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Inducing Private Finance for Renewable Energy Projects: Evidence from Micro-Data

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OECD ENVIRONMENT WORKING PAPER No. 67 - INDUCING PRIVATE FINANCE FOR RENEWABLE ENERGY PROJECTS: EVIDENCE FROM MICRO-DATA

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ABSTRACT

This paper analyses the effects of government policies on flows of private finance for investment in renewable energy (inducement effect). It also examines whether direct provision of public finance for a project increases the volume of private finance raised ("crowding in" effect). A unique dataset of financial transactions for renewable energy projects with worldwide coverage is constructed using the Bloomberg New Energy Finance database. The analysis covers 87 countries, six renewable energy sectors (wind, solar, biomass, small hydropower, marine and geothermal) and the 2000-2011 time-span. Main findings are that, in contrast to quota-based schemes, price-based support schemes are positively correlated with investors' ability to raise private finance. The paper suggests that, rather than the type of instrument (price vs. quota), it is the specific design of such schemes that is key to providing a predictable signal and an effective incentive to attract private investors. It is also found that public finance supports precisely those projects that have had difficulty raising private finance (co-financed projects), where neither quota-based measures nor price-based support schemes have a significant effect on private finance flows. This raises the concern that in the absence of well-designed policies which incentivise private finance investment, governments wishing to secure project completion have no other choice than to support projects directly through the use of public finance.

Keywords: renewable energy, finance, investment, policy instrument choice, technology deployment

JEL classification: Q42, Q48, Q54, Q55, Q58; G3; H23; L94; O3

RÉSUMÉ

Ce document porte sur l'analyse des effets des politiques publiques sur les flux financiers privés affectés à l'investissement dans les énergies renouvelables (effet d'induction). Il examine également si l'apport direct de fonds publics à un projet renforce la probabilité d'obtention de financements privés (effet d'attraction). Cette analyse est fondée sur une base de données sans équivalent sur les financements d'actifs (c'est-à-dire sur les opérations d'investissement réalisées dans des projets d'énergie renouvelable) construite à partir de la base de données Bloomberg sur le financement des énergies nouvelles (BNEF, *Bloomberg New Energy Finance*), couvrant tous les pays. Les principaux résultats indiquent que contrairement aux systèmes fondés sur des quotas, les dispositifs de soutien fondés sur les prix sont corrélés positivement avec la capacité des investisseurs à obtenir des financements privés. Notre analyse suggère que, davantage que le type de dispositif utilisé (instrument fondé sur les prix ou système de quotas), c'est la conception spécifique de ces dispositifs qui est déterminante pour donner des signaux prévisibles et des incitations efficaces attirant les investisseurs privés. L'analyse conclue également que les financements publics sont précisément affectés aux projets qui ont eu des difficultés à attirer des fonds privés (projets cofinancés), très probablement parce qu'ils ne sont pas économiquement viables en l'absence d'un tel soutien. Cela laisse à penser qu'en l'absence de politiques publiques judicieusement conçues, permettant d'attirer des investissements financiers privés, les gouvernements souhaitant garantir l'achèvement d'un projet n'aient pas d'autre choix que de soutenir directement ledit projet à travers des financements publics.

Mots clés : énergie renouvelable, investissement, financement d'actifs, choix des instruments d'action, innovation induite

Classification JEL: Q42, Q48, Q54, Q55, Q58; G3; H23; L94; O3

FOREWORD

This paper has been authored by Miguel Cárdenas Rodríguez, Ivan Haščič, Nick Johnstone, Jérôme Silva (OECD Environment Directorate) and Antoine Ferey (ENSAE ParisTech). A draft of this report was reviewed by delegates to the Working Party on Climate, Investment and Development (WPCID) at their April 2013 meeting. The paper was also presented at the Annual Conference of the European Association of Environmental and Resource Economists (June 2013 in Toulouse, France) and the International Energy Workshop (June 2013 in Paris, France). It has benefited from the comments received. The authors would like to thank to Randy Caruso, Anthony Cox, Chiara Criscuolo, Jane Ellis, Raphaël Jachnik, Chris Kaminker, Osamu Kawanishi, Nannette Lindenberg, Walid Oueslati, Victoria Shestalova and Simon Upton for helpful comments on earlier drafts of this paper, and Barbara Aiello for editorial assistance.

