Portfolio Choice And Investments In Renewable Energy: Evidence From U.S. Household Surveys

Nicholas Apergis, University of Piraeus, Greece

ABSTRACT

Economic theory predicts that investing in renewable energy should generally have a negative effect on risk-taking in financial portfolios, which can affect the optimal design of a wide variety of financial and insurance policies. However, there is no empirical work to confirm a relationship between renewable energy investments and portfolios. Using data for 15,600 U.S. households spanning the period 2001-2012, we find that increases in renewable energy investments also increase investments in risky assets. Therefore, investing in renewable energy has a substantial impact on portfolio choice decisions.

Keywords: Portfolio Choice; Renewable Energy Investments; U.S. Household Survey

1. INTRODUCTION

Global renewable energy developments are striding ahead. Total worldwide investment in renewable energy increased 17% to a record $257 billion in 2012, a six-fold increase since 2004 (Global Status Report Renewables, 2011). With traditional fixed income assets offering low yields, many institutional investors are in search of alternative investments to meet the steady flow of payment obligations. Other asset categories, such as equities, have frequently generated unsatisfactory results in the past due to high levels of volatility. Against this backdrop, real assets are viewed as promised investments because they are driven by long-term macro trends, independent of the capital markets.

To increase the share of renewable energy in the global energy mix, significant innovations are needed not only in the technical field, but also in the financial context (Krewitt et al., 2007). In addition, a number of energy analysts estimate that huge additional investments are needed to realize this transition to a low carbon economy. To this end, a number of financial innovations are provided to overcome the disadvantage that investors are reluctant to heavily invest in this industry unless dedicated policies are implemented to stimulate renewable energy investments (Masini & Menichetti, 2012).

Renewable energy offers investors an attractive risk/return profile, a low level of correlation with traditional asset classes, i.e. equities and bonds, and long-term stable cash flows. With insurance firms and pension funds focused on asset-liability management, this combination of benefits makes renewable energy a highly attractive investment opportunity. At the same time, renewable energy benefits from the favorable political conditions, where its use is actively promoted to reduce the dependence on fossil fuels. The supply of fossil fuels is expected to reach its peak in coming decades and then decline, while by then energy demand will probably be twice the supply that can be met by fossil sources alone. Furthermore, the environmental factor plays an increasingly substantial role in supporting the investment case for renewable energy, which represents a clear advantage over fossil fuels in terms of sustainability.

As renewable energy is a comparatively ‘young’ asset category, it includes a range of various assets with differing risk/return profiles, indicating that investors are faced with a potentially complex valuation process. Investment risk depends to a large extent on the technology used, the remuneration system, the project phase, and

prices. The risk can be reduced by diversifying across different technologies, projects, and countries with their perspective remuneration systems. This diversification can have a positive effect on a portfolio and, thus, considerable diversification advantages can be derived in the form of far lower volatility in conjunction with higher returns over time.

To empirically identify for the first time the presence or not of a relationship between investing in renewable energy and portfolio choice, we implement this strategy using microdata on renewable energy investments (i.e., investments in firms producing renewable energy related goods) and portfolios for 15,600 households from the Survey of Income and Program Participation panels spanning the period 2001-2012. The lack of emphasis on investors' preferences is an important shortcoming in the finance literature (Burer & Wustenhagen, 2009). This paper intends to provide such information to the relevant literature by shedding new light on the determinants of portfolio decisions through which investors allocate capital to renewable energy securities. To this end, we make use of the panel GMM methodology, recommended by Arellano and Bond (1991), to estimate the effect of renewable energy investments on the share of liquid wealth that a household holds in stocks. This panel research design mitigates concerns about the endogeneity of renewable energy investment choices.

The empirical results are expected to provide essential information on the underlying relations between renewable energy investments and financial performance, while they will help policy makers design more effective policies that will motivate potential investors to increase their portfolio investments in renewable energy, given that such investments are of high risk. Therefore, effective policies could target to support the financial performance of firms that are directly involved in environmental activities (Reinhardt, 1999).

The rest of this paper is structured as follows. Section 2 discusses the literature. Section 3 presents the model. Section 4 describes the data, evaluates the empirical results, and presents results for forecasts. Finally, Section 5 concludes the paper.

