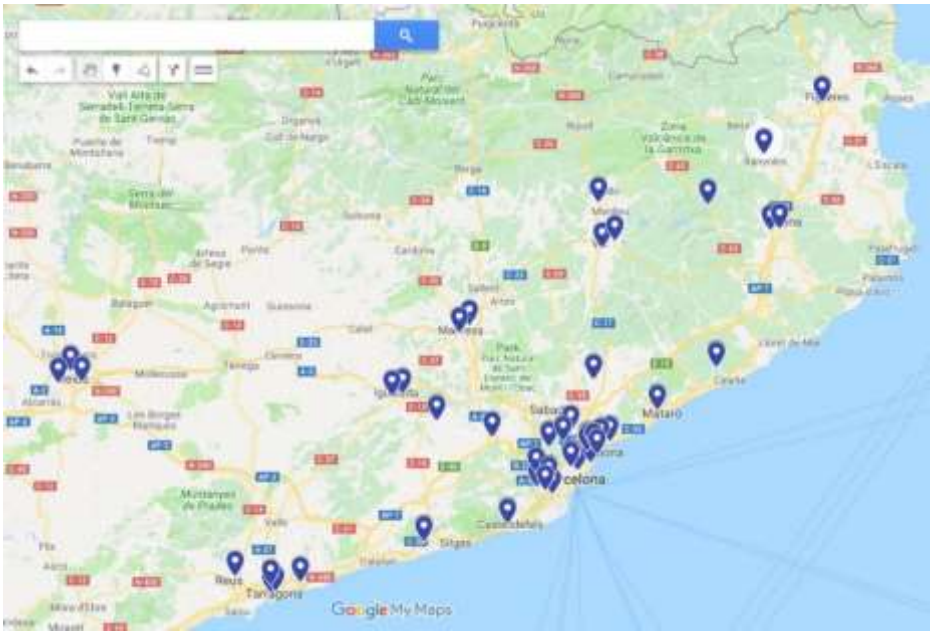


Table 4.1, Demographic characteristics of the respondents.

	Frequency	**Percentage (%)**
GENDER		
Female	259	63.8
Male	147	36.2
AGE		
18-29	107	26.4
30-39	122	30.0
40-49	108	26.6
50-64	64	15.8
> 65	5	1.2
EDUCATION		
Without completed primary education	4	1.0
Primary or Secondary education	182	44.8
Associate or bachelor degree	200	49.3
Master degree or PhD	20	4.9
MARITAL STATUS		
Single	135	33.3
Married	179	44.1
Living together	71	17.5
Divorced/Separated	17	4.2
Widowed	4	1.0

Continue from previous page

Table 4.1, Demographic characteristics of the respondents.

	Frequency	**Percentage (%)**
EMPLOYMENT STATUS		
Unemployed (looking for a job)	59	14.5
Student	45	11.1
Employed part-time	62	15.3
Self-employed	24	5.9
Retired	23	5.7
Employed full time	193	47.5
HOUSEHOLD INCOME (Monthly)		
Less than 750 €	58	14.3
751€ - 1500€	118	29.1
1501€ - 2500€	115	28.3
2501€ - 3500€	69	17.0
3501€ - 4500€	27	6.7
4501€ - 5500€	13	3.2
More than 5500€	6	1.5
NUMBER OF VEHICLES IN THE HOUSEHOLD		
0	82	20.2
1	204	50.2
2	98	24.1
3	20	4.9
> 3	2	0.5

4.3. Construct validity and Confirmatory Factor Analysis (CFA)

First, we considered internal consistency of the constructs items. As shown in table 4.2 the total items' $\alpha = 0.945$. The Corrected Item-total Correlation (CIC) reported in a range of 0.568 and 0.866. All items met the minimum cut-off of > 0.3 for the CIC and also the constructs met the minimum cut-off of > 0.7.

Then, the measurement model was assessed by means of a CFA of the estimated extended model of TPB, which included all latent variables (intention to pay, attitude, subjective norms, perceived behavioral control and environmental concern). The data show a very good fit with the hypothesized structural model

(χ^2=152.527; df=87; GFI=0.950; CFI=0.995; NFI=0.989; SRMR=0.030; RMSEA=0.043).

Table 4.2, Internal consistency of the constructs items.

Constructs	**Indicators**	**Corrected Item-Total Correlation**	**α if item deleted**	**α**
Intention to pay (IP)	IP1	0.814	0.918	.925
	IP2	0.866	0.876	
	IP3	0.864	0.877	
Environmental concern (EC)	EC1	0.665	0.663	.783
	EC2	0.568	0.763	
	EC3	0.650	0.684	
Attitude (AT)	AT1	0.805	0.874	.907
	AT2	0.831	0.853	
	AT3	0.808	0.873	
Subjective norms (SN)	SN1	0.774	0.896	.906
	SN2	0.846	0.835	
	SN3	0.816	0.861	
Perceived behavioral control (PBC)	PBC1	0.692	0.854	.863
	PBC2	0.770	0.782	
	PBC3	0.761	0.787	
Total Cronbach's Alpha (α):				**.945**

As can be seen in table 4.3, all the indicators are reflective and Tau-equivalents (α *and* Ω have similar values) and show high reliability of the constructs. Moreover, as mentioned, AVE is always above 0.5, the usual threshold for convergent validity, and the comparison of its square root with the correlations among factors (Table 4.4) shows strong evidence discriminant validity.