EXECUTIVE SUMMARY

The paper analyses the effects of government policies on private finance for investment in renewable energy and investigates two principal research questions: what is the effect of a range of public policy instruments on the ability of investors to raise private finance for renewables projects (inducement effect); and does direct provision of public finance for a project increase the likelihood of raising private finance (”crowding-in” effect).

While the analysis focuses on the role of renewable energy support policies, attempts are made to also account for capital market imperfections that might also play an important role. Difficulties in obtaining financing due to the failure of markets to allocate capital efficiently are distinct, and additional, to the presence of environmental externalities. Addressing the latter is typically a pre-requisite for an investor to seek financing for environment-related projects. Indeed, public policy that aims to encourage greater penetration of renewable energy sources must first help create demand for such type of energy (by providing incentives that close the gap between production costs of energy from renewable relative to fossil sources) and, as explained above, also address the specific difficulties of raising funds for such investment projects. The simultaneity of two market failures – the environmental externality and capital market imperfections – implies that it might be difficult to design public policies in a manner that addresses the two failures optimally. This paper seeks to provide empirical evidence to support a discussion on the most effective design of such policies.

Using historical data on financial transactions, several patterns can be discerned. First, in terms of investment per MW of installed capacity in the renewable energy sector, co-financed projects are on average more costly than projects financed only from private funds[1]. Second, there is variation in the share of private finance participation in the co-financed projects – both across countries and technologies. The contribution from public sources is highest in geothermal energy (67%) and small hydro (63%), followed by biomass (44%), solar (43%), marine (33%) and wind energy (31%). However, this share has been varying over time. For example, in small hydro, geothermal and solar energy the public finance contribution might change by as much as 50 percentage points over time, while in biomass, wind and marine energy public finance has been relatively stable. Particularly high shares of private participation (80%) with commensurately low shares of public finance are in German wind projects, Chinese hydro power, Spanish solar, and US biomass projects. Conversely, a particularly low share of private participation (implying high public involvement) can be observed in Brazilian biomass projects (20%). This paper examines to what extent these differences can be related to public policies in these countries.

This paper examines the determinants of private finance for renewable energy – focusing on the role of public policies but controlling for firm, project and country characteristics. It is found that policy instrument choice matters a great deal. There is evidence that price-based instruments such as feed-in tariffs (or premiums) are positively correlated with the volume of private finance raised, while no such evidence is found for quota-based instruments. It is hypothesised that this might be because feed-in payment schemes provide a more predictable investment incentive, similar to tax relief (tax credit) measures whose effect is also found to be positive. In terms of relative magnitudes, the results suggest that the introduction of tax relief for renewable energy investments is, on average, equivalent to a 6.6% increase in feed-in tariff payments.

[1] Identifying why co-financed projects are more expensive is beyond the scope of this paper.

There are two elements that might help explain these findings – how governments address the environmental externality and what is done to alleviate the additional capital market imperfections. First, it is possible that different types of instruments might not generally be of an equivalent degree of ambition in achieving environmental objectives. Second, some policy instrument types might be better suited to deal with the specific capital market imperfections relevant for renewables projects. The paper provides further discussion of these issues.

Furthermore, the impact of renewable energy policies on private finance is found to vary across generation technologies. While feed-in tariffs have a positive and significant effect on finance for solar and biomass projects, quota schemes are significant for small hydro. This is consistent with the degree of maturity of the respective technologies and their distance from the market. A utility facing a quota, which is not sector-specific, will choose the lowest-cost option (e.g. hydropower) to meet the requirements.

