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Article

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Impact of Public Policies on the Technological Innovation in the Renewable Energy Sector

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ABSTRACT

The challenges posed by climate change require that the society reconsider its patterns of production and energy consumption, which is why the innovation in the renewable energy sector is fundamental. For this reason, the participation of the State through actions that promote research, development and dissemination of the technologies in this sector is essential to overcome the technical and economic barriers it faces. This research analyzes the impact of six public policy instruments implemented to promote the technological development of the renewable energy sector: economic instruments, regulatory instruments, policy support, research, information and adaptation, and voluntary approaches; differentiating both among groups of countries according to their level of income as well as among energy sources. Through the implementation of a negative binomial model in a panel data panel setting ranging from 1970 to 2012, the results corroborate the positive impact of the implementation of public policy strategies on the innovative activity of the renewable energy sector. However, the effectiveness of the instruments varies according to the level of the wealth of the country and the energy source analysed. These results can add public policy inputs to promote innovative activity in the sector.

Keywords: Environmental Policy, Innovation, Patents, Renewable Energy, Technological Change
JEL Classifications: Q55, Q58, O34, O38

1. INTRODUCTION

Different nations have expressed their support for the implementation of public policies that promote sustainable economic development, supported by the establishment of clear objectives in terms of reducing carbon emissions (OECD, 2017). To this end, actions have been separated according to the sector to which they are directed according to their environmental impact, of which energy, transport, agriculture and fisheries stand out (OECD, 2008). However, among these, the implementation of efforts aimed at increasing the efficiency of the energy sector is essential in achieving internationally established environmental goals, given that it provides a fundamental input for developing economic activities (Sawin and Flavin, 2006; OECD, 2011).

Boosting innovation in the energy sector is essential to increase its efficiency and explore new, more environmentally friendly sources of energy supply, such as renewable energies. Innovation in this sector is a crucial factor that enhances the transition from the use of fossil fuels (oil, coal and natural gas) to renewable energies (wind, solar, geothermal, marine and hydraulic) in different countries, regardless of their income level, due to its impact on reducing the costs of investment, operation and maintenance of the technologies used (OECD, 2011). However, it requires an appropriate framework, modeled by the implementation of public policies aimed at promoting environmental science and technology such as regulatory and economic instruments (EI), education and information programmes and funding for research and development (R&D) (Jaffe et al., 2005; Sawin and Flavin, 2006; Menanteau et al., 2003; Stavins, 2003; Johnstone et al., 2010; Brunnermeier and Cohen, 2003; OECD, 2011).

Specific public policy actions promoting innovative activity in the renewable energy sector in European and Organization for Economic Co-operation and Development (OECD) countries have been studied in the literature (Johnstone et al., 2010; Popp, 2006; Arimura et al., 2007; Lanoie et al., 2011). However, until now the impact of these actions had not been analysed according to the income level of the country or by including some of the emerging countries in the analysis (South Korea, Mexico and Turkey). The results from the present analysis are important since provide new insights to answer the following question: what is the effectiveness of the different public policy instruments on technological innovation in the renewable energy sector, according to source and income level of the country? The objective consists showing evidence regarding public policy instruments that may be suitable for an energy source, or country with a specific income level, may not necessarily be suitable for another with different characteristics.

As such, the results obtained add inputs to the elaboration of policies for the promotion of innovative activity in the renewable energy sector, distinguishing not only by sector of analysis but also by country group according to its historical average income level. Along these lines, the public policy actions implemented by 33 countries during the period 1970-2012 are analyzed in order to identify their impact. Thus, this research is composed as follows. The first section reviews the literature on the role of the State in promoting technological innovation, and the specific impacts of each measure implemented on the number of patents registered in the renewable energy sector. The second section describes the data considered in the analysis, the methodology used and the specification of the model. The third section presents and discusses the empirical results obtained and ends in the fourth section with conclusions.

2. LITERATURE REVIEW

The implementation of diverse actions on the part of the government in matters of environmental technological innovation has been referred to in the literature with the existence of market failures, which can be in the form of positive and negative externalities (Arrow, 1962; Mohr, 2002; Jaffe et al., 2005; Mohr and Saha, 2008; Foxon and Pearson, 2008). As such, the implementation of an environmental policy can internalize the costs of pollution through the use of economic and regulatory instruments (Pigou, 1932; Jaffe et al., 2005).

EIs make it possible to incorporate the environmental costs associated with its production into the price of non-renewable energy, making the "total price" of the service payable. The market-based instruments in this category are: market-based instruments, with the capacity to encourage companies to adopt the best option in terms of technology that allows them to control polluting emissions; fiscal/financial incentives that encourage the provision of competitive financing and fiscal advantages for the development of technologies that generate renewable energies; and direct investments that are investments made by the government to promote the development of the renewable energy sector (Hockenstein et al., 1997; Stavins, 2000; IEA, 2013).

Regulatory instruments include the use of laws, regulations and standards, which establish frameworks for action by society, as well as sanctions in the event of non-compliance (Daley and Preston, 2009). For environmental regulation, a regulatory body (usually a government department or agency) is usually designated to define and monitor acceptable levels of pollutant emissions into the environment. The implementation of these measures can boost the business sector in detecting organizational problems that may limit them from achieving their environmental objectives (Arjalies and Ponssard, 2010). It is important that these regulations are efficiently coordinated, have clear goals, use market mechanisms (emissions taxes, tradable allowances, performance standards), and favour innovation in the environmental sector by giving economic agents sufficient freedom to detect and use that technological solution that maximizes their benefits while complying with what has been stipulated (Porter and Van der Linde, 1995; Ambec et al., 2013).

The implementation of an innovation policy aims to provide incentives to invest in knowledge by granting direct support for scientific research that generates marketable products or processes, increasing certainty about property rights and establishing subsidies and fiscal subsidies to invest in R&D that encourage technological change to comply with environmental regulations (Ambec et al., 2013).

The policy support (PS) measure includes: (a) Strategic planning, which defines the problem to be addressed, establishes the objectives pursued, as well as strategies and measurement indicators; and (b) the creation institution, to design, coordinate, implement and evaluate the actions established (IEA, 2013; UN, 2010). According to the literature, this type of measure generates a positive impact on technological innovation in the sector in general provided that clear and long-term objectives are established on the subject, facilitate the necessary institutional changes and generate a long-term, stable and consistent scenario for its development (Foxon and Pearson, 2008).

The information and education (I&E) programmes include information provision, advice/aid implementation, performance label and professional training and qualification (IEA, 2013), which make it possible to strengthen the education of citizens regarding renewable energies and promote their consumption (Owens and Driffill, 2008). Education and dissemination of information regarding the renewable energy sector include analysis of projects and information on different renewable energy sources, as well as training and information on government incentives in this area (Sawin and Flavin, 2006). This type of measure is considered to be useful for reducing the risk of private investment in the renewable energy sector, which is why conferences are held, capacity-building is offered, and training programs are implemented that usually involve educational institutions in order to develop specific skills (planning, construction, maintenance, etc.) (Waissbein et al., 2013).

Finally, voluntary approaches (VA) refer to voluntary agreements made by private bodies in relation to environmental issues. They rely on educational initiatives and on raising the awareness of organisations and individuals who influence their behaviour; based on collaboration, self-regulated codes of conduct, and corporate responsibility (Daley and Preston, 2009). These mechanisms are based on the willingness to contribute on the part of private agents, which, however, calls into question the functioning of this measure as being too weak (Daley and Preston, 2009). The "Green tariffs" are the most popular instruments of this category (Haas et al., 2000).

The impact of the implementation of these instruments can be evaluated through the level of innovation inputs (R&D expenditures), or through their results by counting the number of inventions by the number of patents registered or even their level of commercialization. However, among these measures, patent counting stands out as a direct indicator of the level of innovation in a country, because it is a reliable measure of innovative activity at the industrial level and because it bears similarities to innovation at the regional level (Acs et al., 2002). In this regard, the number of patents offers benefits by studying environmentally friendly technological change due to its detailed classification system, which makes it possible to identify advances in well-defined technological fields (Popp, 2005). However, it is important to be aware of the limitations of this measure due to the fact that not all innovations are patented and that the number of innovations does not provide information regarding their economic impact, adaptation, or commercial value (Popp, 2005; Acs et al., 2002; Cloodt et al., 2006; Johnstone et al., 2010).

With respect to their effectiveness, there is empirical evidence in the literature that market-based instruments, such as green taxes and tradable certificates, can encourage innovation in the renewable energy sector rather than standard-setting; the promotion of R&D activities, investment incentives, fiscal and preferential tariffs, as well as the establishment of quantitative obligations also contribute to this objective (Popp, 2005; Johnstone et al., 2010). In addition, there is evidence of a positive relationship between the number of patents registered in the sector and the implementation of environmental regulation (Lanjouw and Mody, 1996; Brunnermeier and Cohen, 2003; Popp, 2005; 2006; Arimura et al., 2007; Johnstone et al., 2010; Lanoie et al., 2011).

However, their impact differs according to the specific source of renewable energy generation (wind, solar, geothermal, marine and hydro), their cost structure and level of technological maturity. For example, quantitative obligations and tradable certificates favour the development of wind energy, while direct investment incentives favour innovation for solar energy and tax incentives positively affect the renewable energy sector in general (Johnstone et al., 2010).

Furthermore, the effectiveness of the implementation of public policy instruments may vary depending on the country in which they are implemented. Developing countries may find it feasible to support their growth in the use of environmentally unfriendly technologies and thus ignore international environmental concerns and regulations, which could represent a barrier to achieving internationally established environmental goals (Akella et al., 2009). The limited use of environmentally friendly technologies by these countries is mainly due to their high cost, compared to traditional projects; and the impossibility of developing them locally, due to high financing costs arising from the perception of a higher level of risk in the energy market, the low level of trust in the authorities, a high perception of inefficiency of the regulatory framework, existence of social resilience, technical, financial, and macroeconomic risks (Sawin and Flavin, 2006; Waissbein et al., 2013; Chow et al., 2003).

