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Paying for green energy: The case of the Chilean Patagonia☆

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Abstract

We survey and assess the willingness to pay (WTP) for environmentally-friendly sources of energy, in the context of the proposed construction of five hydroelectric dams in the Chilean Patagonia. We then compare the estimated WTP to the real costs of generating electricity with different currently available technologies for renewable sources of energy. Overall, we find that the WTP of Chilean citizens would be more than enough to pay for greener sources of energy. We also find that the WTP is affected by age and gender of the respondents, but surprisingly not by income.

JEL classification: O1; Q2; Q4

Keywords: Green economy; Sustainable development; Energy; Environment; Chilean Patagonia

1. Introduction

Many emerging economies that are at a crossroads of their development processes face the critical question of choosing the energy sources needed to promote economic growth. Traditional sources based on fossil fuels have been proved to be damaging to the local and global

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environment. The more environmentally-friendly sources, such as solar, wind, geothermal and mini-hydro generating plants, tend to have higher operational costs, which poses a challenge to poorer economies.

An emerging economy that faces this critical choice is Chile. The country has been increasingly using coal- and natural-gas-powered plants to produce energy, along with declining hydroelectric generation. Traditionally, the country has exploited its hydroelectric potential by building big hydroelectric dams in several rivers of its central regions. Unfortunately, the rainfall is quite irregular in the central zone of Chile, which causes frequent disruptions in the supply of electricity. This has prompted a trend toward the construction of thermal fossil fuel plants. However, the unreliable supply of natural gas from Argentina and the declining Chilean coal production, coupled with the increased environmental awareness of the population, are threatening the viability of this new mix.

In recent years, the construction of five big hydro-electric dams was proposed on the rivers Baker and Pascua, two pristine rivers in the Patagonia region of Chile. Never before had this region been used for such purposes, and in fact its whole extent of some 150 thousand km^2 of rainforest, glaciers and snow-capped mountains remains basically in its primitive state, with sparse settlements of aboriginal people and early settlers. There are a few scattered towns which live off the agricultural and fisheries activities. But the area is mostly known for its rugged nature, its scenic beauty and the abundant reserves of water it contains.

This project (HidroAysén) would have required flooding 29 km^2 of natural reserve lands and also building power lines and 70-meter-high towers along a stretch of about 1000 km in the Chilean Patagonia, which in turn would have entailed clearing a considerable amount of rainforest. The benefits promised by the private consortium in charge of the construction were 2750 MW of new installed capacity for the Chilean energy grid, which represents 20% of its current installed capacity.

The threats to the environment posed by large-scale hydroelectric generation are not circumscribed to the displacement of local populations, the destruction of native forests and ecosystems and some esthetic considerations. It has also been found that the operation of large dams in the generation of electricity can produce considerable amounts of greenhouse gases (Fearnside, 2004), on occasions as much as fossil-fuel generating processes.

Before the project was recently rejected on environmental grounds by the government of Chile (June 2014) after seven years of negotiations, some studies and surveys were carried out to measure the degree of support for the project from the local population and the population of Chile at large. Most of them showed reticence to accept alterations to the natural environment of Patagonia and a relatively widespread support for the introduction of green tariffs in the production and distribution of electricity. Ponce, Vásquez, Stehr, Debels, and Orihuela (2011), using the contingent valuation method (CVM), showed that urban dwellers of four major cities in Chile had a willingness to pay (WTP) per year equivalent to 28% of the cost of the project for one of the five dams.

In this paper, we also use CVM to estimate WTP, with a nationwide sample of respondents and referring to the whole project (five dams). The study was concluded in March 2013, just a year before the project was canceled. In spite of the project having been recently discarded, we think this exercise has enormous value for the design of energy generation policies – and particularly the consideration of *green* policies – in developing countries.

We expect this paper to offer a fresh look at a problem that is currently affecting many developing countries in their quest for growth. In the South American context, this concern is shared by countries like Ecuador, Peru and Brazil, which face increasing threats over their Amazonian rainforest. Also, from a policy perspective, we aim to find some evidence of the Chileans' WTP to preserve Patagonia's pristine status, from where we can extrapolate some conclusions for similar situations in other developing economies.

There are three questions that are of interest to us, to which we try to offer an answer:

(i) Are there *green* alternatives (to the dams) that could be capable of generating the electricity that Chile needs for its developing economy?

This question is addressed in Section 2. We find there to be multiple options which could replace hydroelectric power.

(ii) How much is the value of the endangered natural capital, as estimated by the WTP of the Chilean people?

We address this question and attempt an answer in Section 6. The validity of this answer is obviously dependent on the representativeness of the random sample used in the survey (which is our main methodological tool for the analysis). We are aware of the fact that a larger sample would eventually be desirable.

(iii) If this value is substantial, would it be enough to pay for the transition to alternative (*greener*) modes of energy generation?

The value that we have calculated in Section 4, based on the results of the survey, seems to be more than enough for this purpose, as stated in Section 6 (policy recommendations and conclusions), given the information we have on costs of different modes of energy generation (Section 2).

Additionally, we carry out a brief analysis on the determinants of the WTP for environmental resources, as revealed by the responses to the survey of this study. This analysis might be useful for the purpose of eventually establishing differentiated green tariffs among energy consumers.

