Consumers Behind Solar Energy: A Case Study of Households' Demand for Four OECD Countries

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We investigate households' demand for solar energy in France, Germany, Italy and US, using a loglinear demand for each, and a combined panel data, with fixed effects, for 2000-2012. The dependent variable is household's installed solar panels; whereas the independent variables are income, price of solar panels, interest rate, representing the cost of financing of a project, and price of "traditional energy." With R^2 being 0.9, all coefficients having expected theoretical signs and statistical significance in all specifications, our model can be generalized for other countries' households' solar demand. This is a major contribution to the theoretical and empirical literature.

INTRODUCTION

There is evidence that the rise in carbon emission results in global warming since it depletes the ozone layer (Birol, 2010). One-third of the total global emissions is attributed to fossil-fuel powered electricity, while approximately 25 percent of the global emissions comes from power plants that burn coal. Solar energy only compounds 0.08-0.2 pounds of carbon dioxide. Although Dincer (2000) argues that the manufacturing of appliances that harness solar power such as solar panels have some adverse environmental impact. The overall benefits from solar energy outweigh its limitations.

Numerous studies have shown that the demand for solar energy in the Organization for Economic Cooperation and Development (OECD) jurisdictions has risen by an average of 30 percent over the past two decades.

Collectively, the 35 countries of the OECD have invested in solar energy capacity and pursued various policies to encourage households and businesses to use solar energy. Over 20,000 households in ten OECD countries have embraced the use of green energy of which 47 percent of households use solar appliance (Sims and Gregory, 2003). Yet, many scholars believe that governments still need to adopt more favorable polices and regulations to encourage households' demand for solar energy. Some OECD countries have stepped up their efforts in that direction. For example, Australia, Italy and Germany have taken initiatives to provide every home with smart electricity meters by the end of 2020 to enable households to monitor their use of clean energy (Apergis and Payne, 2010), of which solar is the most common type. In France, there has been a sustained increase in demand for solar power steadily. For our research, we have focused on the solar demand for the top four users among the OECD countries: Germany, US, Italy and France.

In the following five sections, we review the pertinent current literature, followed by presentation of our theoretical model, then describe our data, their sources and years considered, as well as regression results and analysis; and in conclusion, we offer a summary of our findings and suggestion for the extension of this research for future studies.

LITERATURE REVIEW

Recent research shows that over 20,000 households in ten OECD countries have embraced the use of green energy in their homes. More specifically 40 percent of the households use photovoltaic appliances to harness solar power (Sims and Gregory, 2003). In Mexico, the government has rolled out a photovoltaic rural electrification program. Research estimates that up to 40,000 households are to benefit from that program.

According to Sardorsky (2009), energy is the most heavily funded sector in OECD countries. This is to accentuate the process of implementation of sustainable energy systems such as non-polluting end-user appliances. In doing so, the state will have to afford further support for research and development. Several scholars are in agreement that governments ought to put in place favorable policies and regulation that are targeted to increasing demand for solar energy. Such public policies could include favorable tax policies, among others, to create a framework that integrates local regulatory systems and the cost of installation. Such actions could induce elaborate investment strategies. In addition, some countries in the OECD area, such as Australia, Italy and Germany have taken initiatives to provide every home with smart electricity meters by the end of 2020. These smart meters also incorporate clean energy use such as solar energy. It is argued that such smart meters will enable households to monitor their level of energy consumption and adjust to the desired level (Apergis, et al., 2010).

According to International Energy Agency (IEA), the use of infinite and inexpensive clean energy such as solar energy comes with great long-term benefits anywhere. One major benefit of solar energy would be higher energy security for OECD members since solar provides an indigenous and, most importantly, an inexhaustible resource. It is a scientific fact that the sustainability and non-polluting aspect of solar energy lowers the cost of alleviating global warming and keeps the prices of fossil fuel at the minimum level (Pedroni, 2001).

There has been a sustained increase in demand for solar power in France as well as the other three counties in our data.

France, as a country, over the years has moved towards more environmentally sustainable sources of power. The change has risen as firms associated with the production of nuclear energy have continued to struggle with meeting their operational costs. France has for a long time relied on nuclear energy as a source of power, although the industry has not performed well in terms of revenues. A more viable alternative had become a necessity. Data from Réseau de Transport d'Electricité (RTE), which is the grid operator in France, has shown solar power coverage to be slightly over nine percent of the total energy demand in the country (Masson, Bonhomme, Salagnac, Briottet, & Lemonsu, 2014). That is a significant use of solar for France, in fact the highest level ever until then.