In spite of this, some developing countries are interested in developing the renewable energy sector mainly due to the increase in the price of fossil fuels, their growing demand in the market and the possibility of export, as well as risks related to energy security (IRENA, 2015). However, due to cost they have had to concentrate their efforts on small-scale renewable energy projects, generally from the bioenergy, wind and solar sectors (Chow et al., 2003). For this reason, the role of the State is fundamental in encouraging the generation of technologies and increasing their competitiveness, by supporting R&D activities through the granting of subsidies or by increasing the price of fossil fuels through the establishment of taxes that discourage their consumption (Chow et al., 2003).

Finally, variables such as GDP per capita, R&D expenditure as a percentage of national GDP and changes in energy prices can also be considered as factors impacting technological innovation in the renewable energy sector. In this regard, when comparing the innovative activity of the sector between different countries, it is necessary to consider the size of their economies in relation to their population through GDP per capita (Johnstone et al., 2010), as well as the relationship between the number of patents per unit of GDP (Hascic and Migotto, 2015). It is also important to have a direct indicator of innovative activity such as R&D expenditure capable of increasing the number of patents registered (Popp, 2005). Finally, there is evidence that the number of patents in the renewable energy sector, especially the solar sector, responds positively to rising energy prices (Newell et al., 1999; Popp, 2002).

3. DATA AND MODEL SPECIFICATION

3.1. Patents

Data on the number of patents registered in the renewable energy sector are taken from the OECD statistics published online (https://stats.oecd.org/). Specifically, the analyzed database corresponds to the patent registry referring to the technological development for the mitigation of climate change through the generation, transmission or distribution of energy, which considers the renewable energy sector in general (REG) and the five sub-sectors that integrate it in particular: wind, solar (photovoltaic, thermal and hybrid), geothermal, ocean, and hydraulic. This information is provided annually and is available for the period from 1960 to 2012.

In addition, information from a total of thirty-three countries is considered, which means a total of 8,514 observations for an analysis period of 42 years (Table 3). It is important to note that the number of patents varies considerably for each year and country analyzed.

3.2. Public Policy Actions

Data on the number of public policy actions were taken directly from the International Energy Agency (IEA) (https://www.iea.org) in its portal addressing climate change, policies and measures databases, from where it is possible to obtain information per country regarding the name or title of the public policy action implemented, the year of implementation, status (in force or completed), type of policy to which it belongs, and its objective. These data are sent to the agency by each of the OECD member countries in a common format and methodology to allow international comparisons. It is published annually and considers the following sub-sectors: hydroelectricity, solid biofuels, geothermal, municipal renewable waste, wind, biomass gas, liquid biofuels, photovoltaic solar energy, solar thermal energy, tidal/wave/ocean, non-renewable municipal waste and industrial waste.

As shown in Table 1, the types of policies are grouped into six categories: EI, regulatory instruments, PS, research, development and deployment; I&E, and VA; which are in turn integrated by various specific public policy actions. The number and type of public policy actions implemented by each of the thirty-three countries analyzed in the period from 1970 to 2012 varies significantly (Annex 2). As can be seen, not all the policy instruments analyzed have been implemented by all the countries with the same frequency, since among them the most commonly used are those related to the promotion of R&D directly to the sector (RD&D) and EI.

3.3. Model Specification and Empirical Results

3.3.1. Model specification

In order to achieve the stated objectives, the equation (in its general form) used is presented below:

$$Patents_{i,t} = \alpha_i + \beta_1 Policy_{i,t} + \beta_2 R\&D_{i,t} + \beta_3 GDP_{i,t} + \beta_4 Price_{i,t} + \varepsilon_{i,t} \quad (1)$$

The sub-index i represents the number of analyzed units, in this case, the sample of thirty-three countries; where i = 1.,33; on the other hand, the sub-index t represents the time interval used in the sample, which spans 43 years, from 1970 to 2012, which means that t = 1970..., 2012. The sample of countries analyzed considers the member countries of the OECD, with the exception of Chile and Slovenia, given that it was not possible to find the necessary information concerning the public policy actions that these countries have implemented, directed towards the renewable energy sector.

With respect to the variables analyzed, the dependent variable concerning the number of patents is found in principle, which is calculated from the counting of the number of applications for patents made in the sample of countries analyzed in each of the technological areas that make up the renewable energy sector according to the OECD (wind, solar, geothermal, marine and hydraulic). On the other hand, explanatory variables are composed of a vector of public policy variables ($Policy_{i,t}$), R&D expenditures are expressed as a percentage of gross domestic product ($R\&D_{i,t}$), GDP per capita ($GDP_{i,t}$) is expressed in trillions of dollars at the same 2010 prices, as well as the annual change registered in the price of electricity ($Price_{i,t}$). Fixed effects (α_i) are introduced to account for the unobservable specific heterogeneity per country and residual variation is accounted for by the error term ($\varepsilon_{i,t}$).

The dependent variable of the present research (Patents) follows a negative binomial distribution, for this reason the equation (1) is calculated by using a model of this type, suggested for the variables that consist of counting data (such as the Poisson and negative binomial) in order to estimate the number of occurrences of an event (Maddala, 1983; Cameron and Trivedi, 1998). The analysis of this dependent variable through the implementation of a model of this nature has been previously conducted in the literature (Johnstone et al., 2010a; Johnstone et al., 2010b). Occasionally, the counting of an event is considered to be the implementation of a non-negative random variable of integer value (Johnstone et al., 2010b). In this research, an event is considered to be the registration of a patent, according to information obtained from the OECD; that is, the number of events will be equal to the number of patent applications registered per country in the technological area of the renewable energy sector.

In addition, in order to have a more specific interpretation of the selected sample per country, the historical average (1970-2012) of its per capita GDP was used as the basis. The result of this analysis

Table 1: Public policy instruments for the renewable energy sector

Economic instruments	Regulatory instruments	Policy support
Market-based instruments (GHG emission trading, green certificates, and white certificates), Fiscal/financial incentives (grants and subsidies, taxes, feed-in tariffs/premiums, loans, tax relief, and user chargers), Direct investments (funds to subnational governments, infrastructure investments, RD&D funding, and procurement rules).	Codes and standards (product standards, building codes and standards, sectoral standards, vehicle fuel-economy and emission standards), Monitoring, Obligation schemes, Other mandatory requirements, Auditing.	Strategic planning. Institutional creation.
Research, development and deployment	**Information and education**	**Voluntary approaches**
Demonstration project Research program (technology deployment and diffusion, and technology development).	Information provision, Advice/aid implementation, Performance label (endorsement label and comparison label), Professional training and qualification.	Negotiated agreements (public-private sector), Unilateral commitments (private sector), Public voluntary schemes.

Source: Own elaboration with data of IEA (2013) is divided into two sub-samples from the general sample of thirty-three countries. The first, called sub-sample 1, includes nineteen countries that are above the average obtained, while sub-sample 2 includes those countries that are below it (Table 2).

Likewise, and in order to carry out a more specific analysis of each of the energy sources that make up the renewable energy sector, such as wind, solar, geothermal, marine and hydroelectric; with respect to the impact of the public policy instruments analyzed regarding the innovative activity of each of them, the estimation of the general model and the model broken down in a particular way was then conducted. This in order to identify those public policy instruments that benefit the innovative activity of each source.

4. RESULTS AND DISCUSSION

According to the results obtained in the estimation of the general and disaggregated model, the increase in the price of electricity and the percentage of national GDP directed towards R&D activities in general, have a positive impact on the innovative activity of the renewable energy sector, which is statistically significant at 1% and 5% (Table 4). This is regardless of the level of wealth of the country or of the energy source analyzed, although with some variability according to the type of control (time, country, time/country) carried out on the heterogeneity of the estimate. These results coincide with what has been pointed out in the literature, where it is argued that the increase in the price of electricity provides incentives to increase innovation in the renewable energy sector, regardless of the level of wealth of the country; and that the R&D expenditure is determinant in the promotion of patent registration (Johnstone et al., 2008; Johnstone et al., 2010b).

Regarding the impact of GDP on innovative activity in the sector, there is an important difference according to the level of wealth of the country. For the sub-sample of countries whose historical GDP is above the average, the impact of this variable is negative; while for the sub-sample of countries below the historical average the GDP is positive (Table 4). This can be explained by considering that according to the data, there is a relative difference between the level of innovation of the countries analyzed that does not have a direct relationship with their level of wealth. In other words, countries with a GDP below the historical average, such as Korea, Latvia and Israel, show an important performance in innovation within the renewable energy sector per unit of GDP in the period analyzed. On the other hand, countries belonging to the first subgroup such as Denmark and Germany also show an important performance in the area measured by the number of patents registered per unit of historical GDP, which is even higher than that registered by countries such as the United States and Japan. These results coincide with what has been pointed out in the literature where it has been argued that countries such as Denmark, Switzerland and Austria stand out due to their important performance in this area even above richer countries (Johnstone et al., 2010b).

For its part, the number of public policy actions implemented to increase innovative activity shows a positive impact for the renewable energy sector in general terms (Table 4), which corresponds to what has been presented in the literature (Chow et al., 2003; Foxon and Pearson, 2008; Haas et al., 2011; Ambec et al., 2013). The positive relationship between these variables shows the importance of implementing these actions, regardless of the level of wealth of the country or the renewable energy source analyzed. However, the impact of each of the public policy instruments on innovative activity in each of the energy sources shows some differences.

In principle, the EI have a positive impact on the five energy sources analyzed for the first sub-sample, with a statistical significance level of 1% and 5% (Tables 4-9). According to the literature, this type of instruments (from which market-based instruments and pollution taxes stand out) are favorable in promoting innovation in the sector because they offer freedom of decision to private agents to choose low-cost options and at the same time are shown as incentives for sustaining such measures in the long term (Driesen, 2005; Ambec et al., 2013).