As discussed above, one of the possible explanations for a positive effect of renewables policies is not only their implicit environmental ambition (and thus level of support), but also their ability to overcome any imperfections in a country's credit markets. While this paper does not find explicit support for this argument (likely due to data limitations), a more indirect support is found by differentiating technologies by their maturity since capital markets may have more difficulty assessing risks associated with less mature technologies. The results presented here imply that if credit markets are functioning well, a feed-in tariff will induce private finance for solar PV, while a quota scheme will induce private finance in wind power. However, if credit markets are not functioning well only a feed-in tariff will have an effect on private finance flows, and only for the case of onshore wind power.

Next, the role of direct provision of public finance is studied in a framework where both public and private investments are simultaneously decided for a given project. A particularly important finding of the study is that in the absence of well-designed policy incentives to address the environmental externality associated with electricity generation, governments might have to resort to direct provision of public funding to support such investments. While evidence is found that direct provision of public finance towards a project is positively correlated with private finance raised for the targeted projects, the data also suggest that the characteristics of such projects are important. In fact, while evidence of a substitution effect of public finance is found, it is not adequate to interpret this as a 'crowding out' effect. This would require conducting analysis at a more aggregate level. Rather, the available evidence seems to indicate that public finance is perhaps used as a means to secure completion of projects that are unable to raise sufficient volume of private financing in the first place. This would explain why co-financed projects tend to be 27% more costly (per megawatt installed) than projects that rely solely on private finance.

Environmental policies also seem to affect both public and private investment. For instance, measures of tax relief (or tax credits) have a significant negative impact on the provision and level of public investment. Since tax relief can be considered to be an indirect way of providing public investment, through a diminished tax burden for beneficiaries, this substitution effect between public finance and tax relief is expected.

Interestingly, demonstration programmes appear as a complement of public involvement in projects. Additionally, while the presence of technology deployment and diffusion programmes is negatively correlated with the level of public financing, such schemes seem to be an effective way to induce private financing. Moreover, the presence of renewable energy quotas does not seem to on either public or private investment. Last, our analysis also suggests that in the presence of public co-financing of a given project, public policy incentives (such as feed-in tariffs and tax relief) have a more limited impact on investors' ability to raise private finance, indicating that public policy measures and direct provision of public finance are substitutes for one another.

It is also found that generation capacity is a main driver of public investment decisions suggesting that public authorities favour large projects (particularly in non-OECD countries). However, once a positive decision to invest has been taken, capacity does not seem to influence the level of public finance allocated to the project. It can thus be argued that public funds are used only to pursue completion of projects with insufficient private financing, regardless of the size of the project.

Comparison of results for public and private determinants of investment yields two key messages. First, incentives for private and public investment differ from one another. Private investors are willing to finance projects whose characteristics and any targeted policy support make them profitable. On the other hand, public finance enters the market to secure the completion of projects that may not be economically viable. Second, public finance allocation seems to be inflexible once the investment decision has been made, suggesting that direct public finance could be better tailored to the characteristics of a project. The implications of these findings for policy design, policy instrument choice and direct public intervention are discussed.

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1. INTRODUCTION

Achievement of ambitious environmental objectives often requires mobilising large volumes of finance to undertake the necessary investments. The question of how public policy can help direct private funds towards green investment has become particularly acute in the context of climate change. In fact, finding ways for public policy to increase financing of environmental projects has become one of the central elements of the current climate policy debate. While governments play an important role in providing funding support, public finance cannot be the sole source of finance for such investments. Moreover, given the fiscal context in many countries, directing public funds towards these ends is proving increasingly difficult. As a result, governments are seeking to use policy incentives to encourage private investment in renewable energy generation (for discussion see OECD 2013a and Corfee-Morlot et al. 2012).

Markets for renewable energy finance are characterised by the presence of two types of failures: capital market imperfections and environmental externalities. Addressing the latter is typically a pre-requisite for an investor to seek financing for environment-related projects. Indeed, public policy that aims to encourage greater penetration of renewable energy sources must first help create demand for such type of energy by providing incentives that close the gap between production costs of energy from renewable relative to fossil sources, and also address the specific difficulties of raising finance for such investment projects. The simultaneity of two market failures – the environmental externality and capital market imperfections – implies that it might be difficult to design public policies in a manner that addresses the two failures optimally.