The paper is structured as follows. In the next section, we discuss the possible alternatives existing for Chile regarding environmentally-friendly sources of energy, in an attempt to answer the first question. Section 3 provides a brief discussion of the relevant literature and our choice of methodology. Section 4 describes our survey design and responses. In Section 5, we develop a simple empirical model we use to analyze the determinants of the WTP. Finally, Section 6 presents a brief discussion of the results of the survey and a few concluding remarks.

2. Are there alternatives?

What HidroAysén was proposing was basically expanding the energy grid of Chile with 2750 MW of installed capacity, which would generate an average of 18,430 GWh of electricity generation annually. This would represent 21% of the demand in the Central Interconnected System (SIC) of Chile by the year 2020, according to their own estimates (HidroAysén Website, 2015).

The installed capacity of the Chilean energy grid was 15,700 MW in the year 2010, with the following modes of generation: large-scale hydro (32%), coal and diesel (32%), natural gas (32%) and others, basically mini-hydro, wind and biomass (4%). This compares rather favorably to the world shares: 65% fossil fuels, 15% nuclear, 15% hydro and 5% others (minenergia.cl, 2012). The maximum demand in Chile is currently estimated at 8000 MW, which has the system operating at slightly over 50% of its capacity.

The forms of power generation that are considered "clean" are grouped into what are called the "non-conventional renewable energies" (NCRE), and they can be obtained through wind turbines, biomass (principally poultry and pork manure and agricultural residues), geothermal energy, solar thermal and photovoltaic, ocean tidal waves and mini-hydro plants. The nuclear option has been discarded by the Chilean government for now, in the wake of the disaster of Fukushima, Japan, in 2011 (Chile is also a quake-prone country).

Chile has clear comparative advantages in the production of solar energy, especially of the photovoltaic type. It has the driest desert in the world (the Atacama Desert), with close to 365 sunny days per year. This vast extension of land does not have many other alternative uses. In fact, all the northern half of Chile (a stretch of some 2500 km) enjoys exceptionally high amounts of solar radiation, basically due to the influence of the Humboldt current of the Pacific Ocean. It is estimated that solar concentrations in Chile are producing a KWh at a cost of US$ 10–14 cents. By comparison, coal-powered energy has a cost of 8–10 (without considering environmental costs). HidroAysén promised to produce hydroelectricity at 9–10 cents per KWh (Valdivia, 2015). With the help of nanotechnology, enormous strides of progress are being made in the production, storage and distribution of solar energy (Rogers & Wisland, 2015), which should decrease costs further from their current levels.

The country also has a significant potential for geothermal energy production. The Energy Ministry (Ministry of Energy Chile Website, 2015) estimates that Chile could produce up to 100,000 MW of this type of energy. Chile has one of the largest undeveloped geothermal areas in the world, with more than 300 hot spring sites along the Andes mountains from north to south (Lahsen, Sepúlveda, Rojas, & Palacios, 2005). The government has already laid the foundations of future exploration by enacting a Law of Geothermal Concessions. There is some interest – especially from the mining companies of the northern part of the country –, but very little has been done until recently (Lahsen et al., 2005). The current costs of geothermal generation are estimated at around 10 cents per KWh (Energy Information Administration, 2015).

Chile could well follow the example of Norway, by building more mini-hydro plants on its thousands of rivers and streams that run from the Andes mountains through the width of its territory toward the Pacific Ocean. Experts estimate that this type of plant could generate in Chile up to 10,000 MW of installed capacity, up from the 1600 generated today (Espinola, Schmidt, & Rudnick, 2015).

Biomass (principally poultry and pork manure and agricultural residues) and wind energy are also possible in Chile. Pontt, Pontt, and Guiñez (2015) estimate that biogas generation costs in Chile could range between 7 and 13 cents per KWh, pointing out that this type of energy could represent up to 6% of the total installed capacity.

As for wind, there are already some wind farms producing energy in the Chilean territory, but certainly the southern region of Magallanes and the area close to Cape Horn (with some of the strongest winds in the world and very sparse population) could harbor great extensions of wind farms.

The main options of clean energy open for Chile are then solar, wind, geothermal, biomass and small-hydro. All of them are starting to be used in the country. A recent study by a group of experts (CCTP, 2015) estimates that by 2025 the installed capacity of NCRE in Chile could be 6600 MW (more than 10 times as much as now). It also considers that the country could obtain an additional 3400 MW from improved energy efficiency. That adds up to 10,000 MW of increased installed capacity (almost four HidroAysén projects). In the longer term, they estimate that Chile has a potential of 190,000 MW of installed capacity in NCRE (about 12 or 13 times the current size of the grid).

CCTP (2015) estimates that the average cost of a mix of NCRE for Chile would be much lower than the prevailing prices of energy in the electric market of Chile (without considering the external costs of fossil fuels and mega-dams).

All these possibilities are certainly a realistic hope for the Chilean economy. But the transition to new modes of energy generation is not easy. There is unquestionable political inertia and many barriers to overcome. As it happens in many other developing economies in the world (Haines et al., 2007), vested interests could be opposed to any change.

3. Methodology and related literature

Our paper uses the contingent valuation method (CVM) to estimate respondents' willingness to pay for preserving the Chilean Patagonia in its pristine state. Contingent valuation is a widely used survey-based valuation method first proposed in the works of Siegfried von Ciriacy-Wantrup (Hoyos & Mariel, 2010). It is a stated-preference method used for the valuation of non-marketable resources. For example, Yoo (2004) estimated the South Koreans' mean willingness to pay for the unification of Korea. Also, Lee, Kwak, and Yoo (2006) estimated the willingness to pay for a cyber-ecological park, which was proposed by the South Korean government to provide the public with useful information regarding ecosystems and natural resources related to the Woopoo wetland region. And Simpson and Hanna (2010) used CVM to estimate the willingness to pay for a clear-night sky for a sample of students at the Rochester Institute of Technology.