Table 2: Subsamples

Subsample GDP1		Subsample GDP2	
Country	***GDP per cápita (historic average)**	**Country**	***GDP per cápita (historic average)**
Luxembourg	67.4	New Zealand	23.4
Norway	64.4	Spain	23.0
Switzerland	49.4	Israel	21.9
Denmark	46.0	Greece	21.0
Sweden	38.4	Portugal	16.5
Australia	37.5	Korea	10.5
Netherlands	37.4	Czech Republic	8.6
Canada	37.3	Mexico	7.5
United States	36.9	Turkey	6.8
Austria	34.5	Slovak Republic	5.9
Belgium	33.5	Hungary	5.7
Japan	33.4	Estonia	5.3
Finland	33.0	Poland	4.8
France	32.3	Latvia	3.9
Germany	32.0		
Iceland	31.0		
Italy	29.6		
Ireland	29.0		
United Kingdom	28.7		

This differs from the results obtained for the second sub-sample. Where the EI are statistically significant at 5% for the marine energy source only, but with a negative impact (Table 8). This may be an indicator of the ineffectiveness of these instruments to reduce financing costs (the perceived risk of investment) in the market, negatively affecting the level of competitiveness of the renewable energy sector with respect to traditional energy sources and in this regard, being unable to promote technological innovation in the sector (Waissbein et al., 2013). In addition, it is important to mention that these types of instruments tend to have a political cost due to their impact on "property rightsm," so that when they are implemented their strength is diminished and they are ineffective in achieving their objective (Foxon and Pearson, 2008).

The regulatory instruments (RI) also show a positive impact on the promotion of innovative activity in all energy sources analyzed, in the case of the first sub-sample (Tables 4-9). These results coincide with what is indicated in the literature, where it is argued that these instruments favour the technological development of the sector (Ambec et al., 2013), especially for the case of the wind energy source because it is the most effective in terms of cost-benefit thermals and in this regard it is adequate for private agents to comply with the regulations imposed by the State (Popp, 2003). However, there is a risk that the innovations that are carried out by this type of instrument are only interested in complying with what has been established and no more innovations are generated (Driesen, 2005).

The results of this instrument for the second sub-sample differ. The imposed regulations show a statistically significant negative impact at 1% and 5% for wind and hydropower sources (Tables 5 and 9). This could be explained on the basis of the characteristics of the established regulations. That is, for regulations to have any impact on the target sector they must be stable and predictable, capable of establishing adequate transition periods, focusing on objectives rather than measures and accompanied by the implementation of adequate EI (Lankoski, 2010). If this is not achieved, then the regulation is incapable of making investments in the field more beneficial, limiting innovation in the sector (Porter and Van der Linde, 1995; Driesen, 2005; Chowdhury, 2010; Kriechel and Ziesemer, 2009; Ambec et al., 2013).

The PS instrument shows a positive impact in the case of wind and solar energy sources for both the first and second sub-sample, with a statistical significance level of 1% and 5% (Tables 5 and 6). This is also true for the marine and hydroelectric sources of the second sub-sample (Tables 8 and 9). The positive impact of this instrument on these sources could be due to the implementation of a long-term, stable and consistent strategic framework, which combines the creation of a long-term vision and strategic objectives for the development of a technological area, through projects aimed at developing more sustainable technological alternatives (Foxon and Pearson, 2008).

On the other hand, the RD&D demonstrate a positive impact on all energy sources analyzed, at a significant level of 1% and 5%, for the first sub-sample (Tables 5-9). This could account for the implementation of actions in the matter that are systemic, dynamic, non-linear and that consider an acceptable level of uncertainty; in order to have this impact on innovation in the sector (Foxon and Pearson, 2008). These results differ from those found in the case of the second sub-sample, where they are significant only for geothermal and hydroelectric energy sources, but for the first with a negative impact (Tables 7 and 9). This in spite of the public policy efforts that some countries have implemented in the case of renewable energy sources such as wind power in the implementation of demonstration projects and strategic planning (Espejo, 2004).

Similarly, the actions aimed at increasing I&E on topics that promote innovation in the sector according to the results have a positive impact on all energy sources analyzed, at a significant level of 1% and 5%, for the first sub-sample, but not so in the case of the second sub-sample where statistically significant results were not found (Tables 5-9). However, according to the literature, this type of instrument has proved effective for countries such as Canada (belonging to the first sub-sample) and Mexico (belonging to the second sub-sample), where training programs have been implemented with respect to environmentally friendly productive projects, which are aimed at the business sector, considering that they do not always have sufficient time and technical knowledge to identify this type of profitable opportunities (Rochon-Fabien and Lanoie, 2010; Lyon and van Hoof, 2009). The idea is that the more entrepreneurs become aware of new technologies the quicker they can spread (Popp, 2005).

Finally, the VA for the case of the first sub-sample have a positive impact for the solar energy source, but negative for the geothermal, marine and hydroelectric; with a significant level of 1% and 5% (Tables 6-9). This lack of effectiveness in renewable energy has been pointed out in the literature (Johnstone et al., 2010b). However, in the case of the second sub-sample, this instrument shows a positive impact for all energy sources analyzed with the exception of the geothermal where no statistically significant result is presented (Tables 5-9). These results could be associated with the type and scope of sanctions associated with non-compliance in these countries (Morgenstern and Pizer, 2007), which in turn depends on existing institutional and market characteristics (Johnstone et al., 2010b). This type of instrument requires the accompaniment of other policy instruments such as regulatory instruments for its effectiveness (Sawin and Flavin, 2006; Arimura et al., 2007).

5. CONCLUSIONS

The challenges posed by the ravages of climate change require that the society seriously reconsider production and consumption patterns. In this context, the innovation is a key support tool to facilitate the transition from a traditional economic dynamic to a more environmentally friendly one, which makes it possible to reduce the human environmental footprint while accelerating economic growth.

The energy sector is central to national economic growth. Increasing the efficiency of its production and consumption is key to achieving a country's economic and environmental goals. In this scenario, the promotion of the renewable energy sector is fundamental, since it allows the growing demand for energy to be satisfied from the use of more environmentally friendly sources.

However, its development on a competitive scale requires the overcoming of technical and economic barriers, even more so in lower income countries. In this regard, the State can find a window of action through which it can implement a series of actions aimed at promoting innovative activity in the sector.

This research analyzes the relationship between variables such as the price of electricity obtained from conventional sources, R&D spending, national GDP and the specific actions implemented by the government over a period of 33 years and the technological innovation of the renewable energy sector in general and of five energy sources of this type in particular: wind, solar, marine, geothermal and hydroelectric. The analysis is enhanced by breaking down public policy actions into six specific instruments: economic, regulatory, PS, R&D, education and information, and voluntary; and by dividing the sample of countries analyzed into two groups according to their average historical wealth level.

The results show that both the increase in the price of electricity obtained from conventional sources and the percentage of national GDP allocated to R&D activities have a positive impact on the number of patents registered in the renewable energy sector. This differs from the size of the national GDP, which is not determinant in this regard. In turn, the analysis confirms the importance of the implementation of public policy actions in promoting innovation in the sector regardless of the level of wealth of the country or the renewable energy source to which the efforts are directed.

The more detailed analysis of the impact of public policy enables us to observe differences in terms of the impacts of each instrument analyzed both for different energy sources and for country sub-samples. Thus, it is possible to observe that both the EI, as well as the regulatory ones and the promotion of specific R&D in the sector and the efforts to increase the I&E of the population in this respect are effective instruments in the promotion of innovation for the five renewable energy sources analyzed in those countries whose GDP is above the historical average. In these same countries it is observed that the six public policy instruments analyzed have a positive impact on the innovation of the solar energy source. The results differ significantly for the second sub-sample of countries. In this case, only the PS and voluntary actions carried out by different agents of the population constitute the policy instruments that have a positive impact on all the energy sources analyzed, with the exception of geothermal energy.

The difference in these results according to the sub-sample of countries could be explained by the experience of the most developed countries in the implementation of public policy actions aimed at promoting innovation in the renewable energy sector, as well as by the growing interest shown by the population in the matter. On the other hand, the differences found with respect to the different renewable energy sources analyzed can be explained due to the specific characteristics of each one in relation to the cost-benefit of the projects.

In this regard, the implementation of public policy actions to promote innovation in the renewable energy sector in general and in each of the sources analyzed in particular is indispensable. However, it is necessary to consider that technological innovation by its nature requires the establishment of long-term objectives regardless of the country in which it is implemented and will therefore have to deal with budgetary restrictions and adjustments, as well as changes in administration. In this regard, the implementation of each of the public policy instruments should consider long-term objectives and the use of several instruments at the same time in order to increase the chances of the proposed objectives being achieved.

REFERENCES

Acs, Z.J., Anselin, L., Varga, A. (2001), Patents and innovation counts as measures of regional production of new knowledge. Research Policy, 31(7), 1069-1085.

Akella, A.K., Saini, R.P., Sharma, M.P. (2009), Social, economical and environmental impacts of renewable energy systems. Renewable Energy, 34, 390-396.

Ambec, S., Cohen, M.A., Elgie, S., Lanoie, P. (2013), The Porter hypothesis at 20: Can environmental regulation enhance innovation and competitiveness? Review of Environmental Economics and Policy, 7(1), 2-22.

Arimura, T., Hibiki, A., Johnstone, N. (2007), An empirical study of environmental R and D: What encourages facilities to be environmentally-innovative? In: Johnstone, N., editor. Corporate Behaviour and Environmental Policy. Cheltenham, UK: Edward Elgar in Association with OECD.

Arjalies, D.L., Ponssard, J.P. (2010), A Managerial Perspective on the Porter Hypothesis: The Case of CO_2 Emissions. Paris: Ecole Polytechnique. Available from: http://www.hal.archivesouvertes.fr/docs/00/44/58/47/PDF/2010-02.pdf.