2. THE LITERATURE

Once there is not any direct literature that considers the impact of renewable energy investments on portfolio choice, this part of the paper presents only those strands in the literature that deal directly with portfolio choice. There is a strand of the literature that signifies the role of labor income risk in portfolio choices. Jagannathan and Kocherlakota (1997) provide evidence that a higher share of risky assets at young ages is evident given that the labor income has a low degree of volatility. Cocco et al. (2005) show that low average shares of risky investment and their positive correlation with age is explained by higher degrees of risk aversion and by negative labor income disturbances.

A different strand of the literature focuses on the correlation between labor income risk and risky assets. Deaton (1991) shows that the puzzle characteristics characterizing portfolio choices might be a rational response to non-hedgeable income risk under the presence of borrowing constraints. Smith (1995) argues that given uncertain domestic currency denominated tax payments, risk averse investors hold a portion of their wealth in a tax hedge portfolio, with emphasis on domestic bonds. Tax hedging may, therefore, explain the observed preference for home country assets.

Jorion and Goetzmann (1999) argue that given the historical trade-off between risk and reward on stock markets as well as the level of risk aversion, optimal portfolios tend to be more heavily skewed toward equities than what actual portfolios document. McCarthy (2003) examines the role of benefit pensions and their association with portfolio decisions. His empirical findings show that the presence of such benefits could drive households to invest more heavily in risky assets. Benzoni et al. (2007) show that labor income and stock market returns move together only at a longer time horizon, by providing evidence that stocks are perceived to be much riskier for young than old workers, yielding lower degrees of stock market participation and increasing age profiles of risky assets share. Storesletten et al. (2004) introduce an idiosyncratic risk characteristic in labor income and observe a humped shape investment profile, while Lynch and Tan (2011) show that countercyclical volatility in labor income growth is a crucial determinant of portfolio choices. They find that in the U.S. low wealth and young households display lower shares in stock holdings. Chiappori et al. (2013) find that risk tolerance is not correlated with a number of

demographic variables and/or household's wealth. Ackermann et al. (2013) study how taxes and subsidies affect portfolio choices in a laboratory experiment. They find that the willingness to invest in risky assets decreases markedly when an income tax has to be paid or when a subsidy is paid.

Another way the relevant literature has attempted to explain portfolio choice preferences is by introducing habit formation. This type of preference considers the difference between current levels of consumption and those levels of consumption that agents are accustomed to. This strand of literature finds that habit formation tends to worsen the fit between theoretical and empirical models. Gomes and Michaelidis (2003) show that habit formation models attach greater weight to ensuring smooth consumption over time; in that sense, households accumulate more wealth earlier to acquire higher protection against income fluctuations and, thus, these households can pay easier the fixed cost of stock market investments and so they invest in stock markets in earlier stages of their lifetime. Their results also find empirical support by Polkovnichenko (2005).

More recently, the literature has explicitly considered housing and borrowing constraints as well as retirement pensions and tax effects in modeling household portfolios structures and explaining households' investment preferences. These assets are considered by the majority of investors across countries to be important elements in a portfolio, while financial assets are considered relatively riskier for the same group of investors. According to theoretical predictions, housing tends to reduce the demand for risky assets since households are more exposed to risk and illiquidity (Chetty & Szeidl, 2007). However, the empirical literature has been unable to find a systematic association between housing and portfolios (Cocco, 2005).

3. DATA

Data on consumer choices across households by age and wealth were obtained from microdata on renewable energy investments and portfolios for 15,600 households in the U.S. from the Survey of Income and Program Participation panels spanning the period 2001-2012. This type of survey provides information about the structure of households' characteristics and investment decisions. Data on portfolio shares are collected on an annual basis.