Table 4.3, Reliability and Confirmatory Factor Analysis for the extended TPB model.

Constructs	**Indicators**	**Mean (s.d.)[a]**	λ	α	Ω	AVE
Intention to pay (IP)	IP1	3.17 (1.05)	.867	.925	.926	.792
	IP2	3.04 (1.12)	.912			
	IP3	2.95 (1.15)	.890			
Environmental concern (EC)	EC1	4.09 (0.65)	.807	.783	.790	.557
	EC2	4.46 (0.63)	.646			
	EC3	3.78 (0.78)	.777			
Attitude (AT)	AT1	3.38 (1.06)	.874	.907	.908	.765
	AT2	3.18 (1.04)	.882			
	AT3	3.05 (1.11)	.867			
Subjective norms (SN)	SN1	3.06 (1.01)	.822	.906	.907	.764
	SN2	2.93 (1.02)	.906			
	SN3	2.93 (1.02)	.892			
Perceived behavioral control (PBC)	PBC1	2.94 (1.12)	.744	.863	.866	.683
	PBC2	3.07 (1.03)	.888			
	PBC3	2.77 (1.08)	.841			

[a] s.d: Standard deviation; λ: factor loading; α: reliability (Cronbach's α); Ω: Omega coefficient; AVE: Average variance extracted;

Table 4.4 shows the correlations among the factors of the extended model. High correlation among attitude, subjective norms and perceived behavioral control is likely to lead to multicollinearity consequences in the structural model estimates.

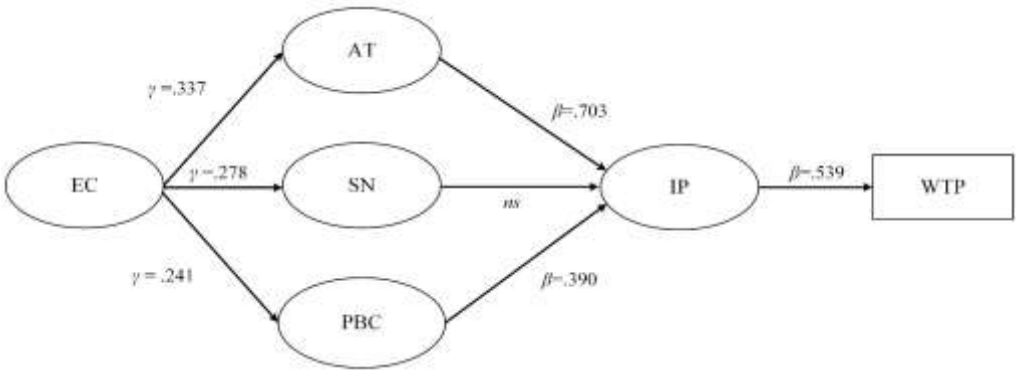
Table 4.4, Correlations matrix among factors.

	1	2	3	4	5	6
1. Willingness to pay	1.000					
2. Intention to pay	0.539	1.000				
3. Attitude	0.511	0.948	1.000			
4. Subjective norms	0.484	0.898	0.894	1.000		
5. Perceived behavioral control	0.478	0.886	0.796	0.877	1.000	
6. Environmental concern	0.165	.311	0.337	0.278	0.241	1.000

4.4. Structural models

Once we ensured that measurements could be trusted, we proceeded to estimate the parameters of the extended structural model (Figure 4.2). Global fit indexes show a very good fit ($\chi^2 = 157.861$; $df = 92$ $GFI = 0.948$; $CFI = 0.995$; $NFI = 0.989$; $SRMR = 0.031$; $RMSEA = 0.042$), and following the strategy of Saris et al. (2009) we detected no misspecification errors. The relevant structural coefficients of this model are significant ($P < 0.01$) and agree with the expected direction (see appendix B).

Figure 4.2, Structural model of WTP based on the extended Theory of Planned Behavior model.



β and γ: Standard regression weight. ns: Non-significant

Moreover, the fit indices shown in Table 4.5 indicate that the hypothesized structural model provided is a suitable fit to the data.

Table 4.5, Goodness of Fit Measures

GOF Measure	Abbreviation	Results
Absolute fit indices		
Chi-square	$\chi 2$	157.861
Chi-square/df	$\chi 2$/df	1.716
Root Mean Square Error of Approximation	RMSEA	0.042
Adjusted Goodness-of-Fit Index	AGFI	0.923
Incremental fit indices		
Standardized Root Mean Square Residual	SRMS	0.031
Comparative Fit Index	CFI	0.995
Parsimony Goodness-of-Fit Index	PGFI	0.641
Parsimony Normed Fit Index	PNFI	0.758

4.4.1. Hypotheses

The results of the structural equation model of the extended Theory of Planned Behavior are shown in figure 4.2. In addition, regarding the hypotheses, which were defined in the section 1.4, in this section hypothesis testing results will present.

H1*:* There is a significant and positive relation between a person's intention to pay and his/her stated willingness to pay to reduce air pollution and GHG emissions*.*
Intention to pay on WTP showed a positive significant relation which supports H1, being the standardized regression coefficient ($\beta = 0.539$; $t = 12.998$). This finding suggests that respondents' intention to pay is a significant predictor of their willingness-to-pay to reduce air pollution and GHGs emissions.