Arrow, K. (1962), Economic welfare and the allocation of resources for invention. In: The rate and Direction of Inventive Activity: Economic and Social Factors. Princeton: Princeton University Press. p609-626.

Brunnermeier, S.B., Cohen, M.A. (2003), Determinants of environmental innovation in US manufacturing industries. Journal of Environmental Economics and Management, 45, 278-293.

Cameron, A.C., Trivedi, P.K. (1998), Regression Analysis of Count Data. Cambridge, New York: Cambridge University Press.

Chow, J., Kopp, R.J., Portney, P.R. (2003), Energy resources and global development. Science, 302(5650), 1528-1531.

Chowdhury, P.R. (2010), The Porter Hypothesis and Hyperbolic Discounting. Indian Statistical Institute. Available from: http://www.eeri.eu/documents/wp/EERI_RP_2010_42.pdf.

Cloodt, M., Hagedoorn, J., Van Kranenburg, H. (2006), Mergers and acquisitions: Their effect on the innovative performance of companies in high-tech industries. Research Policy, 35(5), 642-654.

Daley, B., Preston, H. (2009), Aviation and climate change: Asssesment of policy options. In: Gössling, S., Upham, P, editors. Climate Change and Aviation: Issues, Challenges and Solutions. London: Sterling, VA: Earthscan. p347-372.

Driesen, D. (2005), Economic instruments for sustainable development. In: Wood, S., Richardson, B., editors. Environmental Law for Sustainability: A Critical Reader. Ch. 9. Oxford, UK: Hart Publications. Available from: http://www.law.syr.edu/Pdfs/0osgoodehallboo.pdf.

Espejo, C. (2004), La energía eólica en España. Investigaciones Geográficas, 35, 45-65.

Foxon, T., Pearson, P. (2008), Overcoming barriers to innovation and diffusion of cleaner technologies: Some features of a sustainable innovation policy regime. Journal of Cleaner Production, 16(1), S148-S161.

Haas, R., Panzer, C., Resch, G., Ragwitz, M., Reece, G., Held, A. (2011), A historical review of promotion strategies for electricity from renewable energy sources in EU countries. Renewable and Sustainable Energy Reviews, 15(2), 1003-1034.

Hascic, I., Migotto, M. (2015), Measuring Environmental Innovation Using Patent Data. OECD Environment Working Papers, No. 89. Paris: OECD Publishing.

Hockenstein, J.B., Stavins R.N., Whitehead, B.W. (1997), Creating the next generation of market-based environmental tools. Environment, 39(4), 12-20, 30-33.

IEA (International Energy Agency). (2013), Energy Efficiency Policy online Database. Paris: OECD-IEA Publishing.

IRENA. (2015), Energías Renovables en América Latina en 2015: Sumario de Políticas. Abu Dhabi: IRENA.

Jaffe, A.B., Newell, R.G., Stavins, R.N. (2005), A tale of two market failures: Technology and environmental policy. Ecological Economics, 54(2), 164-174.

Johnstone, N., Hascic, I., Kalamova, M. (2010a), Environmental Policy Characteristics and Technological Innovations. Economia Politica, 27(2), 275-299.

Johnstone, N., Hascic, I., Popp, D. (2008), Renewable Energy Policies and Technological Innovation: Evidence Based on Patent Counts. NBER Working Paper No. 13760.

Johnstone, N., Hascic, I., Popp, D. (2010b), Renewable energy policies and technological innovation: Evidence based on patent counts. Environmental and Resource Economics, 45(1), 133-155.

Kriechel, B., Ziesemer, T. (2009), The environmental porter hypothesis: Theory, evidence and a model of timing of adoption. Economics of Innovation and New Technology, 18(3), 267-294.

Lanjouw, J.O., Mody, A. (1996), Innovation and the international diffusion of environmentally responsive technology. Research Policy, 25, 549-571.

Lankoski, L. (2010), Linkages between Environmental Policy and Competitiveness, OECD Environment Working Papers No. 13. Available from: http://www.oecd.org/dataoecd/0/8/44392874.pdf.

Lanoie, P., Laurent-Lucchetti, J., Johnstone, N., Ambec, S. (2011), Environmental policy, innovation and performance: New insights on the Porter hypothesis. Journal of Economics and Management Strategy, 20(3), 803-842.

Lyon, T., Van Hoof, B. (2009), Evaluating Mexico Green Supply Chains Program. University of Michigan: Mimeo.

Maddala, G.S. (1983), Limited-dependent and Qualitative Variables in Econometrics. New York: Cambridge University Press.

Menanteau, P., Finon, D., Lamy, M.L. (2003), Prices versus quantities: Choosing policies for promoting the development of renewable energy. Energy Policy, 31, 799-812.

Mohr, R.D. (2002), Technical change, external economies, and the porter hypothesis. Journal of Environmental Economics and Management, 43(1), 158-168.

Mohr, R.D., Saha, S. (2008), Distribution of environmental costs and benefits, additional distortions, and the porter hypothesis. Land Economics, 84(4), 689-700.

Morgenstern, R., Pizer, W. (2007), Reality Check: The Nature and Performance of Voluntary Environmental Programs in the United States, Europe, and Japan. Washington D.C: RFF Press.

Newell, R.G., Jaffe, A.B., Stavins, R.N. (1999), The induced innovation hypothesis and energy-saving technological change. Quarterly Journal of Economics, 114, 941-975.

OECD. (2008), OECD Environmental Outlook to 2030. Paris: OECD.

OECD. (2011), Energy. OECD Green Growth Studies. OECD/IEA. Available from: http://www.oecd.org/greengrowth.

OECD. (2017), OECD DAC Rio Markers for Climate: Handbook. Paris: OECD. Available from: http://www.oecd.org/dac/environment-development/Revised%20climate%20marker%20handbook_FINAL.pdf.

Owens, S., Driffill, L. (2008), How to change attitudes and behaviours in the context of energy. Energy Policy, 36(12), 4412-4418.

Pigou, A. (1932), The Economics of Welfare. London: Macmillan.

Popp, D. (2002), Induced innovation and energy prices. American Economic Review, 92(1), 160-180.

Popp, D. (2003), Pollution control innovations and the clean air Act of 1990. Journal of Policy Analysis and Management, 22(4), 641-660.

Popp, D. (2005), Lessons from patents: Using patents to measure technological change in environmental models. Ecological Economics, 54(2), 209-226.

Popp, D. (2006), International innovation and diffusion of air pollution control technologies: The effects of NOX and SO_2 regulation in the US, Japan, and Germany. Journal of Environmental Economics and Management, 51(1), 46-71.

Porter, M.E., Van der Linde, C. (1995), Toward a new conception of the environment-competitiveness relationship. The Journal of Economic Perspectives, 9(4), 97-118.

Rochon-Fabien, A., Lanoie, P. (2010), Promoting Pollution Prevention in Small Businesses: Costs and Benefits of the "Enviroclub" Initiative. HEC Montreal: Mimeo.

Sawin, J., Flavin, C. (2006), National policy instruments: Policy lessons for the advancement and diffusion of renewable energy technologies around the world. In: Assmann, D., editor. Renewable Energy. A Global Review of Technologies, Policies and Markets. Abingdon, UK: Routledge.

Stavins, R.N. (2000), Market-based environmental policies. In: Portney, P.R., Stavins, R.N., editors. Public Policies for Environmental Protection. Washington, D.C: Resources for the Future.

Stavins, R.N. (2003), Experience with market-based environmental policy instruments. Handbook of Environmental Economics, 1, 355-435.

United Nations (UN). (2010), Trade an Environment Review. Promoting Poles of Clean Growth to Foster the Transition to a More Sustainable Economy. New York and Geneva: United Nations Conference on Trade and Development.

Waissbein, O., Glemarec, Y., Bayraktar, H., Schmidt, T.S. (2013), Derisking Renewable Energy Investment. A Framework to Support Policymakers in Selecting Public Instruments to Promote Renewable Energy Investment in Developing Countries. New York: United Nations Development Programme.

APPENDIX

Table 3: Descriptive statistics

Variable	Variable description	Obs.	Mean	SD	Min.	Max.
Country	Country number	8514	17	9.522464	1	33
Year	Range of years analyzed	8514	1991	12.4104	1970	2012
Patents	Number of renewable energy patents	8514	23.23	142.65	0	3318
PP	Number of policies	8514	1.90	1.32	1	4
Price	Electricity price (index)	8514	45.45	35.19	0	131.49
R&D	Research and development expenditure	8514	1.96	1.32	1	4
GDP	Nnatural logarithm of GDP per capita	7614	1.50	0.50	1	2
Policy instruments (intpp)						
EI	Economic instruments	8514	1.03	2.86	0	42
RI	Regulatory instruments	8514	0.56	1.51	0	16
PS	Policy support	8514	0.57	1.55	0	15
RD&D	Research	8514	0.74	3.50	0	60
I&E	Information and education	8514	0.46	1.84	0	23
VA	Voluntary approaches	8514	0.20	0.97	0	14

1 As GDP percentage
2 GDP per capita at constant 2010 prices in billions of dollars
*int: means "Intensity" which is measure in quantiles from each variable