The rising use of solar energy has shown no signs of slowing down as the improved economics of solar power generation have made it more viable as a venture. The condition is necessary as it serves a basis for attracting investors, and consequently advancing progress towards fighting against global warming. This change comes at a time when the country is seeking to cut back its nuclear power production from 75 to 50 percent, while boosting its use of more solar energy.

Italy has a very high solar capacity compared to China, Japan and US combined. For instance, it was the world's top PV cells market in 2011. Italy also has been in the forefront of the production of solar energy over the years, as the campaign for clean energy has steadily spread across various counties. However, much can be credited to its system of incentives in the solar energy industry, which has given it an upper hand against other energy types and thus a competitive advantage. Some factions have claimed that "incentives" have destabilized the energy industry by making other producers less competitive.

The success of the Italian solar market has been partly due to the subsidies and other preferential policies accorded to the industry. Discussion of the details of such polices are beyond the scope of this review. The rising trend in the use of solar power is due to the fact that increased subsidies have led to substantial decreases in the prices of PV cells and consequently stimulating the uptake of the technology. As the capacity tripled in 2010 to 3.47 GW, the value of incentives climbed to €800 million (Brown, 2013).

Aside from the effect of subsidies, households gain a tax advantage from using solar energy (Birol, et al, 2010) suggests that the use of solar energy adds value to household's property devoid of tax liability since most states in the OECD area exempt energy appliances from taxation. Sims et al. (2003) suggest that, generation of electricity through the solar energy is at its peak during the day when the cost of electricity is highest. It has been argued that the cost of solar power is expected to fall below retail electricity rates in numerous OECD countries (Birol, et.al, 2010). This is due to the fact that solar energy appliances have become more affordable with time. For instance in Italy, research shows that the number of solar panels purchased in 2013 increased by twenty percent since the previous year. The number of solar panel producing companies has been on the rise in most OECD countries, putting a downward pressure on the price of solar panels. Dincer, et al., 2000, suggest that the government also plays a big role in ensuring that the solar energy appliances are affordable by providing subsidies to their manufacturers. That also has lowered the cost of production and thereafter prices. Sadorsky, et al., 2009, points out the pricey installation of solar energy appliances as why they have remained expensive.

Pedroni (2001), predicts immense solar-power buildup in most OECD countries, providing green energy electricity for millions of households. Case in point is the world largest solar power plant in California, USA, with an annual capacity for powering more than 4500 homes.

According to Apergis, et al., 2010, the solar industries in the OECD area are facing alarming scarcity of photovoltaic panels. The oversupply of solar appliances has pushed prices downwards, increasing the competitiveness of the solar power, although, it has resulted in bankruptcy for most manufacturers and depressed capital investment by survivors. The looming scarcity is also contributed to the rise in demand of solar energy in most of these countries. According to Johnstone and Popp (2010), solar power industry in most OECD countries set up nearly 56 Gigawatts, and projected then to have another 64 Gigawatts by 2015. According to a Morgan Stanley report in 2014, the demand is expected to grow in leaps and bounds by an average of 50 gigawatts per year with the lion share of 40 gigawatts going to six markets: US, Germany, Italy, Japan, France and Denmark.

The upsurge in use of solar energy is coupled with the end of cheap oil. Neij (1997) notes the end of cheap oil, foreseeing the price per barrel of oil keep rising due to more sophisticated means of oil extraction that are expected to be adopted in the future. Neij further purports that in the years to come; oil will be produced in more severe environments. As a result, he suggests that it will be hard to maintain its price below USD 65 per barrel. Tahvonen and Salo (2001) argue that most countries especially within the OECD area expect to increase their reliance on non-fossil fuel in the decades to come.

Scholars claim that the shortage risk and volatile prices provide enough motives to abandon the use of fossil fuel in favor of clean solar energy (Jacobsson and Johnson, 2000; Popp and Medhi, 2011). However, other scholars argue that the significant drive remains to mitigate climate change (Jiang et al., and 2006; Neij, et al., 1997). A former Saudi Arabian minster once stated that the lack of stones did not cause the end of the Stone Age. Studies have shown that growing scarcity of land resource due to the growing population pressure in most OECD countries such as Japan, may limit solar generation. Germany is expected to offset growth in solar energy consumption in other European nations (Jacobson et al., 2000).