The method is often used in the context of eliciting willingness to pay (WTP) for ecosystem services and preservation of environmental resources. For example, Carson and Mitchell (1993), an early contingent valuation study, elicited the WTP for minimum water quality in the U.S. that is suitable for swimming, fishing and boating. Veronesi, Chawla, Maurer, and Lienert (2014) surveyed a sample of the Swiss population, and found that 71% would be willing to pay a tax to reduce ecological and health risks from combined sewage overflows in rivers and lakes and wastewater flooding of commercial and residential areas under the uncertainty of climate change. And Yao et al. (2014) estimated the willingness to pay for a proposed biodiversity enhancement of New Zealand's planted forests.

CVM is one of the most popular methods used by environmental and resource economics to estimate people's stated preferences for environmental goods. There is some research that has estimated citizens' willingness to pay for renewable energy sources in developed nations such as the United States (Farhar & Coburn, 2015; Roe, Teisl, Levy, & Russell, 2001; Whitehead & Cherry, 2007; Wiser, 2007; Zarnikau, 2003), United Kingdom (Batley, Colbourne, Fleming, & Urwin, 2001; Diaz-Rainey & Ashton, 2007), Japan (Nomura & Akai, 2004), Australia (Ivanova, 2015), Italy (Polinori, 2009) and Canada (Rowlands, Scott, & Parker, 2003). This extensive literature on valuation of environmental resources using CVM motivated our choice of methodology for this study.

CVM can be very useful to collect information about consumer preferences, which can be used to design effective green-economy policies. These policies are aimed to provide incentives to consumers and producers to make choices that are less damaging to the environment. These choices impose some form of cost on the decision makers, typically either in the form of reduced consumption/production or higher market prices or a combination of the two. Thus, the effectiveness of any policy targeted toward a greener economy essentially depends on how the different market participants respond to the policy by adjusting their consumption and production decisions, i.e., on the relative demand and supply elasticities of the good on which the policy has been imposed. To illustrate this, consider the government imposes a per unit tax ($\$t$) on the supply of

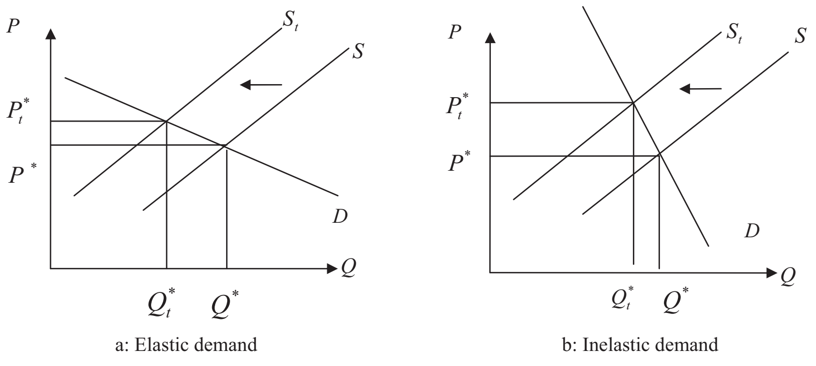

Fig. 1.

Source: own composition.

a good whose production generates pollution. The figures below illustrate the alternative market outcomes that are possible. Let (P^*, Q^*) represent the pre-tax equilibrium price and quantity and (P_t^*, Q_t^*) denote the post-tax equilibrium price and quantity combination. The line S shows the pre-tax linear supply curve and S_t is the new supply curve after the tax has been imposed. As evident from Fig. 1a and b, the resulting change in the equilibrium price and quantity levels from the green tax can be distinctly different given different elasticities of demand for the good. Suppliers of the good would attempt to shift some of the tax burden to the consumers in the form of an increased market price. If demand for the good is relatively elastic, consumers will respond by sharply cutting down their consumption levels, which would in turn reduce production in the market and result in improved environmental conditions. Conversely, the improvement in environmental quality is likely to be significantly lower when demand is inelastic. Similar considerations can be drawn for the elasticity of supply.

The above argument illustrates the role of consumer choices in determining the effectiveness of any green economy policy influencing market behavior and the resulting impact on environmental quality. Information about consumer preferences (obtained in our case by CVM) would allow governments to more accurately predict the market's response to any green-economy policy. This would lead regulatory agencies to design policies aimed at obtaining the desired impact on environmental quality. For the same improvement in environmental quality, the tax rate would have to be adjusted according to the different elasticities of demand and/or supply.

Despite its widespread popularity among researchers, the technique remains controversial (see Hausman, 1993). Also, given that it is essentially a stated-preference method as opposed to a revealed-preference one, there is always concern about the applicability of the results in actual policy initiatives that would require individuals to make real payments for the environmental good they state as valuable. There is always the possibility that individuals will engage in free-riding behavior when they face the option to pay for public goods. Hence, the CVM estimates of mean willingness to pay for environmental goods are often an over-estimation of the actual payments that would be made, considering the free-riding behavior involved. The hypothetical bias that arises from the difference in respondents' behavior between a hypothetical situation and an actual situation where the respondents would have to make an actual payment remains a major limitation of CVM studies (Paradiso & Trisorio, 2001). Nonetheless, the method remains a valuable tool to elicit individuals' WTP for environmental goods and to assess whether individuals are aware of certain environmental problems and are consciously thinking about their role in addressing those problems. This is particularly true in situations where there are no mechanisms in place that would help identify revealed-preference behavior.