(1) Renewable energy sector

Table 4: Total sample

Variable	Gral.	Year	Country	Year country
(a) General model				
PP	**0.4373**** (0.000)	**0.5805**** (0.000)	**0.0972**** (0.000)	**0.0217** (0.363)
Price	**0.0397**** (0.000)	**0.0403**** (0.000)	**0.0294**** (0.000)	**0.0021** (0.272)
R&D	**−0.1861**** (0.001)	**0.6690**** (0.000)	**0.1742**** (0.000)	**0.1012**** (0.009)
GDP	**0.0831** (0.416)	**0.1112** (0.311)	**−0.0244** (0.785)	**(−0.2331**** (0.004)
Obs.	1269	1269	1269	1269
Log lik.	−5222.9	−5069.6	−4397.1	−4069.8
(b) General model with the PP variable broken down into six instruments				
Price	**0.0414**** (0.000)	**0.0432**** (0.000)	**0.0292**** (0.000)	**0.0017** (0.388)
R&D	**−0.1851**** (0.002)	**0.6122**** (0.000)	**0.1856**** (0.000)	**0.1017**** (0.009)
GDP	**−0.0146** (0.890)	**(−0.0682** (0.543)	**−0.0113** (0.900)	**−0.2324**** (0.004)
Instrumentos				
EI	**0.1212**** (0.005)	**0.1909**** (0.000)	**0.0179** (0.524)	**0.0086** (0.708)
RI	**0.0773** (0.079)	**0.1721**** (0.000)	**−0.0107** (0.682)	**−0.0264** (0.198)
PS	**−0.0191** (0.705)	**0.0387** (0.472)	**0.0868**** (0.002)	**0.0359** (0.116)
RD&D	**0.2616**** (0.000)	**0.1747**** (0.002)	**−0.0205** (0.512)	**−0.0014** (0.950)
I&E	**0.1349*** (0.021)	**0.1916**** (0.000)	**0.0302** (0.294)	**−0.0101** (0.651)
VA	**0.0496** (0.415)	**0.1351*** (0.017)	**−0.0164** (0.602)	**−0.0228** (0.352)
Obs.	1269	1269	1269	1269
Log lik.	−5227.5	−5062.2	−4395.9	−4067.6

Table 4: (i) Subsamples

(a) General model				
Subsample 1				
Variable	Gral.	Year	Country	Year country
PP	**0.5894****	**0.8082****	**0.1214****	**0.0435**
	(0.000)	(0.000)	(0.000)	(0.106)
Price	**0.0445****	**0.0457****	**0.0324****	**0.0023**
	(0.000)	(0.000)	(0.000)	(0.325)
R&D	**0.1366***	**0.5111****	**0.2045****	**0.0208**
	(0.040)	(0.000)	(0.000)	(0.559)
GDP	**−1.7210****	**−1.1261****	**−0.3121****	**−0.2298****
	(0.000)	(0.000)	(0.005)	(0.002)
Obs.	807	807	807	807
Log lik.	−3590.6	−3505.3	−3019.2	−2705.5
Subsample 2				
PP	**0.114**	**0.1458***	**0.1086***	**0.0195**
	(0.073)	(0.042)	(0.020)	(0.641)
Price	**0.0303****	**−0.0079**	**0.0289****	**−0.0207****
	(0.000)	(0.254)	(0.000)	(0.000)
R&D	**0.2146**	**1.0819****	**0.058**	**0.2284***
	(0.077)	(0.000)	(0.413)	(0.013)
GDP	**0.6073****	**0.9476****	**0.8357****	**0.8829****
	(0.001)	(0.000)	(0.001)	(0.000)
Obs.	462	462	462	462
Log lik.	−1543.4	−1453.6	−1356.8	−1231.4
(b) General model with the PP variable broken down into six instruments				
Subsample 1				
Price	**0.0446****	**0.0491****	**0.0315****	**0.0015**
	(0.000)	(0.000)	(0.000)	(0.526)
R&D	**0.1967****	**0.4503****	**0.2255****	**0.0206**
	(0.005)	(0.000)	(0.000)	(0.564)
GDP	**−1.8296****	**−1.2992****	**−0.2468****	**−0.2130****
	(0.000)	(0.000)	(0.028)	(0.004)
Instrumentos				
EI	**0.1430****	**0.3196****	**0.0369**	**0.0076**
	(0.007)	(0.000)	(0.283)	(0.760)
RI	**0.1697****	**0.2286****	**0.0134**	**0.014**
	(0.001)	(0.000)	(0.650)	(0.474)
PS	**−0.0398**	**−0.0063**	**0.0786****	**0.002**
	(0.501)	(0.929)	(0.012)	(0.928)
RD&D	**0.2319****	**0.1881****	**−0.0098**	**0.0192**
	(0.000)	(0.004)	(0.767)	(0.367)
I&E	**0.1856****	**0.2250****	**0.0169**	**−0.017**
	(0.003)	(0.000)	(0.578)	(0.410)
VA	**0.0461**	**0.0952**	**−0.0780****	**−0.0533***
	(0.474)	(0.132)	(0.016)	(0.013)
Obs.	807	807	807	807
Log lik.	−3594.1	−3499.8	−3018.9	−2703.1
Subsample 2				
Price	**0.0299****	**−0.0053**	**0.0289****	**−0.0195****
	(0.000)	(0.434)	(0.000)	(0.000)
R&D	**0.2267***	**1.0726****	**0.0633**	**0.2233***
	(0.049)	(0.000)	(0.372)	(0.014)
GDP	**0.5193****	**0.8187****	**0.7789****	**0.8580****
	(0.003)	(0.000)	(0.002)	(0.000)
Instrumentos				
EI	**−0.0881**	**−0.0602**	**0.0359**	**−0.004**
	(0.247)	(0.434)	(0.517)	(0.925)
RI	**−0.1437**	**−0.0910**	**−0.0356**	**−0.0626**
	(0.053)	(0.201)	(0.491)	(0.127)
PS	**0.2102****	**0.2059****	**0.0882**	**0.0613**
	(0.006)	(0.009)	(0.103)	(0.155)
RD&D	**−0.0254**	**0.0652**	**−0.0276**	**0.02**
	(0.826)	(0.540)	(0.710)	(0.724)

(Contd...)

Table 4: ***(Continued)***

(b) General model with the PP variable broken down into six instruments				
Instrumentos				
I&E	**0.0491**	**0.0442**	**0.0426**	**−0.0039**
	(0.640)	(0.664)	(0.536)	(0.941)
VA	**0.3711****	**0.3027***	**0.1989***	**0.1203**
	(0.005)	(0.024)	(0.024)	(0.078)
Obs.	462	462	462	462
Log lik.	−1531.4	−1445.3	−1351.0	−1227.2

(2) Wind energy

Table 5: Total sample

(a) General model				
Variable	Gral.	Year	Country	Year country
PP	**0.3805****	**0.5705****	**0.1065****	**0.0326**
	(0.000)	(0.000)	(0.000)	(0.298)
Price	**0.0361****	**0.0260****	**0.0322****	**(−0.0058***
	(0.000)	(0.000)	(0.000)	(0.035)
R&D	**0.0357**	**0.7304****	**0.2448****	**0.1391****
	(0.565)	(0.000)	(0.000)	(0.008)
GDP	**0.1726**	**0.1917**	**0.1332**	**(−0.2949****
	(0.115)	(0.099)	(0.240)	(0.009)
Observations	1269	1269	1269	1269
Log like.	−3371.8	−3261.1	−2822.9	−2621.9
(b) General model with the PP variable broken down into six instruments				
Price	**0.0369****	**0.0285****	**0.0320****	**(−0.0066***
	(0.000)	(0.000)	(0.000)	(0.017)
R&D	**0.0386**	**0.6853****	**0.2576****	**0.1412****
	(0.550)	(0.000)	(0.000)	(0.007)
GDP	**0.1055**	**0.0541**	**0.1357**	**(−0.3084****
	(0.345)	(0.650)	(0.235)	(0.006)
Instrumentos				
EI	**0.1212***	**0.2337****	**0.0302**	**0.041**
	(0.012)	(0.000)	(0.362)	(0.164)
RI	**0.0527**	**0.1234***	**−0.0176**	**(−0.0533***
	(0.273)	(0.013)	(0.560)	(0.040)
PS	**0.0451**	**0.0869**	**0.0961****	**0.022**
	(0.400)	(0.133)	(0.002)	(0.437)
RD&D	**0.2041****	**0.1466***	**−0.0325**	**−0.0299**
	(0.001)	(0.018)	(0.372)	(0.311)
I&E	**0.1125**	**0.1558****	**0.0098**	**−0.0308**
	(0.062)	(0.006)	(0.766)	(0.266)
VA	**−0.024**	**0.0308**	**0.0072**	**−0.006**
	(0.702)	(0.608)	(0.842)	(0.843)
Observations	1269	1269	1269	1269
Log lik.	−3375.1	−3265.1	−2821.8	−2617.8