Most studies show that rooftop solar use among residential and commercial building has grown on an average of more than forty percent per year between 2008 and 2014 (GTM Solar and SEI Solar).

According to a 2014 study by Morgan Stanley, the continued growth of the market for rooftop solar has become a key catalyst of demand and showcases a huge promise for solar power consumption growth. It is argued that rooftop solar system for private households as opposed to large-scale solar power plants, has change the perception on everyday practicality and sustainability of solar power (Geller and Unander, 2006). It is further argued that new ownership structure has led to increased usage of solar power in most OECD countries (Neij, et al., 1997). This involves a third-party ownership mechanism option in which household make small or zero payment upfront for installation of roof top solar system. Later the households get electricity for a long time at fixed rates. Use of high capacity batteries ensure users of solar energy go off-grid entirely. This could result in the disruption of utilities among OECD countries (Jiang and Hu, 2006). For instance, in the United States, the state of Hawaii, which has one of the best natural solar advantage, coupled with its high electricity rate, has a high chance of going off-grid.

According to Tahvonen et al., 2001, solar industry has created thousands of jobs globally. As a result, the industry has spurred economic development in most countries. For instance, a recent study shows that in the United States the solar power industry has employed more than 150,000 people in the year 2014. This represents a fifty-four percent increase over 2009 (the solar foundation, 2014). In 2014, two solar energy firms reported more than 5000 solar companies in the United States, spread across all the states. Their studies also estimated that these solar companies injected approximately 15 billion USD into the economy annually, (GTM Solar and Solar Energy International (SEI), 2014, research). It is argued that some of the big corporations such as Apple and Wal-Mart have entered the solar power industry (Jiang, et al., 2006). Wal-Mart is ranked as the highest company producing solar energy at an estimated 90 megawatts. Jacobsson et al., 2000, assert that it serves as enough proof that the sun energy is the fuel of the future.

As research shows, there is clear evidence that the demand for solar energy is on the rise and is expected to continue rising in the foreseeable future. For many OECD countries, all governments have adopted several policies to promote clean energy such as solar, instead of conventional energy generation. Numerous studies analyzed here suggest sufficient empirical evidence in support of solar energy.

On the opposite side of the spectrum, there are suggestions that manufacturing of solar energy harnessing appliances has adverse environmental impacts. Validity of any claim against solar energy, hinges upon some credible research.

We present our theoretical model below.

THE MODEL

Consider a representative consumer who has a constant flow of income to allocate between purchase of electricity and purchase of other goods, which we lump together as a composite good. We assume that the consumer has Cobb-Douglass preferences over electricity and the composite good, with the utility function

$$U = C^{\alpha} Y^{\beta}, \tag{1}$$

where C is the quantity of the composite good, and Y is the quantity of electricity purchased by the consumer. Given the Cobb-Douglass utility function, the consumer will allocate β, a fraction of her income I, to the purchase of electricity. Hence the total expenditure on electricity is βI.

The consumer can purchase the electricity from a utility, or install solar panels that produce electricity. While the electricity generated from solar panels or purchased from a utility is identical in physical terms, a consumer would not necessarily treat them as perfect substitutes. The consumer may have preferences (for example, because of environmental concerns) that may lead her to treat these as separate goods. Hence, we assume that the consumer treats these two as differentiated goods, and has a Constant Elasticity of Substitution (CES) preferences over these two forms of electricity, so that

$$Y = \left(Y_S^{\frac{\rho-1}{\rho}} + Y_O^{\frac{\rho-1}{\rho}}\right)^{\frac{\rho}{\rho-1}}, \tag{2}$$

where Y_S is the total quantity of solar electricity, Y_O is the electricity from other sources, and ρ is the elasticity of substitution between these two types of electricity. The consumer allocates the total electricity expenditure βI between these two sources, hence the consumer's problem can be written as,

$$\text{Max}\left(Y_S^{\frac{\rho-1}{\rho}} + Y_O^{\frac{\rho-1}{\rho}}\right)^{\frac{\rho}{\rho-1}}, \tag{3}$$

subject to the income constraint, $P_S Y_{S+} P_O Y_O = \beta I$.