H2*:* Attitude toward payment to reduce air pollution and GHG emissions will positively predict a person's intention to pay for these reductions.
Attitude appears to have the strongest effect ($\beta = 0.703$ $t = 7.393$) on intention to pay and H2 is supported. Here also we can say the respondents' attitude toward the pro-environmental behavior is a significant predictor of the intention to pay to reduce air pollution and GHGs emissions.

H3*:* Subjective norms toward payment to reduce air pollution and GHG emissions will be positively related to a person's intention to pay for these reductions.
In this case, however, we did not find evidence of a relationship between the subjective norms and intention to pay ($\beta = -0.073$; $t = -0.620$), so H3 would seem, on the one hand, to have to be rejected. On the other hand, we suspect that this point estimate has been distorted due to the above-mentioned multicollinearity in Table 4.4.

H4*:* Perceived behavioral control toward payment to reduce air pollution and GHG emissions will positively predict a person's intention to pay for these reductions.
The perceived behavioral control ($\beta = 0.390. t = 4.431$), appears to have a strong effect on intention to pay, so H4 is supported.

***H5**:* There is a significant and positive relation between individuals' environmental concern and attitude toward paying to reduce air pollution and GHG emissions.
The relationships between environmental concern and attitude ($\beta = 0.337;\ t = 5.670;\ P < 0.01$) is significant, thus H5 is supported.

***H6**:* There is a significant and positive relationship between individuals' environmental concern and subjective norms toward paying to reduce air pollution and GHG emissions. The significance of the relationships between environmental concern and subjective norms ($\beta = 0.278;\ t = 4.516, P < 0.01$) is confirmed, so H6 is supported.

***H7**:* The relationship between a person's environmental concern and his/her perceived behavioral control toward paying to reduce air pollution and GHG emissions is significant and positive.
Environmental concern appears to have a significant effect on the perceived behavioral control ($\beta = 0.241;\ t = 3.773;\ P < 0.01$), so this relationship is supported.

4.4.2. Multicollinearity

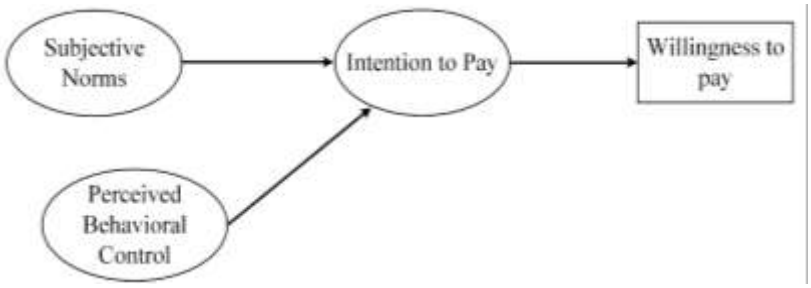
In order to see the aforementioned effect of multicollinearity, we have specified a model (Figure 4.3) excluding attitude (due to its high inter-factor correlations). The numbers that raise the assumption of the multicollinearity are bolded in table 4.6.

Table 4.6, Multicollinearity and the Correlations matrix among factors.

	1	2	3	4	5	6
1. Willingness to pay	1.000					
2. Intention to pay	0.539	1.000				
3. Attitude	0.511	**0.948**	1.000			
4. Subjective norms	0.484	**0.898**	**0.894**	1.000		
5. Perceived behavioral control	0.478	**0.886**	**0.796**	**0.877**	1.000	
6. Environmental concern	0.165	.311	0.337	0.278	0.241	1.000

The Results from mentioned partial model show a very good fit ($\chi^2 = 63.207;\ df = 31\ \ GFI = 0.966;\ CFI = 0.996; NFI = 0.992; SRMR = 0.020;\ RMSEA = 0.051$), and demonstrate that, as mentioned, both the contribution of subjective norms on IP ($\beta = \ 0.524. t = 4.523$) and the contribution of perceived behavioral control on IP ($\beta = \ 0.424. t = 3.566$) are actually positive and statistically significant. Results confirm that the previous estimates were distorted by the multicollinearity among attitude, subjective norms and perceived behavioral control.

Figure 4.3, A part of extended model—excluding attitude—to account for the multicollinearity effect.



In total, our results imply that the extended TPB model could predict households' intention to pay for the improvement of air quality and mitigation of climate change. Fortunately, multicollinearity does not affect global goodness of fit indices, so we can trust the predictive power of the specified model. Thus, R-square –percentage of variance of WTP accounted for IP is 29.1%, while Attitude, Subjective Norms and Perceived Behavioral Control explain 94.7% of the intention's variance.

4.5. WTP Analysis

As it explained before we used a single-bounded dichotomous-choice question as elicitation question format for this study. For two hypothetical scenarios, five pairs of bids randomly distributed in five groups of respondents. In the table 4.7,

we summarized the percentage of respondents' willingness to pay answers to the proposed plans regarding the bid values.