Table 5: (i) Subsamples

Variable	Gral.	Year	Country	Year country
		Subsample 1		
PP	**0.5569****	**0.7825****	**0.1743****	**0.0813***
	(0.000)	(0.000)	(0.000)	(0.020)
Price	**0.0424****	**0.0154****	**0.0395****	**−0.0028****
	(0.000)	(0.005)	(0.000)	(0.000)
R&D	**0.3341****	**0.6113****	**0.2628****	**0.0234**
	(0.000)	(0.000)	(0.000)	(0.635)
GDP	**−1.7045****	**−1.2116****	**−0.5103****	**−0.5829****
	(0.000)	(0.000)	(0.000)	(0.000)
Obs.	807	807	807	807
Log lik.	−2342.2	−2259.8	−1967.9	−1758.9
		Subsample 2		
PP	**0.1439***	**0.2103***	**0.0987**	**0.0389**
	(0.041)	(0.012)	(0.074)	(0.478)
Price	**0.0324****	**−0.0039**	**0.0280****	**−0.0248****
	(0.000)	(0.654)	(0.000)	(0.000)
R&D	**0.3349****	**1.0444****	**0.2249****	**0.4052****
	(0.008)	(0.000)	(0.009)	(0.001)
GDP	**0.0567**	**0.6154****	**0.6994***	**0.8687****
	(0.802)	(0.007)	(0.029)	(0.001)
Obs.	462	462	462	462
Log lik.	−968.5	−909.2	−842.6	−761.7
		(b) General model with the PP variable broken down into six instruments		
		Subsample 1		
Price	**0.0417****	**0.0177****	**0.0386****	**−0.0133****
	(0.000)	(0.002)	(0.000)	(0.000)
R&D	**0.3633****	**0.5915****	**0.2774****	**0.0251**
	(0.000)	(0.000)	(0.000)	(0.615)
GDP	**−1.6948****	**−1.2647****	**0.4520****	**−0.5491****
	(0.000)	(0.000)	(0.002)	(0.000)
		Instrumentos		
EI	**0.1795****	**0.3859****	**0.073**	**0.054**
	(0.003)	(0.000)	(0.078)	(0.092)
RI	**0.1479****	**0.1695****	**0.036**	**0.0013**
	(0.007)	(0.003)	(0.308)	(0.957)
PS	**0.0363**	**0.027**	**0.0852***	**−0.0156**
	(0.569)	(0.718)	(0.020)	(0.584)
RD&D	**0.1812****	**0.1211**	**−0.0389**	**−0.0082**
	(0.008)	(0.082)	(0.326)	(0.760)
I&E	**0.1719****	**0.2042****	**0.0023**	**−0.0219**
	(0.007)	(0.001)	(0.949)	(0.400)
VA	**−0.065**	**0.0329**	**−0.024**	**−0.0214**
	(0.335)	(0.607)	(0.533)	(0.425)
Obs.	807	807	807	807
Log lik.	−2345.0	−2265.0	−1970.1	−1759.5
		Subsample 2		
Price	**0.0317****	**−0.0014**	**0.0283****	**−0.0245****
	(0.000)	(0.864)	(0.000)	(0.000)
R&D	**0.3708****	**1.0460****	**0.2409****	**0.4009****
	(0.002)	(0.000)	(0.005)	(0.001)
GDP	**0.0271**	**0.4946***	**0.6345***	**(0.8237****
	(0.899)	(0.028)	(0.043)	(0.002)
		Instrumentos		
EI	**−0.0655**	**−0.0322**	**0.0402**	**0.025**
	(0.460)	(0.718)	(0.544)	(0.652)
RI	**−0.1598***	**−0.1153**	**−0.1199***	**−0.1328***
	(0.048)	(0.166)	(0.045)	(0.010)
PS	**0.2752****	**0.3037****	**0.1059**	**0.086**
	(0.001)	(0.001)	(0.085)	(0.099)
RD&D	**−0.0663**	**0.0263**	**−0.009**	**0.0269**
	(0.597)	(0.829)	(0.919)	(0.703)
I&E	**−0.0074**	**−0.0376**	**0.0227**	**−0.0794**
	(0.948)	(0.738)	(0.770)	(0.212)

(Contd...)

Table 5: ***(Continued)***

(b) General model with the PP variable broken down into six instruments				
Instrumentos				
VA	**0.3241***	**0.2771**	**0.1778**	**0.0986**
	(0.019)	(0.069)	(0.065)	(0.227)
Obs.	462	462	462	462
Log lik.	−958.8	−902.3	−837.4	−756.2

(3) Solar energy

Table 6: Total sample

(a) Modelo general				
Variable	**Gral.**	**Year**	**Country**	**Year country**
PP	**0.4690****	**0.6151****	**0.0878****	**−0.0032**
	(0.000)	(0.000)	(0.001)	(0.896)
Price	**0.0432****	**0.0498****	**0.0310****	**0.0051***
	(0.000)	(0.000)	(0.000)	(0.016)
R&D	**−0.2788****	**0.6805****	**0.1313****	**0.0541**
	(0.000)	(0.000)	(0.000)	(0.197)
GDP	**0.0895**	**0.2113**	**−0.135**	**−0.1418**
	(0.435)	(0.089)	(0.166)	(0.100)
Obs.	1269	1269	1269	1269
Log lik.	−4491.5	−4329.1	−3645.0	−3309.4
(b) General model with the PP variable broken down into six instruments				
Price	**0.0454****	**0.0520****	**0.0307****	**0.0047***
	(0.000)	(0.000)	(0.000)	(0.030)
R&D	**−0.2814****	**0.6173****	**0.1465****	**0.0515**
	(0.000)	(0.000)	(0.000)	(0.221)
GDP	**−0.0239**	**−0.0149**	**−0.122**	**−0.1402**
	(0.840)	(0.907)	(0.216)	(0.106)
Instrumentos				
EI	**0.1267****	**0.2137****	**0.0198**	**−0.0039**
	(0.007)	(0.000)	(0.504)	(0.868)
RI	**0.0776**	**0.1837***	**0.0059**	**−0.0143**
	(0.110)	(0.000)	(0.831)	(0.501)
PS	**−0.0494**	**−0.0246**	**0.0731***	**0.0076**
	(0.376)	(0.686)	(0.012)	(0.747)
RD&D	**0.2950****	**0.1923****	**−0.0249**	**−0.0055**
	(0.000)	(0.002)	(0.450)	(0.819)
I&E	**0.1396***	**0.2112****	**0.0088**	**−0.0257**
	(0.032)	(0.000)	(0.774)	(0.272)
VA	**0.0933**	**0.2150****	**−0.0235**	**−0.0074**
	(0.170)	(0.001)	(0.475)	(0.767)
Obs.	1269	1269	1269	1269
Log lik.	−4494.8	−4315.4	−3645.3	−3308.0

Table 6: (i) Subsamples

(a) General model				
Subsample 1				
Variable	Gral.	Year	Country	Year country
PP	**0.6261****	**0.8693****	**0.1038****	**0.0297**
	(0.000)	(0.000)	(0.002)	(0.285)
Price	**0.0488****	**0.0572****	**0.0288****	**−0.0014**
	(0.000)	(0.000)	(0.000)	(0.539)
R&D	**0.1091**	**0.5273****	**0.1684****	**−0.0197**
	(0.124)	(0.000)	(0.000)	(0.600)
GDP	**−1.9667****	**−1.3338****	**−0.1566**	**−0.075**
	(0.000)	(0.000)	(0.198)	(0.343)
Obs.	807	807	807	807
Log lik.	−3146.0	−3059.9	−2570.9	−2236.2
Subsample 2				
PP	**0.120**	**0.1515**	**0.0948***	**−0.0418**
	(0.085)	(0.057)	(0.047)	(0.340)
Price	**0.0339****	**−0.0027**	**0.0342****	**(−0.019****
	(0.000)	(0.735)	(0.000)	(0.000)
R&D	**0.0907**	**1.1211****	**−0.044**	**0.1249**
	(0.495)	(0.000)	(0.569)	(0.223)
GDP	**1.0813**	**1.1477****	**0.9354****	**1.1052****
	(0.000)	(0.000)	(0.000)	(0.000)
Obs.	462	462	462	462
Log lik.	−1246.9	−1176.6	−1058.3	−952.6
(b) General model with the PP variable broken down into six instruments				
Subsample 1				
Price	**0.0494****	**0.0629****	**0.0276****	**−0.0022**
	(0.000)	(0.000)	(0.000)	(0.358)
R&D	**0.1835***	**0.4454****	**0.1854****	**−0.0229**
	(0.016)	(0.000)	(0.000)	(0.541)
GDP	**−2.1472****	**−1.5682****	**−0.0899**	**−0.0577**
	(0.000)	(0.000)	(0.463)	(0.469)
Instrumentos				
EI	**0.1381***	**0.3524****	**0.0264**	**0.0008**
	(0.015)	(0.000)	(0.468)	(0.975)
RI	**0.1754****	**0.2471***	**0.028**	**0.0354**
	(0.001)	(0.000)	(0.379)	(0.082)
PS	**−0.0751**	**−0.0492**	**0.0843***	**−0.0004**
	(0.246)	(0.541)	(0.012)	(0.983)
RD&D	**0.2512****	**0.2141****	**−0.0049**	**0.0171**
	(0.001)	(0.003)	(0.889)	(0.436)
I&E	**0.1969****	**0.2483****	**−0.0065**	**−0.0335**
	(0.005)	(0.000)	(0.843)	(0.121)
VA	**0.1146**	**0.1849****	**(−0.0859***	**(−0.0461***
	(0.108)	(0.010)	(0.013)	(0.037)
Obs.	807	807	807	807
Log lik.	−3148.2	−3047.9	−2568.7	−2232.2
Subsample 2				
Price	**0.0339****	**−0.0011**	**0.0341****	**(−0.0182****
	(0.000)	(0.882)	(0.000)	(0.000)
R&D	**0.0855**	**1.1333****	**−0.0458**	**0.1384**
	(0.500)	(0.000)	(0.555)	(0.173)
GDP	**0.9797****	**1.0302****	**0.8961****	**1.0896****
	(0.000)	(0.000)	(0.001)	(0.000)
Instrumentos				
EI	**−0.1299**	**−0.0807**	**0.042**	**−0.0459**
	(0.118)	(0.368)	(0.479)	(0.333)
RI	**−0.1253**	**−0.0772**	**−0.005**	**−0.0611**
	(0.124)	(0.332)	(0.926)	(0.158)
PS	**0.1819***	**0.1279**	**0.0565**	**0.0376**
	(0.027)	(0.155)	(0.313)	(0.398)
RD&D	**0.0085**	**0.1105**	**−0.0379**	**0.0311**
	(0.946)	(0.357)	(0.622)	(0.595)

(Contd...)