There are several reasons why investors face difficulties in raising capital for renewable energy projects. These difficulties mainly relate to capital market imperfections (e.g. difficulties to obtain credit, limited financing for high-risk investments or for projects with a long pay-off period) that arise due to asymmetric or imperfect information, risk aversion, or agency problems.[2] Other market conditions may create additional barriers for raising capital, such as market power, entry and exit barriers, network effects and consumption externalities (slow adoption of innovations). All these conditions have been addressed in the general finance and investment policy literature.

While the conditions exposed above are generic for all firms and project types, investment in renewable energy concentrates several of these characteristics, namely: (a) long pay-off period – slow capital turnover is typical for most energy sources; (b) large volume of investment funding required – again, a rather typical feature of the energy sector; (c) high risk – typical for investments in early-stage technologies whose long-term viability is yet to be proven (including those using renewable resources); and (d) temporal distribution of costs, revenues, and available financing – compared with conventional alternatives, renewable energy generation is often characterised by a high ratio of up-front investment costs to operation costs (incl. fuel and maintenance); the extent to which this matters will depend on investors' discounted cost of capital.[3]

When analysing the effects of different policy measures on private finance flows it is important to bear in mind that measures of equal apparent ambition may have very different implications for

[2] For seminal papers see e.g., Stigler 1967; Akerlof 1970; Stiglitz and Weiss 1981.

[3] Another notable feature is the importance of production and grid externalities due to the intermittent nature of some renewable resources (see e.g. Benatia et al. 2013).

investor uncertainty. Given the characteristics of the sector set out above (significant sunk costs and considerable policy influence), the uncertainty and unpredictability of the policy regime can be a significant brake on investment. This is particularly true when capital markets are imperfect. Two distinct types of policy uncertainty come to mind.

First, there is uncertainty about the level of support provided under a given policy setting at a point in time. Some measures provide complete certainty about the level of support (e.g. a one-off grant for capital investment or a pre-determined feed-in payment schedule), while for other instruments there may be considerable uncertainty with respect to the actual level of support provided under a given policy setting (e.g. volatile prices of renewables certificates). Second, there can also be uncertainty arising out of the viability of the policy setting itself over time. This is better characterised as policy risk, and may be a function of many factors. For example, the implications of the recent economic and financial crisis for the viability of different support measures have proven to be important. A number of countries reformed their feed-in payment regimes (and reduced their tax credits) in the face of the economic and fiscal crisis of the late 2000s. Other measures such as renewable energy quotas were generally left untouched whether because the fiscal implications were less important or less apparent. Therefore, the level of support provided by some measures over time was subject to change depending upon prevailing circumstances. If the measures proved to be financial unsustainable the level of support provided could change unexpectedly, with long-run implications for investors' risk perceptions.

Moreover, these two types of uncertainty may be negatively correlated. Therefore, while some instruments might be viewed more favourably by investors than others, it is far from clear for which instrument type this is likely to be the case. For example, the extent to which an instrument depends directly on public budgets may be looked upon favourably by the beneficiaries, but this might affect its perceived viability over time (see e.g., Barradale 2008). Policymakers need to understand this trade-off if their objective is to induce private finance flows. More specifically, they need to be able to design policy measures which provide predictable signals to investors, but which do not "tie the hands" of policymakers in the discovery of new information about market, technological or environmental conditions. This can be achieved through programmed adjustments to existing regulations or support formulas based on parameters that are linked to market and other developments. Many of the reforms to feed-in payment schemes implemented in recent years represent important steps in this direction. However, isolating these effects in practice is complicated not least because they are to some extent correlated with policy ambition.