Table 4.7, Bid values and percentage of respondents willing to pay the proposed plan

No. of respondents in each group		Plan "L"			Plan "H"		
		Bid (€/year)	% yes		Bid (€/year)	% yes	
			First step	Confirmed		First step	Confirmed
Group 1	94	13	57.45	25.53	24	60.64	50.00
Group 2	70	32	61.43	30.00	61	41.43	28.57
Group 3	79	54	49.37	32.91	102	45.57	32.91
Group 4	89	69	48.31	29.21	134	34.83	23.60
Group 5	74	96	43.24	18.92	185	41.89	33.78

Mean WTP was estimated by means of a logit model. Dependent variable was extracted from the continuous variable for the following structural equation modeling estimations. According to equation (9), the results of the estimation of the logit model for the overall user sample ($n = 406$) reveal that the mean WTP is 64.47€ for implementing plan "L" and 120.17€ for implementing plan "H". The significance of the two bid price variables ($t = 6.454;\ p < 0.01; and\ t = 5.502;\ p < 0.01$), indicates the presence of starting-point bias. In addition, another logit model with covariates was used to determine the influence of socio-economic variables on the WTP of the respondents. Higher WTP amounts for reducing emissions and air pollution in both scenarios were obtained from people with a higher income level ($t = 2.782;\ p < 0.01; and\ t = 2.934; p < 0.01$) and people younger in age ($t = 2.432;\ p < 0.05; and\ t = 2.981; p < 0.01$).

The percentage of positive WTP answers in our study is similar to the percentage obtained in previous studies in Spain and other studies around the world (see Table 4.8). Mean WTP differs in each study because of different social, political and economic situations of the respondents, the time of the survey and the valuation scenarios used in the study.

Table 4.8, Mean WTP to reduce air pollution and GHG emissions in previous studies.

Author (year)	Country	Estimated Mean WTP				% of Positive	Scenario
Carlsson and Johansson-Stenman (2000)	Sweden	2000 SEK/year (235€/year[a])				66%	50% reduction of harmful substances
Adaman et al. (2011)	Turkey (26 cities)	150 TL/year (69.77€/year)				63.7%	Decrease CO_2 emissions by making existing power plants more efficient and green
Carlsson et al. (2012)	Sweden, USA, China	US$/year (€)	30%	60%	85%		Reduce CO_2 emissions by 30%, 60%, and 85%
		Sweden	21.7 (18)	39.54 (33)	54.24 (50)	92%	
		USA	17.27 (15)	27.95 (25.5)	36.43 (34.3)	75%	
		China	4.99 (4.2)	8.32 (7.52)	11.18 (9.3)	88%	
Longo et al. (2012)	Spain (Basque Country)	16%	4%		0.5%		Reduce GHG emissions by 16%, 4%, and 0.5%
		281.61 €(PH/Y)[c]	176.24 €(PH/Y)		132.01 €(PH/Y)	> 65%	
Kotchen et al. (2013)	USA	Between $79 and $89 per year (58.6€ to 66€ per year)				49.6%	17% reduction in emissions by 2020
Lera-lópez et al. (2013)	Spain	9.31€/year and 9.56€/year				53.9% and 54.2%	Reduce air pollution for mildly and severely affected populations
Istamto et al. (2014)	NL, UK, DE, ES, FI[b]	1	2	3			1: General health risk 2: Half year shorter life expectancy 3. 50% decrease in road-traffic air pollution
		130 €/(PP/Y)[d]	80 €/(PP/Y)	330 €/(PP/Y)		43.6% (General)	
Yang et al. (2014)	China (Suzhou)	314.4 CNY/year (80€/year)					30% carbon mitigation
Current study		Plan "L"			Plan "H"		Plan "L": Reduce 13% Plan "H": Reduce 28% In air pollution and GHG emissions
		64.47 € (PH/Y)[d]			120.17 € (PH/Y)	61.42%	

Source: Own elaboration

[a]. Costs are proximately exchanged to euro based on the related rates in the period of study.
[b]. NL: Netherlands; UK: United Kingdom; DE: Germany; ES: Spain; FI: Finland.
[c]. PH/Y: Per Household per Year.
[d]. PP/Y: Per Person per Year.

Chapter 5

Conclusions

5.1. Summary of the results

As we mentioned in chapter 1, transport is one of the biggest energy consumers in the world. More than 31.6% of the total world energy was consumed by the transport sector in 2016. In the same year, the transport sector in Spain was the biggest energy consumer with more than 34.9%. On the other hand, transport was responsible for 24.3% of the total GHGs emissions in EU-27 in 2016, while road transport generated 72% of these emissions. In Spain and Catalonia the situation was very similar. In case of air pollution, road transport is also accountable for a considerable proportion of the pollutants in EU, Spain and Catalonia (see table 1.3 and table 1.4). These numbers reveal the gravity and urgency to tackle this emissions problem and the importance of considering their costs for society (externalities).

The thesis contributes to existing knowledge in the environmental economics literature by investigating how people feel and think about pollution reduction and how these factors can explain their intentions to engage in a pro-environmental behavior. We proposed an extended TPB model to identify the psychosocial factors that play a role in determining individuals' WTP in order to reduce environmental externalities from private road transport. The survey was realized in Catalonia, Spain. As far as we know, no study has tried to quantify this WTP with this method.