This present paper contributes to the existing literature on green-economy policies by emphasizing the link between consumer preferences over green goods and services, such as green energy, and green economy policies. Understanding this relationship and incorporating information about consumer preferences in the design of green economy policies is critical for at least a couple of reasons. First, the effectiveness of any policy designed to improve environmental quality is dependent of the market response because producers and consumers will revise their decisions in response to the policy. Second, information about consumer preferences would be useful in identifying the degree of government intervention needed in the form of designing and implementing green policies.

Along these lines, Nyborg, Howarth, and Brekke (2006) develop a theoretical model to illustrate that demand for green products and services can exhibit *herd behavior* when consumers are motivated by internal social norms. Their results imply that consumers can influence each other in being more responsive to any green economy policy, thereby increasing the policy's effectiveness in meeting the environmental target. Borchers, Duke, and Parsons (2007) use a choice experiment to estimate willingness to pay for voluntary participation in green-energy electricity programs. They use data for Delaware, U.S., and find that there is a positive willingness to pay for green energy as exhibited by their sample. However, consumers differ in their willingness to pay for different sources of green energy, solar energy being the most popular choice. A number of studies highlight the need to understand consumer preferences for designing and implementing effective green-economy policies. For example, Ek (2005) and Yoo and Kwak (2009) show how consumers differ in different parts of the world in their responses to the green energy sources.

Our study adds to this growing body of work on green-economy policy initiatives by providing evidence on the specific case of Chile. Following in the footsteps of Ponce et al. (2011) and Aravena, Hutchinson, and Longo (2012), our research is wider in scope than the first one and more policy-specific than the second one, but our results are broadly in line with their findings. While Aravena et al. (2012) focused on the Chilean willingness to pay for renewable energy sources in general, our primary focus was on identifying whether respondents are willing to pay (and how much) to preserve Patagonia in its pristine state. In other words, we are more interested in the value of the environmental resources involved, working toward the establishment of a *green economy*.

4. The survey results and characteristics of the random sample

In 2013, we designed a survey to collect data on a random sample of the Chilean population. The survey was conducted by random sampling of the entire population of Chilean residents 18 years or older, in March 2013, by an online survey company specialized in academic research with operations worldwide. The sample contains 334 respondents, with 100% of the participants agreeing to the statement that their participation has been voluntary and informed and their responses are being kept anonymous. The survey asks respondents about their monthly WTP for preserving Patagonia in its pristine state and also a number of questions that allow us to study the characteristics of our sample and identify the key determinants of the respondents' WTP. These other questions refer to (i) energy bill and housing costs as a percentage of the monthly budget, (ii) nationality and place of residence, (iii) age, gender, income and educational level, (iv) political and religious preferences, and (v) occupation.

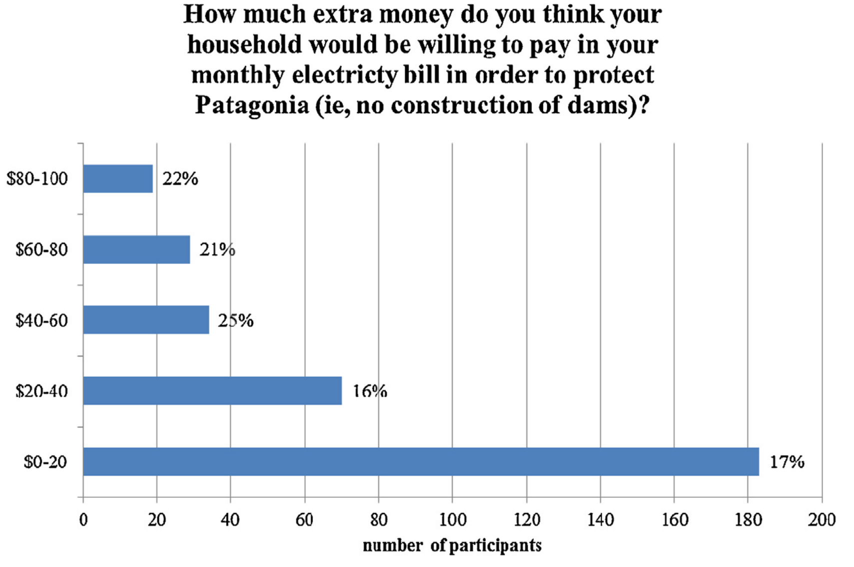

Fig. 2. Willingness to pay for protection of environmental resources of Patagonia.
Source: own composition, based on survey of this study.

Table 1
Responses to main question of the survey.

How much extra money do you think your household is willing to pay in your electricity bill in order to protect Patagonia (i.e., prevent the construction of dams)? Give a specific value between 0 and CLP 50 thousand. (NB: your response to this survey implies no commitment for you.)

	Min value	Max value	Average value	Median	Standard deviation	Responses
Thousands of Chilean pesos (CLP)	0	50	14.86	10	13.45	334

Exchange rate March 2013: USD 1 ≈ CLP 500.