Assets have been classified according to their degree of riskiness. In particular and for the ends of the empirical analysis, assets are classified as 'risky' assets and 'safe' assets. In our analysis the category of 'safe' assets includes: checking accounts, savings accounts, money market accounts, certificates of deposits, cash value of life insurance, government bonds, mutual funds invested in tax-free bonds, mutual funds invested in government backed bonds, trusts and annuities invested in bonds, money market accounts, life insurance, and pension plans. By contrast, the category of 'risky' assets includes: stocks and brokerage accounts, mortgage-backed bonds, foreign bonds, corporate bonds, mutual funds invested in stock funds, trusts and annuities invested in stocks-real estate, and pension plans characterized as a thrift, profit sharing or stock purchases. The category of 'risky' assets also includes investments in stocks of firms that generate renewable energy goods and/or electricity from renewable energy sources.

Households are grouped by education levels, gender, marital status, and number of children. In particular, education levels are defined as: high school graduates, college graduates, and households with a graduate or PhD degree; gender is defined as male and female; marital status is defined as: single, married, and divorced; number of children is defined as: zero children, 1-2 children, and more than 2 children.

When the household is married, the reported income and asset information refers to the combined values of the household and spouse. The asset and income data are expressed in 2001 exchange rate dollars. Finally, households considered as outliers were dropped from the sample if at least one of the following criteria is met for the period under consideration: a) total income less than $100 in any year and b) the household spent more than 25 weeks out of the labor force in any year. Table 1 reports the share of the population who hold an amount across specific accounts. The evidence clearly shows that investors have a strong preference towards holding safe assets.

Table 1: Statistics on Portfolio Choice

Type of Account	Investment Participation
Checking accounts (safe)	91.5%
Savings accounts (safe)	74.3%
Money market accounts (safe)	39.8%
Certificates of deposits (safe)	21.5%
Mutual funds: tax-free bonds (safe)	28.7%
Mutual funds: government bonds (safe)	26.5%
Trusts and annuities in bonds (safe)	18.9%
Government bonds (safe)	34.6%
Life insurance (safe)	35.2%
Retirement accounts (safe)	49.3%
Total (safe)	**99.3%**
Stocks (risky)	32.5%
Mutual funds: stock funds (risky)	19.8%
Retirement=pension accounts (risky)	57.9%
Mortgage-backed bonds (risky)	26.4%
Foreign bonds (risky)	19.3%
Corporate bonds (risky)	32.4%
Trust and annuities: stocks-real estate (risky)	14.7%
Renewable energy investments	14.7%
Total (risky)	**51.2%**

4. EMPIRICAL ANALYSIS

Econometric estimation uses a fixed effects maximum likelihood panel estimation to examine the impact of the type assets on portfolio choices, given a number of demographic variables. In particular, the model is given in Equation 1 as follows:

$$\text{risky share}_{it} = a\, X_{it} + \beta_1\, \text{assets}_{it} + \beta_2\, \text{ren}_{it} + \alpha_i + \delta_i\, t + u_{it} \quad (1)$$

where the dependent variable is the percentage of risky asset holdings and i = 1, …, N for each household in the panel and t =1, …, T refers to the time period. X denotes a vector of demographic control variables, such as education, sex, marital status, number of children. *Assets* describe total financial assets excluding investments in renewable energy stocks, while the investment in those stocks is reflected in the variable *ren*. Finally, the parameters α_i and δ_i allow for the possibility of fixed effects and deterministic trends, respectively. The error term u captures other sources of heterogeneity in portfolios, such as entrepreneurial risk (Heaton & Lucas, 2000), investment mistakes (Calvet et al., 2007), heterogeneity in risk aversion, and measurement errors (especially in income-Cocco, 2005). Given that these other sources could be correlated with assets, the model must satisfy the variation in assets that is orthogonal the set of the control variables. To generate such a variation and to ensure consistency of the estimates, this paper employs the panel GMM methodology recommended by Arenallo and Bond (1991) with 3 lags for instruments and in terms of the assets variables along with the other explanatory (control) variables.

The empirical findings are reported in Table 2. The signs of the control variables are as expected and the coefficients are statistically significant. By focusing on the coefficients of interest, β_2 and β_3, the estimates across all countries imply that an increase in both financial assets and renewable energy securities increases the share in risky investments in a portfolio. More specifically, the estimates show that a 1% increase in the amount of total financial assets leads to an increase in the risky share investing by 1.25% in the U.S., while a 1% increase in the amount of renewable energy securities leads to an increase in investments in renewable energy securities by 0.58%.