We developed an extended model of TPB with a higher explanatory power to study pro-environmental behavior than the basic TPB model. To evaluate the model, we used Structural Equation Modelling (SEM). This study, in comparison with previous studies, has two elements, which differentiate it from them. The first

one refers to the model that is used. We extended the TPB model by adding environmental concern prior to the factors of the original model. In addition, we divided the behavioral intention (BI) into two variables, intention to pay (latent) and willingness to pay (observed as their stated willingness to pay). The second difference is the use of this extended model to examine the behavioral intention to reduce air pollution and GHG emissions in the case of private road transport.

Empirically, the study shows that the proposed extended TPB model offers a useful framework for identifying a series of factors motivating behavioral intention to reduce air pollution and GHG emissions from private road transport. As it has been argued in many studies, entering additional constructs to the TPB model, such as the case of environmental concern, leads to an improvement of the explanatory power of this theory. It improves understanding of how psycho-social determinants motivate the intention to pay to reduce GHG emissions and air pollution from private road transport. As a result, the proposed extended TPB, may be useful in public policy, for example in order to propose a new vehicle tax system.

Policy makers must try to understand which factors lead people to pro-environmental behavior, especially in the case of reducing GHG emissions and air pollution. Accordingly, investigation of the persuasive constructs that affect this behavior, such as attitude and environmental concern, is recommended. This information would be useful in supporting efforts to reduce the attitude–behavior gap and to encourage pro-environmental behavior.

As we reported in section 4.5, the mean WTP, which was calculated through the contingent valuation method, indicated that households are willing to pay, on average, €64.47 and €120.17 to reduce CO_2 emissions and air pollution, respectively, under plan "L" and plan "H". As we mentioned before the mean WTP differs from other studies because it depends on the context of the respondents, and the scenarios and bid levels proposed in the questionnaire of the survey (see Table 4.8).

The empirical results of our study reveal that respondents' intention to pay to reduce air pollution and GHG emissions affects their WTP. This intention is significantly influenced by people's attitude and perceived behavioral control. We observed a positive relationship between environmental concern and attitude (H5), subjective norms (H6) and perceived behavioral control (H7). This means that people with a strong environmental concern will probably be more willing to pay to reduce GHG emissions and air pollution. In line with previous studies, environmental concern was directly related to attitude (Gardner and Abraham, 2010; Groot et al., 2007), subjective norms (Chen and Tung, 2014) and perceived behavioral control (Bamberg, 2003).

As we expected, we found a significant and positive relationship between intention, which is defined as the extent of effort an individual is planning to exert to perform a specific behavior, and willingness to pay, which is an individual's openness to performing a certain behavior (H1). Despite confirmation of this hypothesis, the results demonstrated that "intention to pay" and "willingness to pay" are not the same (see section 3.2).

The attitude of an individual regarding paying for GHG emissions and air pollution reduction was the strongest determinant of intention to pay (H2). Numerous authors have shown the same significant direct relation between attitude and intention to behave pro-environmentally (Spash et al., 2009; Wall et al., 2007).

The component that had the second greatest impact on intention to pay to reduce GHG emissions and air pollution was people's perceived behavioral control (H4). This supports the results found in other studies that mentioned PBC as one of the incentives for people to pay for improvements in environmental issues (Pouta and Rekola, 2001; Spash et al., 2009).

We can highlight the fact that the extended TPB model of our study had a strong model fit (see table 4.5). Furthermore, the square multiple correlations indicate

that 29.1% of willingness to pay and 94.7% of intention to pay is explained by the constructs of the study.

Regarding the limitations of this study, first, at the theoretical level, we would like to point out that it would be interesting to examine the influence of motivational factors of the proposed model on real payment rather than WTP. According to Ajzen (1991), the most accurate prediction of behavior will be provided by an appropriate measure of intention. However, there is a gap between adoption intention and actual behavior (Ajzen and Fishbein, 1980).

Second, the sample used was a general sample based on the Catalonia census. In order to obtain a more specific result based on vehicle ownership status, it would be interesting to do the same study on two different and independent samples: one on vehicle owners and another one on individuals or households without vehicles. Of course, in this case, we should consider an appropriate payment vehicle for each group (e.g., vehicle tax, circulation tax, tax on other modes of transport). A proper sample size of the two groups would help to determine whether there are differences in their respective environmental profiles regarding the economic valuation of the reduction of air pollution and GHG emissions.

Third, since respondents were only being asked about private road transport, the results obtained cannot be generalized to all types of transport.

5.2. Policy suggestions

Environmental activists and urban managers should try to inform citizens about the importance of reducing GHG emissions and air pollution, thus increasing the public's environmental concern. This in turn will positively affect the public's economic valuation of policies that make such reductions possible. A potential target population segment of this awareness-raising campaign should be that part of the society which shows less environmental concern and therefore less WTP to reduce air pollution and GHG emissions. As our survey revealed, these are the people in the mid-income level range and in the following age groups: middle-aged

adults (age 30-55 years) and older adults (age 55 and above). All types of media could be used to promote environmental knowledge and pro-environmental behaviors in that they can educate people in car-use reduction habits, promote the use of travel alternatives, encourage WTP to reduce pollution, and so forth (see Gärling and Schuitema, 2007). These behavioral changes can improve the effectiveness of economic tools such as taxes (higher WTP, less car use and more use of alternative transport modes).