Indeed, the effect of a policy instrument will depend first and foremost on the strength of its commitment to achieving a given policy objective. However, in practice alternative policy instruments implemented in different countries, or within a country, are often of very different ambition. For example, to isolate the differential effect of quota versus price-based renewable support schemes, one would need to compare two schemes of equivalent level of ambition (see OECD 2011 for an in-depth discussion). Therefore, this paper uses a novel dataset of the levels of support through alternative policy instruments to better control for differences in policy stringency.

Previous literature in the domain of renewable energy investment and environmental policy instrument choice and design is scarce. One of the few micro-econometric studies in this field is Criscuolo and Menon (2014). The study draws upon a deal-level database of financing deals in the "clean tech sector" (which includes renewable energy). The focus of the study is on the role of different environmental policy measures (e.g. feed-in-tariffs, tradable renewable certificates, sales tax or VAT reduction, and direct capital investment support through subsidies, grants, rebates, and tax incentives) in inducing early-stage financing. They find robust evidence for the role of such policy measures in inducing higher levels of finance, particularly for policy measures which relate to investment costs. Interestingly, when confined to the sample of deals related to renewable energy generation, the results confirm the positive association of generous feed-in tariffs (FITs) with risk-finance investment. However in the solar sector excessively generous FITs tend to discourage investment. The authors hypothesise that this might arise from potential concerns about the sustainability of overly-generous regimes.

With the focus on the details of the policy regime and the use of deal-level data this latter study is closest in spirit to the present study. However, the present study draws upon a richer description of the characteristics of the individual deals and projects in an effort to gain a deeper understanding of how public policy influences the risk-return profile of different deals, thus inducing private finance for renewable energy projects. Moreover, the question has similarities to the analysis of the role of policy design in encouraging technological innovation in environmental technologies. As such this paper also builds on the induced innovation literature in the field of renewable energy (e.g., Johnstone et al. 2010; Popp et al. 2011).

More specifically, the present paper analyses the effects of a range of public policies on private finance for investment in renewable energy projects. Drawing on a large micro-level database of financial transactions and a comprehensive dataset of renewable energy policy support levels, we construct a dataset of 5267 financial deals towards renewable energy projects (including wind, solar, biomass, geothermal, marine, and small-scale hydropower) located in one of 87 countries worldwide and spanning the 2000-2011 time period.

Following this introduction, the next section presents an overview of the data included in the analysis. Next we discuss the modelling strategy and provide sample statistics. In the fourth section we present and discuss results. The final section concludes the paper.

2. DATA SOURCES

2.1. Financial investment in renewable energy projects

The Bloomberg New Energy Finance database (BNEF 2013) is used to construct measures of private and public finance directed towards renewable energy. BNEF maintains a relational database that includes information on financial transactions associated with “new energy” (defined as renewable energy generation, energy storage, carbon capture and storage, etc.). According to the metadata, the database covers all relevant projects worldwide above a certain threshold capacity. For example, projects with at least 1 MW of installed capacity in geothermal, solar and wind energy generation, 1-50 MW for hydropower, and all marine energy projects are included (BNEF 2012). Three basic data objects in the database can be distinguished – projects, deals (financial transactions) and organisations (firms, government agencies, etc.).

In this paper, the BNEF database is used to construct a comprehensive dataset that links renewable energy projects, financial deals and organisations. Financial deals fund the projects, while various organisations can be either involved in deals or projects (or both). In BNEF, these financial deals (hereafter “deals”) are referred to as “asset finance” – defined as investment in a specific renewable energy project.[4]