Table 6: *(Continued)*

(b) General model with the PP variable broken down into six instruments				
Instrumentos				
I&E	**0.1295**	**0.147**	**0.0376**	**0.0295**
	(0.263)	(0.208)	(0.599)	(0.593)
VA	**0.3615***	**0.3187***	**0.1615**	**0.08**
	(0.012)	(0.029)	(0.071)	(0.242)
Obs.	462	462	462	462
Log lik.	−1236.4	−1168.6	−1054.9	−950.1

(4) Geothermal energy

Table 7: Muestra total

(a) General model				
Variable	**Gral.**	**Year**	**Country**	**Year country**
PP	**0.4282****	**0.6900****	**0.1438****	**0.1413****
	(0.000)	(0.000)	(0.002)	(0.007)
Price	**0.0310****	**0.0355****	**0.0349****	**0.0141****
	(0.000)	(0.000)	(0.000)	(0.002)
R&D	**−0.1844***	**0.8115****	**0.0197**	**0.1123**
	(0.035)	(0.000)	(0.742)	(0.260)
GDP	**−0.0770**	**−0.0578**	**−0.6445**	**−1.0294****
	(0.641)	(0.744)	(0.000)	(0.000)
Obs.	1269	1269	1269	1269
Log lik.	−1533.6	−1461.8	−1144.8	−1081.7
(b) General model with the PP variable broken down into six instruments				
Price	**0.0341****	**0.0408****	**0.0342****	**0.0132****
	(0.000)	(0.000)	(0.000)	(0.004)
R&D	**−0.1858***	**0.7048****	**0.0543**	**0.1144**
	(0.042)	(0.000)	(0.377)	(0.260)
GDP	−0.2418	−0.3057	(−0.6445**	(−1.0766**
	(0.148)	(0.089)	(0.000)	(0.000)
Instrumentos				
EI	**0.0073**	**0.1242**	**0.013**	**0.0273**
	(0.918)	(0.136)	(0.797)	(0.587)
RI	**0.1460***	**0.2691****	**0.0665**	**0.0843**
	(0.030)	(0.000)	(0.137)	(0.052)
PS	**−0.0895**	**−0.0619**	**0.0782**	**0.03**
	(0.259)	(0.482)	(0.107)	(0.539)
RD&D	**0.2937****	**0.2268***	**−0.0331**	**−0.0353**
	(0.001)	(0.010)	(0.524)	(0.473)
I&E	**0.1944***	**0.2684****	**−0.0007**	**−0.0237**
	(0.036)	(0.002)	(0.987)	(0.614)
VA	**0.0814**	**0.1472**	**−0.0355**	**−0.0203**
	(0.387)	(0.088)	(0.498)	(0.682)
Obs.	1269	1269	1269	1269
Log lik.	−1528.5	−1455.5	−1146.2	−1082.5

Table 7: (i) Subsamples

Variable	Gral.	Year	Country	Year country
(a) General model				
Subsample 1				
PP	**0.5995****	**0.9540****	**0.1854****	**0.2445****
	(0.000)	(0.000)	(0.000)	(0.000)
Price	**0.0308****	**0.0262****	**0.0310****	**0.0118***
	(0.000)	(0.000)	(0.000)	(0.016)
R&D	**0.0649**	**0.7062****	**0.0545**	**0.1466**
	(0.518)	(0.000)	(0.418)	(0.117)
GDP	**−1.3736****	**−0.6022***	**−0.3772**	**−0.2372**
	(0.000)	(0.033)	(0.057)	(0.224)
Obs.	807	807	807	807
Log lik.	−1147.4	−1089.7	−866.1	−799.5
Subsample 2				
PP	**−0.037**	**0.1016**	**0.0279**	**0.1004**
	(0.792)	(0.552)	(0.800)	(0.353)
Price	**0.0231****	**−0.0216**	**0.0298****	**−0.0128**
	(0.004)	(0.260)	(0.000)	(0.419)
R&D	**0.4107***	**1.3845****	**−0.1336**	**−0.0663**
	(0.043)	(0.000)	(0.399)	(0.821)
GDP	**1.6636****	**2.0614****	**2.1541**	**3.0737****
	(0.000)	(0.000)	(0.000)	(0.000)
Obs.	462	462	462	462
Log lik.	−338.3	−311.3	−264.0	−233.1
(b) General model with the PP variable broken down into six instruments				
Subsample 1				
Price	**0.0318****	**0.0292****	**0.0288****	**0.0087**
	(0.000)	(0.000)	(0.000)	(0.080)
R&D	**0.1271**	**0.6467****	**0.0909**	**0.1328**
	(0.213)	(0.000)	(0.180)	(0.160)
GDP	**−1.4930****	**−0.7504****	**−0.2057**	**−0.1737**
	(0.000)	(0.007)	(0.305)	(0.384)
Instrumentos				
EI	**0.0462**	**0.2395***	**0.0096**	**0.0129**
	(0.574)	(0.022	(0.861)	(0.810)
RI	**0.2854****	**0.3922****	**0.0888**	**0.1209****
	(0.000)	(0.000)	(0.060)	(0.005)
PS	**−0.1706**	**−0.0691**	**0.0596**	**0.0143**
	(0.053)	(0.473)	(0.246)	(0.765)
RD&D	**0.3357****	**0.2621***	**0.043**	**0.0481**
	(0.001)	(0.006)	(0.402)	(0.313)
I&E	**0.2103***	**0.2472****	**−0.0155**	**−0.0092**
	(0.027)	(0.008)	(0.755)	(0.842)
VA	**0.0198**	**0.0601**	**−0.1204***	**−0.0768**
	(0.837)	(0.510)	(0.022)	(0.102)
Obs.	807	807	807	807
Log lik.	−1140.2	−1086.4	−866.7	−803.0
Subsample 2				
Price	0.0224*	−0.0174	0.0273**	−0.0142
	(0.040)	(0.351)	(0.000)	(0.338)
R&D	0.3908**	1.2869**	−0.127	−0.0521
	(0.000)	(0.000)	(0.414)	(0.853)
GDP	1.5478**	1.9173**	2.2888**	3.2949**
	(0.000)	(0.000)	(0.000)	(0.000)
Instrumentos				
EI	**−0.2515**	**−0.0925**	**0.0395**	**0.1587**
	(0.144)	(0.633)	(0.774)	(0.199)
RI	−0.0853	−0.0567	0.043	0.1081
	(0.557)	**(0.736)**	**(0.714)**	**(0.264)**
PS	0.1888	0.1524	0.0529	0.077
	(0.249)	(0.437)	(0.658)	(0.479)
RD&D	**0.3677**	**−0.2859**	**−0.4689***	**−0.4739***
	(0.124)	(0.264)	(0.022)	(0.010)

(Contd...)

Table 7: ***(Continued)***

(b) General model with the PP variable broken down into six instruments				
Instrumentos				
I&E	**0.0996**	**0.1297**	**−0.0179**	**−0.1128**
	(0.618)	(0.541)	(0.907)	(0.400)
VA	**0.3833**	**0.3937**	**0.2387**	**0.267**
	(0.106)	(0.135)	(0.191)	(0.076)
Obs.	462	462	462	462
Log lik.	−332.5	−308.6	−260.6	−228.2

(5) Marine energy

Table 8: Total sample

(a) General model				
Variable	**Gral.**	**Year**	**Country**	**Year country**
PP	**0.3875****	**0.5353****	**0.1522****	**0.057**
	(0.000)	(0.000)	(0.000)	(0.096)
Price	**0.0221****	**0.0160****	**0.0315****	**0.0158****
	(0.000)	(0.000)	(0.000)	(0.000)
R&D	**0.047**	**0.5787****	**0.1098***	**−0.0342**
	(0.493)	(0.000)	(0.014)	(0.588)
GDP	**0.1967**	**0.4389****	**−0.1966**	**−0.0015**
	(0.107)	(0.000)	(0.108)	(0.991)
Obs.	**1269**	**1269**	**1269**	**1269**
Log lik.	−2135.6	−2036.4	−1658.6	−1530.0
(b) General model with the PP variable broken down into six instruments				
Price	**0.0235****	**0.0182****	**0.0308****	**0.0148****
	(0.000)	(0.000)	(0.000)	(0.000)
R&D	**0.0286**	**0.5492****	**0.1457**	**−0.0223**
	(0.693)	(0.000)	(0.001)	(0.725)
GDP	**0.0875**	**0.2837***	**(−0.2213**	**−0.0359**
	(0.480)	(0.024)	(0.074)	(0.778)
Instrumentos				
EI	**0.0561**	**0.1268***	**0.0467**	**0.0265**
	(0.298)	(0.036)	(0.193)	(0.426)
RI	**0.1206***	**0.1793****	**0.0494**	**0.0067**
	(0.021)	(0.001)	(0.120)	(0.811)
PS	**0.0333**	**0.0833**	**0.0637**	**0.0014**
	(0.584)	(0.202)	(0.068)	(0.963)
RD&D	**0.1624***	**0.1149**	**(−0.0740***	**(−0.0733***
	(0.017)	(0.078)	(0.043)	(0.017)
I&E	**0.1789****	**0.2315****	**0.0616**	**0.0173**
	(0.008)	(0.000)	(0.069)	(0.559)
VA	**−0.0053**	**0.0492**	**−0.0553**	**−0.0306**
	(0.939)	(0.451)	(0.132)	(0.324)
Obs.	1269	1269	1269	1269
Log lik.	−2137.3	−2031.3	−1658.6	−1527.5