In addition, for supporting the message of the campaign, drawing people's attention to the type of payment vehicle for these policies (i.e. an earmarked tax) could be a positive point. Individuals may increase their intention to pay if they are informed that the tax revenue will only be used to tackle the specific environmental problems mentioned.

5.3. Future research

Concerning future lines of research, we would suggest to examine people's WTP by their level of trust in the government, at both local and national level, as well as in the legal system for collecting taxes. A positive mindset toward the efficiency and honesty of the government will probably increase their intention to pay for a given policy. Accordingly, a comparison of WTP to pay a tax in different countries could be interesting to reveal the consequences of people's trust in their government and public administration.

Second, other kind of taxes, instead of the annual obligatory transport tax, could be considered in the survey; these might include taxes in function of the pollution generated (e.g. tax per kilometer or tax based on vehicle pollution category) or taxes in function of the income of the taxpayer. If the people consider the tax fair, they will likely be willing to pay more for the environmental policy. Other payment vehicles, such as voluntary payment, could also be considered as an alternative for a tax; however, the free rider problem could rise. Research could also demonstrate

whether there are changes in WTP amount and percentage of positive answers according to the payment vehicle (e.g. Akcura, 2015; Wiser, 2007).

Third, it would be interesting to use other methodological frameworks of stated preference such as Choice Experiments (Adamowicz et al., 1994) instead of contingent valuation method. This technique offers an attribute-based definition of the good in question. As Bateman et al. (2002) explained, Choice Experiment is easier for people to understand because this technique does not openly ask "How much are you willing to pay?" In fact, in this case, the design of the valuation scenario is different from the one we use with Contingent Valuation.

Finally, there are cultural differences between territories (countries and regions), and that is why, in order to increase the generalizability of the model, we need to study the effect of the cultural specificity of the territory on the psycho-social factors and intention to pay to reduce GHG emissions and pollution.

5.4. Publication derived from thesis

1. One of the most valuable result of this thesis is that the results of this study has been published in the Journal of Science of the total environment:

Zahedi, S., Batista-Fouget, J.M., Van Wunnik, L. (2018) Exploring the public's willingness to reduce air pollution and greenhouse gas emissions from private road transport in Catalonia. *Science of the Total Environment.* (IF=4.9, Q1)

5.5. Additional researches, seminars and conferences

During my Ph.D. period, this work has been introduced in conferences, seminars and schools, which I attended.

- **ESADE Business School**:

I had an opportunity to improve the progress of my Ph.D. thesis under supervision of Prof. Joan M. Batista in ESADE Business School, Department of Management and Organization. I attended two different courses there. First, the

quantitative research design, then, structure equation modelling. In addition, the survey of this thesis has been presented there as a case study.

- **Doctoral school: SINO-Europe Logistics, informatics, management and services sciences, Summer School, 2015, China.**

One of the valuable experiences during my Ph.D. period was the opportunity to attend SINO-Europe logistics, informatics, management and services sciences Summer School. Working on a team project and guidance's of Prof. Jose Maria Sallan Leyes and Prof. Vicenc Fernandez Alarcon in this school, has helped me on the process of researching and improving this thesis.

- **Conferences and seminars:**

1. My very first work in my Ph.D. period was a conference paper. We tried to do a comparison study on different taxes related to the vehicles among EU countries.

Zahedi, S., & Cremades, L. (2013). Vehicle taxes in EU countries. How fair is their calculation? In *16th International Congress on Project Engineering*. Valencia, Spain.

2. The application of an extended Theory of Planned Behavior in quantifying external cost of air pollution and CO_2 emissions from private road transport in Catalonia, is presented in the Jornada de recerca JoSost 2016, a One-day Seminar at Universitat Politècnica de Catalunya (UPC), Barcelona(Spain), May 2016.

One of the interesting projects, which has been done during my Ph.D. period, was applying Multi-Criteria Decision Aiding techniques to the survey of this study. In order to investigate the role of beliefs, moral pressure and environmental concerns on households' willingness-to-pay for reducing GHG emission and air pollution of private road transport, MCDM method provided a different classification. This study was presented In *83rd EURO Working Group in Multicriteria Decision Aiding*, (83rd EWG-MCDA), Barcelona, Spain.

Zahedi, S., Ghaderi, M., (2016). Analyzing Households' Willingness to Pay for External Costs of Air Pollution and GHG Emissions: A Multiple Criteria Decision

Aiding Approach. In *83rd EURO Working Group in Multicriteria Decision Aiding*, (83rd EWG-MCDA), Barcelona, Spain.

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Appendix A

The questionnaire introduction and hypothetical scenarios

Policy against Climate change and Air pollution

Good morning/Good evening

My name is Siamak Zahedi and I am conducting a survey as a part my of Ph.D. thesis in Universitat Politecnica de Catalunya (UPC) on the opinion of the general public towards the environment, specially air quality and climate change, in Catalonia. Your household is one of a small numbers of households across Catalonia being randomly selected to participate in this research.

We are only interested in your opinion. Therefore, there are no correct or incorrect answers. All responses to this survey will be confidential and information will never be associated with any result of this study. This questionnaire should take about 15-20 minutes to answer.

May I begin?

Introduction

Before entering to the main part, please read this introduction.