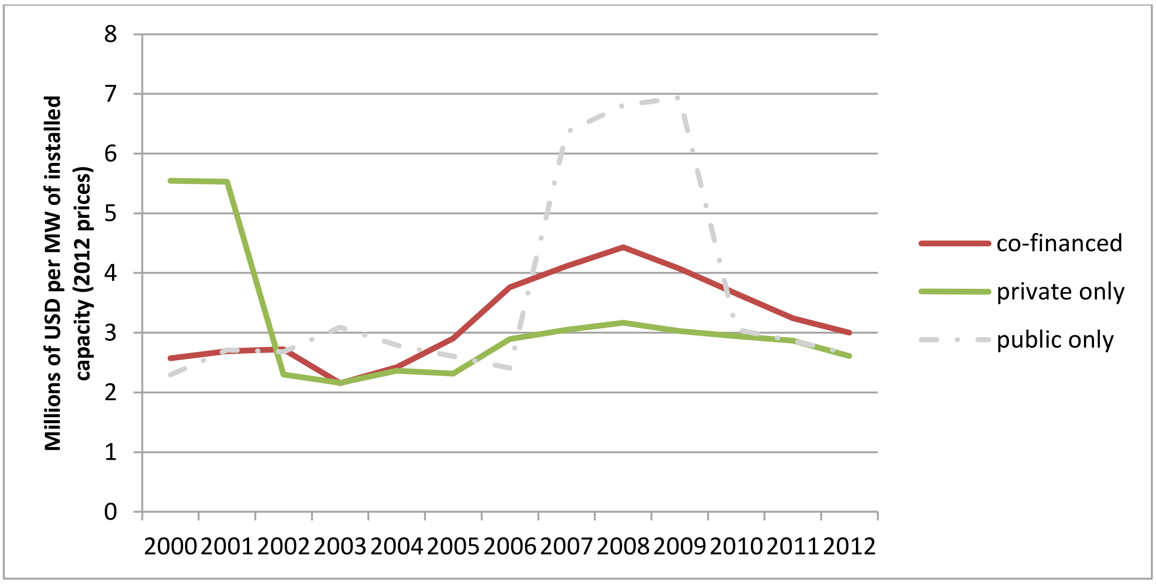
The relationship between these three data objects is rather complex at times. For instance, a project can be financed through multiple deals and, in turn, a given deal might finance multiple projects. Moreover, organisations are associated with a given project (as owner or developer) and with a given deal (as equity provider or debt provider). An organisation can take on one or several of such “roles”, and there might be multiple organisations taking on a given role. For example, there might be multiple organisations listed as developer of a project, or as debt provider in a deal.

[4] Note that the definition used by BNEF might differ from other common uses of the term “asset finance”.

To construct the dataset, the renewable energy projects were matched with the associated financial deals using BNEF's relational identifiers. Thereafter the descriptive data were retrieved on the various organisations associated with these projects and deals. This is done through name-matching (99% precision). Our full dataset contains 18927 projects associated with 19626 financial deals. They are located in one of 151 countries and span the 1977-2013 time period.

Figure 1 shows the evolution of investment per MW of installed capacity in the renewable energy sector. Interestingly, among projects in which private capital invests those with public co-financing are more costly. Moreover, projects that rely solely on public finance are sometimes less costly than such co-financed projects. However, it is not clear whether these differences truly reflect the effectiveness of the different sources of finance, or whether the differences arise due to varying propensities of private versus public finance to invest in certain renewable energy technologies (e.g. public finance might target early-stage technology development and deployment, despite its higher cost).