As is known for CES utility, the demand for solar generated electricity would be given by

$$Y_S = \left(\frac{P_S}{P_E}\right)^{-\rho} \frac{\beta I}{P_E}, \tag{4}$$

where P_E is the CES price index for electricity, given by

$$P_E = \left(P_S^{1-\rho} + P_O^{1-\rho}\right)^{\frac{1}{1-\rho}} \tag{5}$$

Households sometimes purchase solar generated electricity directly, for example in the case of community solar installations that supply electricity to groups of households. In most cases, however, households buy the solar panels and install them on the rooftops or yards to produce electricity. Hence the price that is relevant is the purchase price of solar panel equipment. Since the purchase price of a solar installation runs into tens of thousands of dollars, such purchases are usually made by taking loans. With these considerations in mind, we assume that the price of solar generated electricity depends on the interest rate on loans and the purchase price of solar panel equipment, and assume a relationship of the form,

$$P_s = r^{-\sigma} P^{-\mu}, \tag{6}$$

where *r* is the interest rate and *P* is the purchase price of solar equipment.

Further, the quantity of electricity that can be generated from a solar panel installation, Y_S, depends on the electric power capacity of the installation, measured in kilowatts (KW). The amount of electricity that can be generated from 1KW panel depends on the conversion efficiency of the panel and the solar irradiation in the place where the panels are installed. We abstract from these considerations and assume that,

$$Y_s = kQ_s\ , \tag{7}$$

where Q_s is the electric power capacity in kW and *k* is a constant.

Substituting (6) and (7) into (4), and taking logs, we get the regression equation that we use for the analysis,

$$\ln Q_S = \mathrm{B} + a\ \ln P_s + b\ \ln I + c\ \ln P_E + d\ \ln r \tag{8}$$

For a point of comparison, we also explore a linear version of the model, in addition to the log-linear form. Next, we proceed to our data analysis.

DATA AND ANALYSIS

Our data sources are: US Energy Information Administration (EIA) and International Energy Information (IEA), specifically IEA Quarterly Statistics for Energy Price & Taxes, and the World Bank Database. We could not find electronic links for our data sources to include in References. Our data encompasses years 2000-2012. Our focus is on these years because the Solar Industry took off during this period.

Our demand model is based on the conventional model and grounded in consumer utility theory, as we have delineated above. We use such demand model for estimation of households' solar energy demand in four largest solar users among OECD countries--Germany, the United States, Italy, and France. Accordingly, quantity demanded for solar energy would be a function of the solar energy prices, income, price of related goods (substitutes and complements), etc. Since the Sun energy is free, then the price of solar energy appliances would be the price of solar. As price of solar energy appliances increase, households will consume fewer appliances, which implies, less solar energy. In addition, householder income is also one of the factors that influence solar energy consumption. As disposable income increases, households are inclined to consume more appliances, which will stimulate an increase in demand for solar energy. Solar energy consumption is also a function of the price of related energy options, such as natural gas, oil and coal. We assume the cost of "traditional energy," which is a solar energy substitute, will influence demand for solar energy. As the cost of traditional energy increases, householders are more likely to substitute them with solar energy. Furthermore, interest rate also influences demand for solar energy, since the cost for solar energy appliances are usually financed. High interest rate implies higher cost of borrowing. Therefore, high interest rates dampen households' solar energy.

In addition, government subsidies for households also have influence on demand for solar energy. Thus, there should be a direct relationship between demand for solar energy and government subsidies or tax incentives for households. As government subsidies increase, the demand for solar energy would increases, ceteris paribus. However, the subsidy/tax incentive data were not available for all countries in our study for the observed period of 2000-2012. Therefore, we could not quantify their effect in our estimation. Once more data become available, we plan to expand our estimation model to account for such policy.

DEMAND ESTIMATION

We considered two variations of the demand equation (8): Model 1, a linear specification of all variables, and Model 2, the double log-transformation of Model 1. Our linear equation is given in (9.1),

$$Q_{1,it} = B_{1,i} + a_1 P_{1,it} + b_1 I_{1,it} + c_1 P_{TE1,it} + d_1 SI_{1,it} + \varepsilon_{1,it} \,, \tag{9.1}$$

where $Q_{1,it}$ is the dependent variable, represents the quantity of net solar PV installment for a given year, where i denotes the country, and t denotes the year, $B_{1,i}$ is the constant intercept for each country, and $P_{1,it}$ is an independent variable, the price of solar residential rooftop PV panels, and a_1 its coefficient. $I_{1,it}$ is also an independent variable, representing income (measured by per capita real GDP in dollars), with b_1, being its coefficient. $P_{TE1,it}$ the third independent variable, the price index of traditional energy (the solar substitutes), with c_1, its coefficient. Furthermore, $SI_{1,it}$is the independent variable representing, the short term interest rate with the coefficient d_1. Finally, $\varepsilon_{1,it}$ represents the error term.