The main question reads as follows (translated from Spanish, the language of the survey): "How much extra money do you think your household is willing to pay in your electricity bill in order to protect Patagonia (i.e., prevent the construction of dams)? Give a specific value between 0 and CLP 50 thousand. (NB: your response to this survey implies no commitment for you)". The cap of 50 thousand Chilean pesos (CLP) represented about USD100 per month at the exchange rate of March 2013. We chose to cap the possible responses, because eliciting the WTP from an open-ended response may lead to substantial bias, as described by Damschroder, Ubel, Riis, and Smith (2007).

The statistics for this main question are summarized above (Fig. 2 and Table 1):

The average WTP for the sample was found to be CLP 14.86 thousand or about USD 29.72, per month. Considering that the average size of the Chilean household is 3.4 persons (INE, 2015) in a country with a population of 17 million, the 5 million households could be contributing an additional USD 1.8 billion annually to the operation of the energy system of Chile. This is equivalent to 20% of the cost of the HidroAysén project.

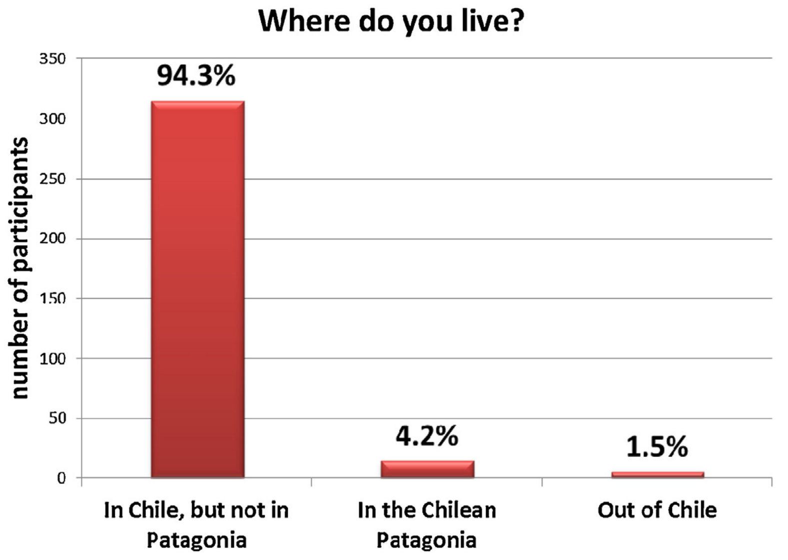

Fig. 3. Place of residence of the respondents of the survey of this study.
Source: own composition.

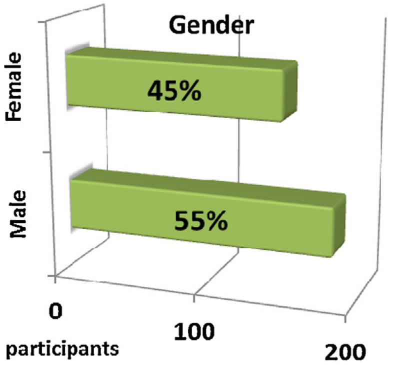

Fig. 4. Gender of the respondents of the survey of this study.
Source: own composition.

The high value for the average WTP might seem surprising, but it can be better understood in the context of growing consciousness about the high levels of pollution in Chile's major urban centers. The median is only USD 20, which seems more affordable for most Chilean households (Figs. 3 and 4).

Other interesting characteristics of the sample showed that 98.5% of the persons surveyed were Chilean permanent residents, but only 4.2% lived in Patagonia (the rest in other regions of Chile), which reflects fairly well the proportion of Patagonia residents in the entire Chilean population. The sample contained 55% male respondents. About 45% of the respondents stated they had a college degree but no post-graduate degree, while 27% had high school degree but incomplete college education. Of the entire sample, 66% of respondents were between 20 and 39 years of age (Figs. 5–8).

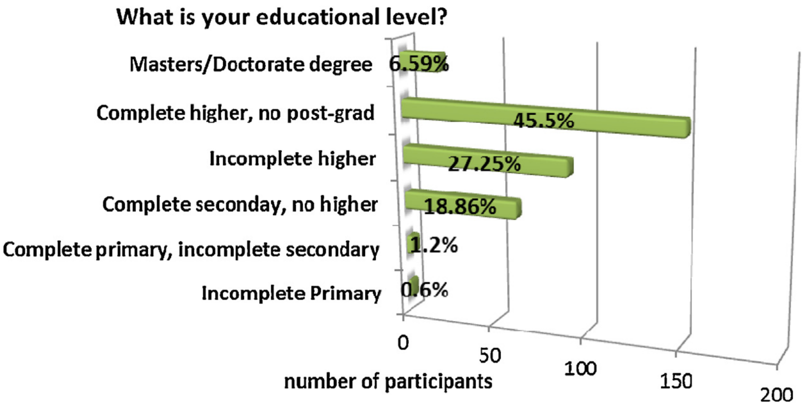

Fig. 5. Educational level of the respondents of the survey of this study.
Source: own composition.

This research instrument must be interpreted carefully as the willingness to pay (WTP) of Chileans may reflect more of the *existence value* of the natural resource to Chileans and not exactly the *use value* of the resource. Many Chileans (or Chilean respondents of this survey for that matter) will never in their lives visit Patagonia, so they will not be properly "using" its natural resources. However, we can claim that a Chilean resident is more a user of Patagonia than a US, African or European resident, since Chileans own that land. On the other hand, most of them would be enjoying the benefits of hydroelectric energy eventually produced down there, so they are users by default. We must also consider that many citizens of the rest of the world might be able to visit that land, which converts them in "users" whose WTP we are not measuring here. Finally, the relatively small size of the sample would also recommend some caution in the interpretation of results. With those caveats in mind, we can proceed.