This survey will try to have your opinion about two environmental issues. The first one is Green House Gas emissions (GHG) which they are known as a cause of global warming and climate change. GHGs are CO_2, N_2O, methane (CH_4) and ozone (O_3), water vapor (H_2O) and human-made emissions such as sulfur hexafluoride (SF_6), hydro fluorocarbons (HFCs) and per fluorocarbons (PFCs). Scientists introduce CO_2 as the representative and symbol of GHGs emissions, whereas it forms 75% of them.

The second issue is Air pollution. It is a combination of Sulfur dioxide (SO2), Nitrogen oxides (NO_X), Particulate matter ($PM_{2.5}$ and PM_{10}), Ozone (O_3), Ammonia (NH_3), Non-methane volatile organic compounds (NMVOCs), Carbon monoxide

(CO), and Methane (CH_4). Air pollution can be a reason of some problems such as pulmonary infections, feeling depressed, asthma, headache and skin problems.

Main Part

Questions related to the citizens' behavioral profile are asked (See table 3.6).

Transport is the main cause of Climate change and Air pollution

The energy we use in transportation is the main cause of greenhouse gas (GHG) emissions and air pollutant in Catalonia, Spain and the second largest in Europe. Scientists say that GHGs emissions, mainly CO_2, are the main sources of global warming, irregular rainfall and raise the sea level; on the other hand air pollutants, such as particulate matter ($PM_{2.5}$ and PM_{10}), are the main reasons of pulmonary infections and serious asthma attacks especially among children and the elderly.

What is the Catalonia government plan? (In case of transport)

The Catalonia government is considering measures to reduce the emissions and air pollution caused by all sectors, so that in 2020 total emissions have to be 20% lower than in 1990, for this purpose they have a new plan and the government needs more financial resources.

What is the Catalonia government plan?

This program, in case of transport, includes policies such as requiring oil companies to produce gasoline and diesel that has lower GHG emissions and pollutants per liter, support bio-fuel production by paying subsidies, investment in public transport development and paying subsidies and encourage the use of electric cars, etc.

The current income is not enough to implement the mentioned plan. Therefore, if all households participate in a new tax policy during the next 5 years, The Catalonia government will be able to implement all proposed projects and will hit the target of the Europe 2020 (20% lower than 1990 level) in case of GHG emissions and Air pollution from transport sector.

Let us assume the Catalonia government has proposed two options:

1. Reduce GHGs emissions and air pollution to 1990 level (13% lower than 2012) and pay a penalty to the EU (Plan L).

Studies have shown that the cost of this policy (plan "L") is equal to LP[25] € per year for each household during the next 5 years.

2. Reduce GHGs emissions and air pollution level to meet EU 2020 target (28% lower than 2012) without paying penalty and enjoying an extra capacity of emissions for the next step of EU 2050 plan as a reward (Plan H).

Studies have shown that the cost of this policy (plan "H") is equal to HP € per year for each household during the next 5 years.

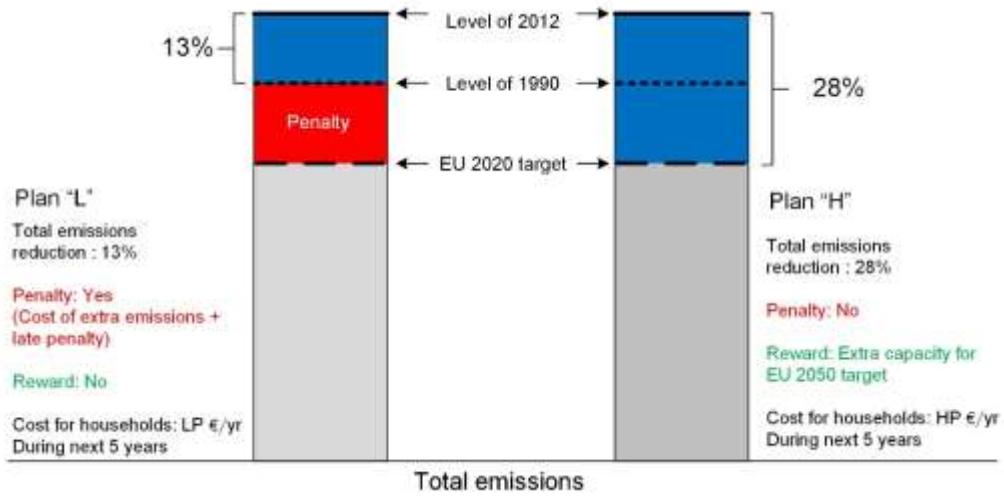
[25] LP and HP amounts in € and they are the bid amounts that were randomly assigned to respondents (see table 4.7).

Please think about "Plan L" and "Plan H".

"Plan L": Pay 13 €/year for 5 years as a transportation tax to reduce GHGs emissions and air pollution to 1990 level (13% lower than 2012) and pay a penalty to the EU.

"Plan H": Pay 24 €/year for 5 years as a transportation tax to reduce GHGs emissions and air pollution to 1990 level (28% lower than 2012). Not only this plan doesn't have any penalty but also has an extra emissions capacity as a reward for Catalonia.

>> I would like to remind you that, this program includes policies such as requiring oil companies to produce gasoline and diesel that make lower GHG emissions and pollutants per liter, support bio-fuel production by paying subsidies, investment in public transport development and paying subsidies and encourage the use of electric cars, etc.