We dismissed Model 1, based on the regression results for DW statistics. Model 2 is a double-log transformation of Model 1, denoted as the "ln" model for solar energy demand in equation 9.2:

$$lnQ_{2,it} = B_{2,i} + a_2 lnP_{2,it} + b_2 lnI_{2,it} + c_2 lnP_{TE2,it} + d_2 lnSI_{2,it} + \varepsilon_{2,it} \,, \tag{9.2}$$

where $lnQ_{2,it}$ is the dependent variable, represents the transformed data for quantity of net solar PV installment from Model 1 for a given year, where i= country and t = time. $B_{2,i}$ is the constant intercept for each country. $lnP_{2,it}$ is independent variable, transformed data for price of solar rooftop PV panels for residential from Model 1, a_2 is the coefficient for $lnP_{2,it}$. $lnI_{2,it}$ is independent variable, transformed data for income (measured by per capita real GDP in Dollars) from Model 1. And b_2 is the coefficient for $lnI_{2,it}$. $lnP_{TE2,it}$ is independent variable, transformed data for price index of traditional energy (solar substitutes) from Model 1. Where c_2 is the coefficient for $lnP_{TE2,it}$. $lnSI_{2,it}$ is independent variable, transformed data for short term interest rate from Model 1. With d_2 being the coefficient for $lnSI_{2,it}$ and $\varepsilon_{2,it}$ represents the error term.

We used Model 2 as given in (9.2), for estimation of solar demand for Germany, the United States, Italy and France (equations 9.3-9.6).

We also formed a panel data for the four couturiers under consideration. To Account for the effect of any omitted variables in our model, we used the fixed effects model. Our egression results for the panel data with fixed-effects estimation are presented in Table 1, followed by the key statistics of our panel estimation result in Table 2.

As seen in Table 1, all variables in our model once again have their expected theoretical signs and are statistically significance (i.e., all t values substantially above the critical value of 2). Also, as we report in Table 2, R^2 and adjusted R^2 and F statistics, which collectively show the strong overall power of our regression estimation. Tables 1 and 2 follow.

TABLE 1
REGRESSION RESULYTS FOR PANEL DATA WITH FIXED EFFECTS (MODEL 2)

Variable	Coefficient	t value	Sig.
Constant	-60.01156	-14.53321	0.000
Log Solar Panel Price	-1.148371	-3.568911	0.0015
Log GDP per Capita	5.287576	10.11963	0.000
Log Cost of Traditional Energy	2.945739	4.013376	0.0005
Log Interest Rate	-0.447366	-5.219291	0.000

TABLE 2
MODEL 2: LOG LINEAR REGRESSION FOR A PANEL DATA WITH FIXED EFFECT

Key Statistics			
R-squared	0.944213	Mean dependent var	6.689482
Adjusted R-squared	0.930824	S.D. dependent var	1.951704
S.E. of regression	0.513323	Akaike info criterion	1.694817
Sum squared resid	6.587514	Schwarz criterion	2.015447
Log likelihood	-20.11707	Hannan-Quinn criter.	1.801097
F-statistic	70.52236	Durbin-Watson stat	0.624698
Prob. (F-statistic)	0.000000		

Our analysis of the results follow.

ANALYSIS

Tables 1 contains the coefficients and t-values for each independent variable, and Table 2 includes the effects specification such as the value of R^2. The results of the panel model with fixed effects show that Adjusted R-Squared has a value of 0.93, which indicates: 1) that the selected independent variables fit this model very well, and 2) that the signs of the estimated parameters (elasticities) correspond with the behavior suggested by theory. The coefficient of the variable log of price of solar rooftop for residential ($lnP_{2,it}$) has a value of -1.15, which suggests that one unit increase in $lnP_{2,it}$ will lead to an expected decrease in $lnQ_{2,it}$ by 1.15. The corresponding t-value for $lnP_{2,it}$, with an absolute value of 3.57, is significant at 95% level of confidence, along with a p-value of 0.0015. The coefficient of variable log of real GDP per capita income or $lnI_{2,it}$ has a value of 5.29, implying that one unit increase in $lnI_{2,it}$ will lead to 5.29 increase in $lnQ_{2,it}$. The latter also indicates a direct relationship between $lnQ_{2,it}$and $lnI_{2,it}$; suggesting that solar energy is a normal good, as expected. The corresponding t-value for $lnI_{2,it}$ being 10.11, in conjunction with its 0.0000 P-value, indicates a high statistical significance at the 95% level.