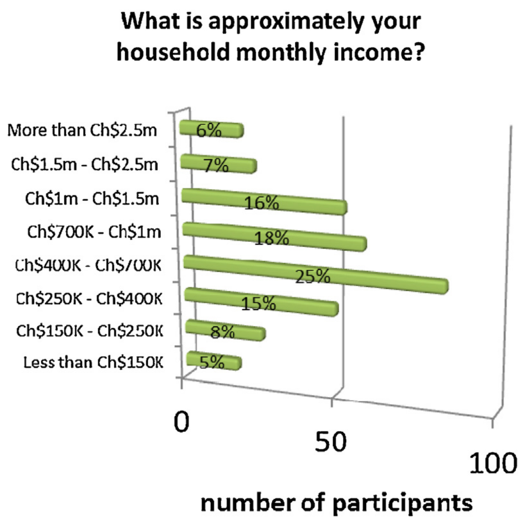

Fig. 6. Household monthly income of the respondents of the survey of this study.
Source: own composition.

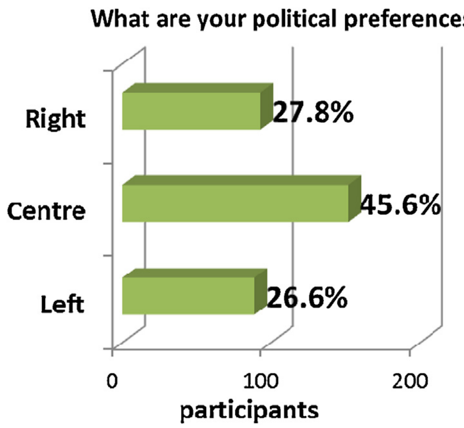

Fig. 7. Political preferences of the respondents of the survey of this study.
Source: own composition.

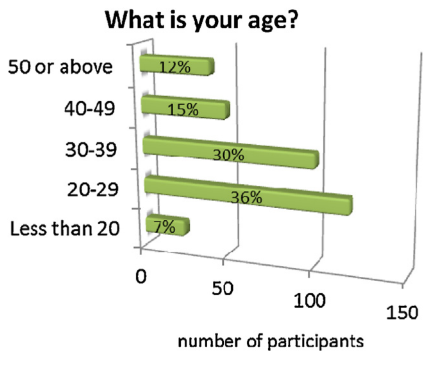

Fig. 8. Age of the respondents of the survey of this study.
Source: own composition.

5. The determinants of the WTP

To obtain estimates for the determinants of respondents' WTP we used our dataset of 334 observations. For all questions where respondents were asked to pick an interval, we chose the mean value for that interval. For example, if an individual stated his or her age lies between 20 and 29, we chose 25. The rationale for the political and faith questions is to try to discern whether these views have any bearing on the WTP for environmental resources.

Although the money responses were in local currency (CLP), we converted all values to dollars (USD) for the purposes of this analysis, using the exchange rate CLP/USD of March 2013.

The model is the following:

$$\begin{aligned} \text{WTP} &= \alpha_0 + \alpha_1 Inc + \alpha_2 Electric + \alpha_3 Edu + \alpha_4 Age + \alpha_5 Male + \alpha_6 Political \\ &\quad + \alpha_7 Faith + u \end{aligned} \tag{1}$$

where WTP: our dependent variable (in USD, capped at USD 100); *Inc:* monthly household income; *Electric*: electric bill as a percentage of monthly income; *Edu*: years of schooling; *Age*:

Table 2
Estimation results.

Dependent variable – WTP	Coefficient	Linearized standard errors	*t*-Test
Inc	.0001642	.0012409	0.13
Electric	.374102	.21625	1.73[a]
Edu	.510652	.64836	0.79
Age	−.23437	.12317	−1.90[a]
Male	5.644568	2.93332	1.92[a]
Political	.123173	3.2381	0.04
Faith	3.543192	3.17951	1.11
Constant	19.66912	11.0609	1.78

[a] Statistically significant at 10% level.

age of respondent, in years; *Male* = 1 if male, 0 otherwise; *Political*: 1 if the person states he/she is liberal or moderate, 0 if conservative; *Faith*: 1 if the person agrees (or strongly agrees) with the following statement "I believe in God and that He created the world and the universe", 0 if indifferent or disagrees; *u:* the error term.

The sampling weight used in the regression analysis is the inverse of the likelihood of being sampled. Table 2 provides the results:

The standard errors are the linearized standard errors reported by Stata from the survey estimation results. They are the counterparts of heteroscedasticity-corrected robust standard errors obtained from regression analysis of non-survey data.

Table 2 provides some interesting results. The estimates for *electric*, *age* and *gender* were found to be statistically significant at the 10% level. Specifically, the results indicate that, all else equal, younger citizens and men reveal a higher WTP for preserving Patagonia. A somewhat puzzling finding is the result for *electric*. It shows a higher WTP for respondents whose electricity bills are a higher percentage of the monthly income than others in the sample. This, coupled with the fact that income has no discernible effect on the WTP, tends to suggest that poorer people might be more environmentally-friendly than the rest of the population.

6. Policy recommendations and concluding remarks

We believe that we have adequately answered (with the necessary caveats that we have expressed before) the two first questions we proposed ourselves: the existence of alternative sources and the value of the natural capital of Patagonia for Chileans (USD 1.8 billion as a rough estimate).