Table 8: (i) Subsamples

Variable	Gral.	Year	Country	Year country
(a) General model				
Subsample 1				
PP	**0.4920****	**0.6918****	**0.1761****	**0.0813***
	(0.000)	(0.000)	(0.000)	(0.037)
Price	**0.0221****	**0.00007**	**0.0316****	**0.0096****
	(0.000)	(0.987)	(0.000)	(0.009)
R&D	**0.1783***	**0.2586***	**0.0733**	**−0.1092**
	(0.037)	(0.013)	(0.154)	(0.070)
GDP	**−0.8607****	**−0.5842****	**−0.169**	**−0.1626**
	(0.000)	(0.003)	(0.257)	(0.207)
Obs.	807	807	807	807
Log lik.	−1550.1	−1480.4	−1197.8	−1071.1
Subsample 2				
PP	**0.2109***	**0.3001****	**0.2060****	**0.0895**
	(0.011)	(0.003)	(0.001)	(0.194)
Price	**0.0249****	**−0.0125**	**0.0282****	**(−0.0219***
	(0.000)	(0.286)	(0.000)	(0.010)
R&D	**0.2802**	**0.8459****	**0.1036**	**−0.0614**
	(0.059)	(0.000)	(0.344)	(0.731)
GDP	**(0.9429****	**1.1863****	**1.0528**	**1.2947****
	(0.000)	(0.000)	(0.007)	(0.000)
Obs.	462	462	462	462
Log lik.	−537.2	−505.9	−454.7	−407.6
(b) General model with the PP variable broken down into six instruments				
Subsample 1				
Price	**0.0221**	**0.0182****	**0.0299****	**0.0085***
	(0.058)	(0.000)	(0.000)	(0.020)
R&D	**−0.8784****	**0.5492****	**0.1119***	**−0.0965**
	(0.000)	(0.000)	(0.031)	(0.106)
GDP	**−0.4746***	**0.2837***	**−0.0687**	**−0.1097**
	(0.034)	(0.024)	(0.647)	(0.396)
Instrumentos				
EI	**0.1257**	**0.2435****	**0.0976***	**0.0734***
	(0.052)	(0.002)	(0.022)	(0.047)
RI	**0.1969****	**0.2222****	**0.0456**	**0.0298**
	(0.001)	(0.000)	(0.218)	(0.321)
PS	**0.0247**	**0.0416**	**0.0449**	**−0.0166**
	(0.725)	(0.598)	(0.262)	(0.618)
RD&D	**0.1997***	**0.1736***	**−0.0409**	**(−0.0576**
	(0.010)	(0.019)	(0.293)	(0.061)
I&E	**0.1639***	**0.2160****	**0.039**	**0.0102**
	(0.026)	(0.002)	(0.291)	(0.735)
VA	**−0.1246**	**−0.0168**	**(−0.13****	**(−0.0686***
	(0.107)	(0.811)	(0.001)	(0.024)
Obs.	807	807	807	807
Log lik.	−1547.0	−1472.9	−1195.4	−1066.1
Subsample 2				
Price	**0.0248****	**−0.0089**	**0.0285****	**(−0.0216****
	(0.000)	(0.431)	(0.000)	(0.007)
R&D	**0.2861***	**0.8396****	**0.1126**	**(−0.0186**
	(0.042)	(0.000)	(0.285)	(0.914)
GDP	**0.8784****	**1.0798****	**1.0406****	**1.3414****
	(0.000	(0.000)	(0.005)	(0.000)
Instrumentos				
EI	**−0.168**	**−0.1118**	**−0.0483**	**(−0.1372***
	(0.101)	(0.311)	(0.513)	(0.038)
RI	**0.0319**	**0.0564**	**0.0908**	**0.0098**
	(0.717)	(0.563)	(0.138)	(0.853)
PS	**0.2527***	**0.2370***	**0.1422***	**0.121***
	(0.010)	(0.032)	(0.032)	(0.036)
RD&D	**−0.07**	**−0.0532**	**−0.1227**	**(−0.0720**
	(0.612)	(0.710)	(0.183)	(0.315)

(Contd...)

Table 8: ***(Continued)***

(b) General model with the PP variable broken down into six instruments				
Instrumentos				
I&E	**0.1081**	**0.2351**	**0.0956**	**0.0936**
	(0.390)	(0.072)	(0.212)	(0.136)
VA	**0.4006****	**0.3585***	**0.2425***	**0.1593***
	(0.008)	(0.024)	(0.010)	(0.039)
Obs.	462	462	462	462
Log lik.	−528.5	−498.4	−448.1	−400.3

(6) Hydro energy

Table 9: Total sample

Variable	Gral.	Year	Country	Year country
(a) General model				
PP	**0.2867****	**0.4390****	**0.0466**	**−0.0113**
	(0.000)	(0.000)	(0.099)	(0.729)
Price	**0.0298****	**0.0308****	**0.0270****	**0.0146****
	(0.000)	(0.000)	(0.000)	(0.000)
R&D	**0.009**	**0.6390****	**0.1125****	**0.1577****
	(0.871)	(0.000)	(0.003)	(0.007)
GDP	**−0.0986**	**−0.2138**	**0.1266**	**−0.0465**
	(0.347)	(0.057)	(0.214)	(0.694)
Obs.	1269	1269	1269	1269
Log lik.	−2788.2	−2725.2	−2231.3	−2162.7
(b) General model with the PP variable broken down into six instruments				
Price	**0.0312****	**0.0327****	**0.0269****	**0.0145****
	(0.000)	(0.000)	(0.000)	(0.000)
R&D	**−0.0081**	**0.5895****	**0.1138****	**0.1559****
	(0.888)	(0.000)	(0.003)	(0.008)
GDP	**−0.1908**	**−0.3774****	**0.1351**	**−0.0334**
	(0.075)	(0.001)	(0.188)	(0.780)
Instrumentos				
EI	**0.0626**	**0.1116***	**0.0038**	**−0.0167**
	(0.211)	(0.041)	(0.902)	(0.596)
RI	**0.0536**	**0.1529****	**−0.0138**	**−0.0256**
	(0.239)	(0.002)	(0.623)	(0.357)
PS	0.0035	0.0882	0.0468	0.0194
	(0.947)	(0.125)	(0.122)	(0.526)
RD&D	**0.1775****	**0.1721****	**0.0275**	**0.0485**
	(0.003)	(0.005)	(0.408)	(0.130)
I&E	**0.1118**	**0.1307***	**0.0204**	**−0.0054**
	(0.061)	(0.023)	(0.512)	(0.858)
VA	**0.0409**	**0.034**	**−0.0311**	**−0.0305**
	(0.509)	(0.574)	(0.353)	(0.346)
Obs.	1269	1269	1269	1269
Log lik.	−2783.9	−2717.1	−2229.4	−2160.6

Table 9: (i) Subsamples

Variable	Gral.	Year	Country	Year country
(a) General model				
Subsample 1				
PP	**0.4555****	**0.6211****	**0.1138****	**0.0542**
	(0.000)	(0.000)	(0.001)	(0.144)
Price	**0.0344****	**0.0318****	**0.0301****	**0.0184****
	(0.000)	(0.000)	(0.000)	(0.000)
R&D	**0.0901**	**0.3468****	**0.0356**	**−0.0626**
	(0.183)	(0.000)	(0.387)	(0.238)
GDP	**−1.1860****	**−0.8173****	**−0.0779**	**0.0641**
	(0.000)	(0.000)	(0.510)	(0.569)
Obs.	807	807	807	807
Log lik.	−1923.1	−1892.0	−1525.3	−1459.9
Subsample 2				
PP	**0.1214**	**0.1499**	**0.0473**	**−0.0753**
	(0.132)	(0.132)	(0.431)	(0.177)
Price	**0.0255****	**−0.0017**	**0.0239****	**−0.0194****
	(0.000)	(0.854)	(0.000)	(0.003)
R&D	**0.336***	**1.4643**	**0.1221**	**0.4886****
	(0.017)	(0.000)	(0.195)	(0.003)
GDP	**−1.1051**	**0.1817**	**0.6333**	**0.7769****
	(0.687)	(0.504)	(0.051)	(0.003)
Obs.	462	462	462	462
Log lik.	−822.5	−766.2	−684.6	−610.2
(b) General model with the PP variable broken down into six instruments				
Subsample 1				
Price	**0.0354****	**0.0328****	**0.0292****	**0.0172****
	(0.000)	(0.000)	(0.000)	(0.000)
R&D	**0.0827**	**0.2858****	**0.0457**	**−0.0664**
	(0.225)	(0.002)	(0.269)	(0.214)
GDP	**(−1.2344****	**(−0.9132****	**−0.0371**	**0.0669**
	(0.000)	(0.000)	(0.755)	(0.557)
Instrumentos				
EI	**0.1105**	**0.1780***	**0.0392**	**−0.0021**
	(0.073)	(0.015)	(0.276)	(0.951)
RI	**0.1749****	**0.2377****	**0.0404**	**0.0439**
	(0.001)	(0.000)	(0.187)	(0.121)
PS	**−0.0237**	**0.06**	**0.052**	**0.0167**
	(0.694)	(0.377)	(0.106)	(0.594)
RD&D	**0.2296****	**0.2322****	**0.0353**	**0.0448**
	(0.000)	(0.001)	(0.275)	(0.136)
I&E	**0.1301***	**0.1576***	**−0.0017**	**−0.0137**
	(0.039)	(0.013)	(0.955)	(0.639)
VA	**−0.031**	**−0.0241**	**(−0.0822***	**−0.0481**
	(0.629)	(0.701)	(0.011)	(0.100)
Obs.	**807**	**807**	**807**	**807**
Log lik.	−1913.9	−1878.6	−1522.7	−1457.5
Subsample 2				
Price	**0.0243****	**0.0012**	**0.0241****	**(−0.0196****
	(0.000)	(0.899)	(0.000)	(0.002)
R&D	**0.3746****	**1.4012****	**0.1389**	**0.5217****
	(0.005)	(0.000)	(0.136)	(0.002)
GDP	**−0.1366**	**0.0527**	**0.5696**	**0.7583****
	(0.579)	(0.845)	(0.071)	(0.003)
Instrumentos				
EI	**−0.0604**	**−0.0708**	**−0.0064**	**−0.0969**
	(0.562)	(0.506)	(0.927)	(0.099)
RI	**−0.1467**	**−0.1212**	**−0.0759**	**(−0.1136***
	(0.094)	(0.181)	(0.219)	(0.024)

(Contd...)

Table 9: ***(Continued)***

(b) General model with the PP variable broken down into six instruments				
Instrumentos				
PS	**0.2235***	**0.2075***	**0.0483**	**0.0231**
	(0.028)	(0.046)	(0.473)	(0.672)
RD&D	**−0.0154**	**0.1359**	**0.0538**	**0.1506***
	(0.912)	(0.328)	(0.568)	(0.050)
I&E	**−0.0606**	**−0.0482**	**0.0238**	**−0.0515**
	(0.642)	(0.712)	(0.774)	(0.435)
VA	**0.4122****	**0.3576***	**0.2305***	**0.1078**
	(0.008)	(0.030)	(0.026)	(0.213)
Obs.	462	462	462	462
Log lik.	−814.6	−760.6	−680.0	−604.8