The coefficient of the log of index of total cost of traditional energy ($lnP_{TE2,it}$) has a value of 2.95, which indicates one unit increase in $lnP_{TE2;\,it}$ leads to about 2.95 increase in $lnQ_{2,it}$. This also indicates a direct relationship between $lnQ_{2,it}$ and $lnP_{TE2,it}$. The corresponding t-value for $lnP_{TE2;\,it}$ is 4.01, and a p-value of 0.005. This relationship is also statistically significant at 95% level of confidence. Our results show that demand for solar energy has tended to increase while the total cost of traditional energy has tended to increase over during the 2000-2012 period. The cost of traditional energy is also a major factor that influences demand for solar energy among the four OECD countries in our sample.

The coefficient of the log of short-term interest rate ($lnSI_{2,it}$) has a value of -0.45, which indicates one unit increase in $lnSI_{2,it}$will lead to about 0.45 decrease in $lnQ_{2,it}$. This also reveals an indirect relationship between $lnQ_{2,it}$ and $lnSI_{2,it}$. The corresponded t-value for $lnSI_{2,it}$ is -5.22, and it has a p-value of 0.0000. Thus, this relationship is statistically significant at 95% level of confidence. We conclude that the demand for solar energy is inversely related to short-term interest rates in our sample.

Overall, we conclude that Per Capita Income is the leading determinant of demand for solar energy in our sample.

According to the value of dummy variables that was created by the software automatically, we could conclude the following final equations for Germany (9.3), the United States (9.4), Italy (9.5) and France (9.6), as follows.

$$lnQ_{2,Gt}=-60.01-1.15lnP_{2,Gt}+5.29\ lnI_{2,Gt}+2.95\ lnP_{TE2,Gt}-0.45\ lnSI_{2,Gt}+\varepsilon_{2,Gt} \tag{9.3}$$

$$lnQ_{2,USt}=-60.80-1.1lnP_{2,USt}+5.29\ lnI_{2,USt}+2.95\ lnP_{TE2,USt}-0.45\ lnSI_{2,USt}+\ \varepsilon_{2,USt} \tag{9.4}$$

$$lnQ_{2,It}=-58.83-1.15lnP_{2,It}+5.29\ lnI_{2,It}+2.95\ lnP_{TE2,It}-0.45\ lnSI_{2,It}+\ \varepsilon_{2,It} \tag{9.5}$$

$$lnQ_{2,Ft}=-60.89-1.15\ lnP_{2,Ft}+5.29\ lnI_{2,Ft}+2.95\ lnP_{TE2,Ft}-0.45\ lnSI_{2,Ft}+\ \varepsilon_{2,Ft} \tag{9.6}$$

In all four counties' demand estimation, the models' variables have their expected theoretical signs. We used both linear and log liner specifications for estimation of our panel data. Once again, the t values and Durbin-Watson statistics confirm the superiority of the fit of our data to the long linear model. Our panel regression confirms our single equations findings reported above; and strong explanatory power of our model, given our statistics for R^2, adjust $R^2$and F values. Several alternative specifications confirm the robustness of our statistical results.

In the following section, we delineate the summary of our findings and concluding remarks.

CONCLUSION

First, this research attempted to establish the determinants of household demand for solar energy in four industrialized countries. To that end, we developed a theoretical model for estimation of solar energy demand by households in case of four OECD countries who lead in use of solar energy—France. Germany, Italy and US. We used time series data for each county and estimated their demand for solar. Our results show that Per Capita Income is the main driver of demand for solar energy in all four cases, followed by the price of traditional energy and price of solar panels., then the rate of interest. Second, we used a panel data for estimation of demand in the four counties under study. Our estimation results for individual countries and their panel data confirm that Per Capita Income has the most influence on residential solar energy demand. Third, we have shown that the cost of Traditional Energy also plays an important role on demand for solar energy, showing an inverse relationship with it for the 2000-2012 period under consideration. With several alternative specifications, we have confirmed the robustness of our model and estimations. Fourth, the shortcoming of our model is inevitable exclusion of the effect of government policy (tax incentive and subsidies) for boosting solar energy demand, although the price of solar panels indirectly account for such policies. With absence of adequate data, we could not evaluate the effect of government incentives directly. Fifth, we suggest expansion of this research to include the estimation of the effect of government subsidies/tax incentives on solar energy demand when data become available.

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