But, is this enough? Would this additional amount of resources be sufficient to pay for alternative modes of energy generation? The answer to the question we set as our main research objective seems fairly easy to discern. If HidroAysén would have been producing (sometime after 2025) 18,430 GWh per year (1 GWh = 1 million kWh), then the 1.8 billion dollars of the Chilean households would be able to finance up to a difference of 10 cents per KWh of a cleaner but eventually costlier production technology. This WTP would be more than enough (at the current estimated costs, specified in Section 3) to substitute HidroAysén or any fossil-fuel source with some type of non-conventional renewable energy.

What drives this apparent generosity of Chileans (reflected in the high WTP revealed by the survey) toward clean sources of energy? Is Chile special in any sense? For one thing, Chileans are extremely conscious of the value of their natural capital. The fact that one third of the population concentrates in a relatively congested and polluted metropolis (Santiago) and another third in the densely populated central zone of the country makes them appreciate all the more the existence of their wilder remote areas. But this could be true of most developing countries, and particularly Latin American ones, like Brazil, Ecuador and Peru. Population tends to concentrate in the larger cities in order to have better access to modern facilities and government subsidies.

We believe our study can recommend the imposition of *green taxes* on the production and/or consumption of energy derived from fossil fuel sources or big hydroelectric dams. While this would certainly prompt exploration and exploitation of NCRE sources under the current Chilean legislation, it would make industrial production more expensive in the country, and could be politically unviable. A more realistic option might be subsidizing new NCRE projects through the current incentive mechanisms that the government of Chile has in place for private investment projects (CORFO and others).

At an environmental level, Chile has established institutions which, under ideal circumstances, can prevent the realization of investment projects of any kind that could be damaging to the environment (SEIA, the environmental impact assessment system), and so do other Latin American countries. However, the lack of political will to move toward greener options has been a major hindrance. Without proper initiative on the part of the government, coupled with support from the Chilean public, Chile's ability to find greener sources to meet its energy demand is questionable. It is also very important that the criteria used by the government agencies of environmental impact assessment be based on scientific and social facts (air and water pollution, community displacements, biodiversity protection, etc.), and not subject to the swaying needs of financial investment that a country might be facing.

Even though in the case we have studied, the *user value* (the WTP of Chileans) seems to be enough to preserve an ecosystem, it is important to take into account that these ecosystems are global assets, and eventually it is important to consider the *existence value* of the resource before deciding about its use. In the case of the Chilean Patagonia, there might also be a substantial *existence value* for those lands of the southernmost tip of the world. Even if Chilean households had revealed a lower WTP than the cost differential of the different types of energy, the case against such invasive hydroelectric dams as proposed by the HidroAysén project could still have been made by appealing to the global value of those environmental resources.

When environmental resources of a country have value for the whole planet, the whole global community has a responsibility to preserve them, and developing countries who own them should be able to receive the financial support that they require in order to maintain them. This global responsibility is starting to be understood as shown by the incipient support that the Organization of United Nations is lending to the preservation of Amazonia and similar ecosystems throughout the world.

The results in our paper, though focused on a small sample of Chileans, have broad implications for Chile's energy strategy as a whole. Based on the findings of our survey, we believe there is scope for public-private partnership in Chile in the effort of moving toward greener energy sources. Chileans might be responsive to incentives designed to reduce fossil fuel demand. For example, given that a considerable proportion of Chileans resides and works in urban areas, employers could provide incentives to employees for carpooling. Also, since the younger generations indicate a higher WTP for environmental protection, maybe an emphasis can be placed on greening Chile's academic campuses flocked by younger members of the population. A green tax on household energy consumption can also be an option.

It is hard to predict which strategy will bring about highest environmental benefits. Nonetheless, the results indicate there is scope in Chile to engage in collaborative efforts between the public and private sectors for exploring environmentally-friendly options to meet Chile's future energy demands. The key to success will lie in the political will of the government.

These policy recommendations could be considered by policymakers, not only in Chile, but also in middle-income economies of similar characteristics, particularly Latin American ones.

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Appendix. The survey

The government of Chile has given its technical approval to a project of hydro-electric energy generation that would entail the construction of five dams in the southern region of Patagonia, one of the major natural reserve areas of the planet. The project would be carried out by a consortium of multinational corporations, which would reap the financial benefits of its exploitation.

More information on this project can be found below:

http://news.nationalgeographic.com/news/2010/05/photogalleries/100512/photos-patagonia-rivers-dams/#/patagonia-chile-dams-freshwater-rivers-rave-lake_20178_600x450.jpg
http://www.msnbc.msn.com/id/42965306/ns/world_news-world_environment/t/chiles-patagonia-get-dams-wild-rivers/#.TqgOoHKZTF8
http://en.wikipedia.org/wiki/HidroAys%C3%A9n

If carried out, the project would involve flooding 29 km^2 of natural reserves in two river basins and building towers and transmission power lines over a stretch of about 1000 miles of pristine wildlife lands. Its opponents emphasize that this would imply altering a fragile ecosystem and endangering vegetal and animal endemic species, some of which are at risk of extinction (like the *huemul*, a Patagonian deer). They say it would cause irreparable damage to one of the most beautiful natural reserves of the earth's biosphere (see pictures attached). According to studies of some preservation movements, just the construction and access roads will impact six national parks, eleven national reserves, twenty-six conservation priority sites, sixteen wetland areas and thirty-two privately owned protected conservation areas. This is in addition to six tribal communities of the aboriginal *Mapuche* people.