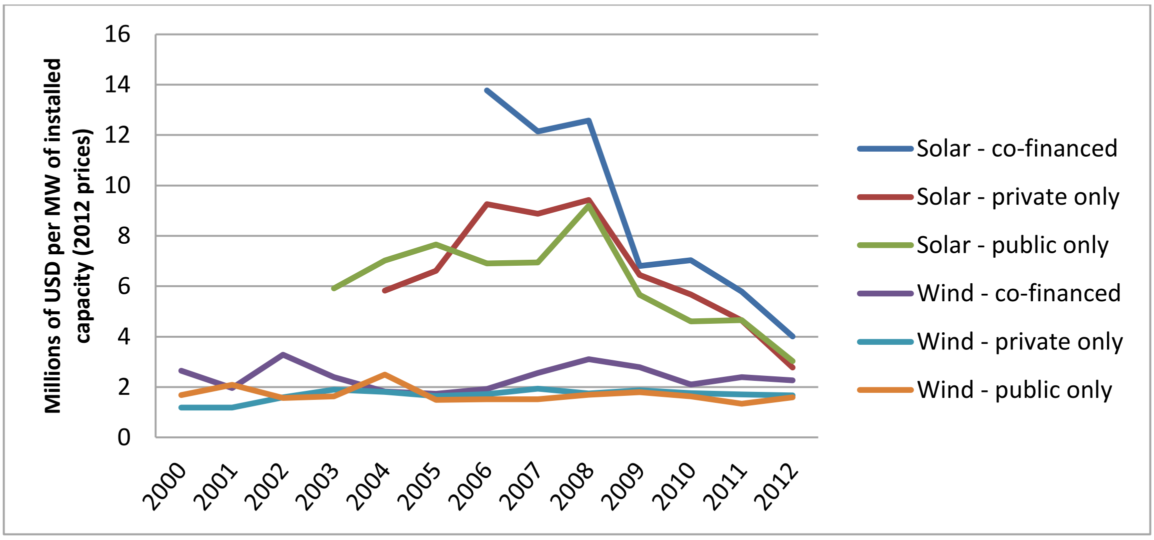
Figure 1. Unit investment costs in renewable energy (mln USD using 2012 prices)



Note: Based on the sample of 6474 projects: 77% private, 11% public, 12% co-financed; of which 48% wind, 21% solar, 14.5% biomass, 14.8% small hydro, 1.3% geothermal, 0.4% marine energy.

Figure 2 gives the investment cost per MW of installed capacity separately for solar and wind electricity generation projects. Indeed, for both of these technologies, co-financed projects are on average more costly than projects financed only from private funds. However, publicly-financed projects are even less costly than private projects. Again, it is not clear what drives the differences, and to what extent the regional distribution of publicly-financed projects plays a role (they are often located in BRIICS countries with generally lower price levels, and hence lower cost of labour, etc.). One would need to adjust for purchasing power differences to correct for such effects. Moreover, it is important to notice the rapid decline in investment costs for solar projects, compared to the steady costs observed in more mature technologies such as onshore wind. Future work will examine econometrically the determinants of the differences in investment costs.

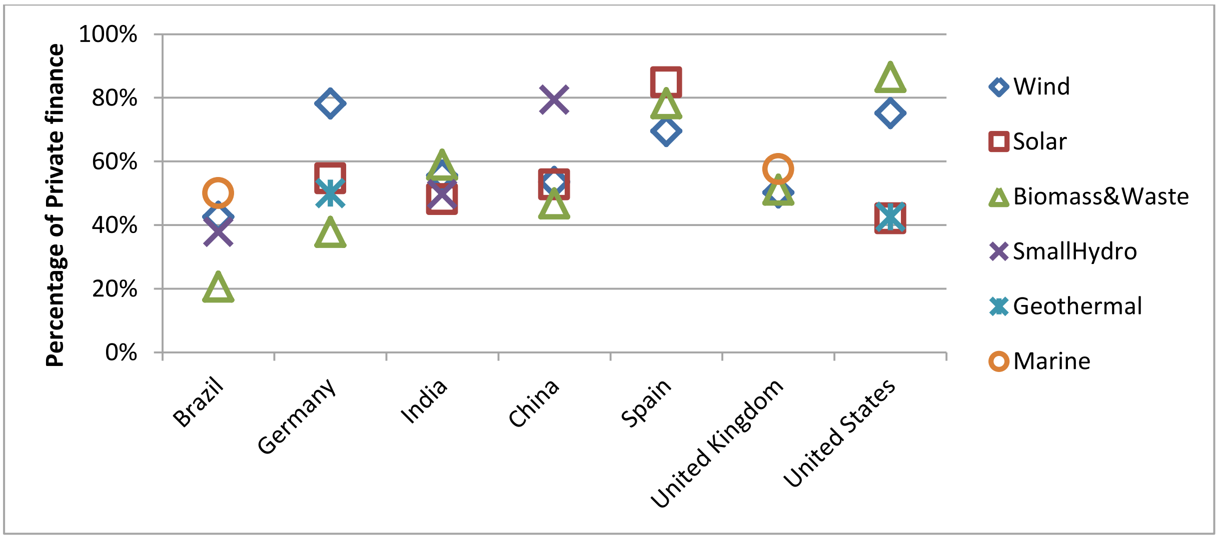
Figure 2. Unit investment costs in solar and wind energy (mln USD using 2012 prices)



Note: Based on a sample of 3104 wind projects and 1331 solar projects.