If investors are male and as they move up the income ladder they tend to exert a positive and significant impact on the likelihood of increasing their share of risky investments across countries. By contrast, if they are married, as they have more children, while they have a higher education certificate, they tend to reduce their share in risky investments, again, across countries. The above findings confirm the significance of the demographic variables in the framework of portfolio choice and they are consistent with the study by Dohmen et al. (2011) who make use

of an experimental approach and show that a number of such variables, i.e. gender, age, have an impact on the willingness to take risk.

The R-squared value indicates that 43% of the variation in the extent of investment in 'risky' accounts is explained by the independent variables in the U.S. Finally, Sargan instruments tests as well as serial for first and second order correlation tests denote the statistical validity of the empirical findings.

Table 2: Two-Step GMM Estimations

Constant	0.781 [0.00]
Assets	1.247 [0.00]
Ren	0.582 [0.00]
Male	0.063 [0.01]
Marital status	-0.069 [0.01]
Education	-0.046 [0.00]
Number of children	-0.038 [0.00]
Total income	0.128 [0.00]
Observations	15,600
R^2	0.43
Sargan test	[0.24]
Test for first order serial correlation	[0.37]
Test for second order serial correlation	[0.46]

Note: Figures in brackets denote p-values.

5. CONCLUSIONS

This empirical study attempted to provide new empirical insights to account for the dynamic effects of renewable energy investments on portfolio choice decisions. By using a survey study for the U.S., spanning the period 2001-2012, the paper provided evidence that as investments in renewable energy securities increase in a portfolio, investors increase their share in risky assets. Moreover, less wealthy, married with children, more educated, and young households invest less in 'risky' accounts across all countries.

The results are expected to shed light on the important determinants explaining not only portfolio choices, but also the pricing of risk in financial markets related to securities in renewable energy. Moreover, they are expected to assist policy makers to design the appropriate efficient policies related to the financial performance of firms' involved in environmental activities. The effectiveness of such policies aimed at mobilizing renewable energy investments is critically dependent upon their impact on investors' behaviors. Therefore, in order for policy makers to get the maximum outcome regarding the impact of future policies, they need to get a better understanding of how investors behave and what the determinants are that dictate such an investment behavior, particularly in regards to the key psychological factors that may influence their behaviors and actions, given the increased risk involved in such renewable energy type of investments, at least in the current situation where the rivalry for adequate funding coming from fossil energy sources is highly intense. They are also expected to assist markets to comprehend the household's behavior across financial markets.

Finally, the results appear highly relevant for practitioners in the renewable energy markets. Prior beliefs and cognitive biases definitely give rise to additional risks that throw more obstacles in raising capital for clean energy. The analysis within a framework that prices rational risk factors can help investors to get a more balanced view of policy risks and opportunities in capital markets.

Nevertheless, understanding portfolio choices remains a fruitful area of research. There are also a larger set of factors that can impact portfolio choices; therefore, a potential venue of research is to consider the role of factors, such as macroeconomic and institutional, in explaining portfolio choice decisions. Furthermore, future research attempts could explore whether interactions between investments in renewable energy and the stock market are consistent with historical fluctuations in asset prices using calibrated general equilibrium models.

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AUTHOR INFORMATION

Dr. Nicholas Apergis is a Professor in MacroFinance at the University of Piraeus. He holds a Ph.D. in Economics from Fordham University. He has taught at Fordham University, Manhattan College, University of Macedonia, and University of Ioannina. He has 190 publications in various journals: *Journal of Policy Modeling*, *Journal of Banking and Finance*, *International Advances in Economic Research*, *Journal of Economic Studies*, *Kredit und Kapital*, *Bulletin of Economic Research*, *Atlantic Economic Journal*, *Weltwirtschaftliches Archiv*, *Manchester School of Economics*, *Economics Letters*, *International Finance*, *Energy Economics*, *Public Choice*, and *Energy Policy*. He is the Editor of IJER and IJFS and the Associate Editor in the JEF. E-mail: napergis@unipi.gr

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