See videos by opponents of the project:

http://www.youtube.com/watch?v=92PdJ_nowng&feature=youtu.be
http://rioslibres.com/?p=386

The government and the corporations involved retort that the environmental impact would be minimal and restricted to the areas of the project. In addition, they state that the electrical power that these dams would generate is an absolute "imperative" for the future development of the Chilean economy, based on studies carried out by the energy agencies of the government:

http://www.minenergia.cl/ministerio/noticias/generales/laurence-golborne-expuso-sobre-los.html
http://www.hidroaysen.cl/?page_id=22

More specifically, the HidroAysén project would expand the energy grid of Chile in 2750 MW of installed capacity, which would generate an annual average of 18,430 GWh of additional electricity. This would represent about 20% of the demand of the Interconnected Central System (SIC) by the year 2023.

On the other hand, independent technical committees have established that while it is true that the country is in need of more energy for its adequate functioning, there are also some alternative sources that could be explored, probably at a higher cost (ignoring the cost of the damage the five-dams project would impose on the environment and aboriginal communities), although recent studies differ regarding the magnitude of the increase in costs. One of those sources is solar energy. The country has one of the greatest potentials in the world of generating solar energy in the northern part of the country, and particularly in the Atacama Desert, with its average of 360+ sunny days per year. And it is precisely the mining industry, close to this desert and thousands of miles away from Patagonia, which will be needing the greatest amount of energy in Chile over the next few decades. The technology for this type of energy generation is quickly advancing and getting cheaper every day. A citizens' committee integrated by NGOs, Congress members and energy specialists in Chile has recently suggested that a mix of non-conventional renewable energies (including solar, biomass, geothermal, wind and small-hydro) would not be operationally more expensive than the present more fossil-fuel oriented mode of generation, and would certainly spare the need of building the mega-dams in Patagonia. Moreover, they have calculated that just by increasing the efficiency in the use of energy over the next thirty years, the energy savings would be larger than the power generated by the Patagonian project and the country would be meeting its energy needs given the potential growth rate of the economy.

http://www.flickr.com/photos/jorgeleoncabello/collections/72157626196641904/ (photos of the Patagonia area where the dams would be built).

In any case, it seems that the transition to any alternative mode of energy generation could be somewhat more costly in the near term, even though – according to the alluded independent studies – it promises significant cost advantages in the future and avoids the destruction of some valuable natural capital. In order to legitimately compare the costs of the five-dams project with alternatives, the cost of the damage to the environment of the project must be taken into account. This is precisely what this survey is directed to do. Specifically, this survey will enable us to estimate the value of preserving Patagonia's natural environment. The true cost of the five-dams project can then be ascertained as the monetary cost of the project plus the cost of the value of preserving Patagonia's natural environment. By answering the questions below, you will enable us to determine how much people are willing to pay to avoid the destruction of Patagonia, or put differently, the value of the existence of this natural environment to people across the globe. We are grateful for your willingness to participate in this survey.

Suppose that the dams will be built unless 80% of the respondents to this survey are willing to pay a certain minimum amount of money to amortize the transition from conventional to non-conventional sources of energy. Taking into account this and the above scenario, please answer the following:

(1) "I hereby state that my participation in this survey has been completely voluntary. Furthermore, I understand that it is totally anonymous and that I cannot derive any major direct benefit from or be harmed in any way by it."
  (a) Agree
  (b) Disagree

(2) How much extra money do you think your household is willing to pay in your electricity bill in order to protect Patagonia (i.e., prevent the construction of dams)? Give a specific value between 0 and CLP 50 thousand ....(NB: your response to this survey implies no commitment for you)
(3) What part of your monthly income is your energy bill (electricity plus transportation)?
   (a) Less than 10%
   (b) Between 10 and 20%
   (c) More than 20%
(4) What part of your monthly income is your housing cost (rent, mortgage, etc)?
   (a) Less than 20%
   (b) Between 20 and 40%
   (c) More than 20%
(5) Where do you live?
   (a) In Chile, but not in Patagonia
   (b) In the Chilean Patagonia
   (c) Not in Chile
(6) What is your nationality?
   (a) Chilean
   (b) Other
(7) What is your age?
   (a) Less than 20
   (b) 20–29
   (c) 30–39
   (d) 40–49
   (e) 50 or above
(8) What are your political preferences?
   (a) Liberal
   (b) Moderate
   (c) Conservative
(9) Sex: ☐ Male ☐ Female
(10) What is you education level?
   (a) Incomplete primary school
   (b) Complete primary, but no secondary level schooling
   (c) Complete secondary, but no college
   (d) Some college, but did not complete and receive college degree
   (e) Complete college with degree, but no post-graduate degree
   (f) Post-graduate degree – master's or doctoral degree
(11) What is approximately your household annual income?
   (a) Under CLP 150,000
   (b) CLP 150,000–250,000
   (c) CLP 250,000–400,000
   (d) CLP 400,000–700,000
   (e) CLP 700,000–1 million
   (f) CLP 1–1.5 million
   (g) CLP 1.5–2.5 million
   (h) More than CLP 2.5 million

(12) How strongly do you agree with the following statement: "I believe in God and believe He created the universe and the world"?
 (a) Strongly agree
 (b) Agree
 (c) Not sure/indifferent
 (d) Disagree
 (e) Strongly disagree
(13) What is your profession or occupation? ....

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