If an election was being held today, would you vote in favor or against of this policy that would promote 13% reduction in GHGs emissions and Air pollution, and cost each household in Catalonia 13 €/year for 5 years as a transportation tax?

☐ In favor ☐ Against

If an election was being held today, would you vote in favor or against of this policy that would promote 28% reduction in GHGs emissions and Air pollution, and cost each household in Catalonia 24 €/year for 5 years as a transportation tax?

☐ In favor ☐ Against

Confirmation!

Please indicate, which one will be your vote?

"Plan L": Pay 13 €/year for 5 years as a transportation tax to reduce GHGs emissions and air pollution to 1990 level (13% lower than 2012), with this plan, Catalonia has to pay a penalty to the EU.

"Plan H": Pay 24 €/year for 5 years as a transportation tax to reduce GHGs emissions and air pollution to 1990 level (28% lower than 2012), with this plan there is no penalty for Catalonia.

According to previous questions, please let us know, if an election was being held today, would you vote in favor or against of "Plan L" or "Plan H"?

☐ **"Plan L"**

☐ **"Plan L"**

☐ **Neither one**

Appendix B

LISREL output

Goodness of Fit Statistics
Degrees of Freedom = 92
Minimum Fit Function Chi-Square = 176.049 (P = 0.000)
Normal Theory Weighted Least Squares Chi-Square = 178.640 (P = 0.000)
Satorra-Bentler Scaled Chi-Square = 157.861 (P = 0.000)
Chi-Square Corrected for Non-Normality = 177.727 (P = 0.000)
Estimated Non-centrality Parameter (NCP) = 65.861
90 Percent Confidence Interval for NCP = (34.944 ; 104.650)
Minimum Fit Function Value = 0.435
Population Discrepancy Function Value (F0) = 0.163
90 Percent Confidence Interval for F0 = (0.0863 ; 0.258)
Root Mean Square Error of Approximation (RMSEA) = 0.0420
90 Percent Confidence Interval for RMSEA = (0.0306 ; 0.0530)
P-Value for Test of Close Fit (RMSEA < 0.05) = 0.880
Expected Cross-Validation Index (ECVI) = 0.607
90 Percent Confidence Interval for ECVI = (0.531 ; 0.703)
ECVI for Saturated Model = 0.672
ECVI for Independence Model = 35.569
Chi-Square for Independence Model with 120 Degrees of Freedom = 14373.647
Independence AIC = 14405.647
Model AIC = 245.861
Saturated AIC = 272.000
Independence CAIC = 14485.749
Model CAIC = 466.141
Saturated CAIC = 952.864
Normed Fit Index (NFI) = 0.989
Non-Normed Fit Index (NNFI) = 0.994
Parsimony Normed Fit Index (PNFI) = 0.758
Comparative Fit Index (CFI) = 0.995
Incremental Fit Index (IFI) = 0.995
Relative Fit Index (RFI) = 0.986
Critical N (CN) = 325.446
Root Mean Square Residual (RMR) = 0.0242
Standardized RMR = 0.0309
Goodness of Fit Index (GFI) = 0.948
Adjusted Goodness of Fit Index (AGFI) = 0.923
Parsimony Goodness of Fit Index (PGFI) = 0.641

Completely Standardized Solution

LAMBDA-Y

	Willtpay	Intentio	Attitude	SubjNorm	PBContro
WTP	1.000	- -	- -	- -	- -
IP1	- -	0.867	- -	- -	- -
IP2	- -	0.911	- -	- -	- -
IP3	- -	0.890	- -	- -	- -
AT1	- -	- -	0.873	- -	- -
AT2	- -	- -	0.882	- -	- -
AT3	- -	- -	0.867	- -	- -
SN1	- -	- -	- -	0.821	- -
SN2	- -	- -	- -	0.906	- -
SN3	- -	- -	- -	0.893	- -
PBC1	- -	- -	- -	- -	0.744
PBC2	- -	- -	- -	- -	0.889
PBC3	- -	- -	- -	- -	0.840

LAMBDA-X

	EnvirCon
EC1	0.812
EC2	0.642
EC3	0.775

BETA

	Willtpay	Intentio	Attitude	SubjNorm	PBContro
Willtpay	- -	0.539	- -	- -	- -
Intentio	- -	- -	0.703	-0.073	0.390
Attitude	- -	- -	- -	- -	- -
SubjNorm	- -	- -	- -	- -	- -
PBContro	- -	- -	- -	- -	- -

GAMMA

	EnvirCon
Willtpay	- -
Intentio	- -
Attitude	0.337
SubjNorm	0.278
PBContro	0.241

Correlation Matrix of ETA and KSI

	Willtpay	Intentio	Attitude	SubjNorm	PBContro	EnvirCon
Willtpay	1.000					
Intentio	0.539	1.000				
Attitude	0.511	0.948	1.000			
SubjNorm	0.484	0.898	0.894	1.000		
PBContro	0.478	0.886	0.796	0.877	1.000	
EnvirCon	0.168	0.311	0.337	0.278	0.241	1.000

PSI

	Willtpay	Intentio	Attitude	SubjNorm	PBContro
Willtpay	0.709				
Intentio	- -	0.053			
Attitude	- -	- -	0.887		
SubjNorm	- -	- -	0.801	0.923	
PBContro	- -	- -	0.715	0.810	0.942