Next, we take a closer look at the co-financed projects. The share of private finance participation also varies by location (country) of the project. Figure 3 gives some of the countries that dominate the sample of co-financed projects. It illustrates the large variation in the share of private finance participation in co-financed projects. For example, particularly high shares of private participation (80%) with commensurately low shares of public finance are in German wind projects, Chinese hydro power, Spanish solar, and US biomass projects. Conversely, a particularly low share of private participation (implying high public involvement) can be observed in Brazilian biomass projects (20%). This paper examines to what extent these differences can be related to public policies in these countries.

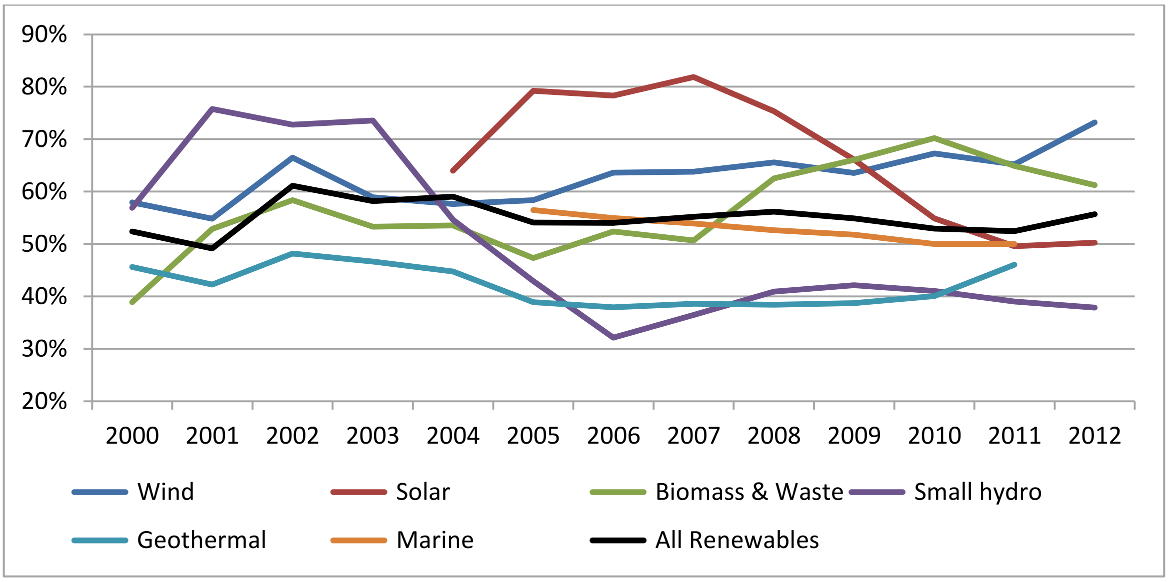
Figure 3. Participation of private finance in co-financed projects



Note: Based on a sample of 783 co-financed projects.

The share of private finance participation in such projects varies widely depending on technology employed, for example it has decreased over time in solar and small hydro projects, increased in biomass projects, and remained fairly constant in wind projects. Based on the 783 co-financed projects, the contribution from public sources is highest in geothermal energy (67%) and small hydro (63%), followed by biomass (44%), solar (43%), marine (33%) and wind energy (31%). However, this share has been varying over time. For example, in small hydro and solar energy the public finance contribution might change by as much as 50 percentage points over time, while in biomass and wind energy public finance has been relatively stable over time (Figure 4). Factors that might explain these trends are differences in upfront costs, and more generally, the overall volume of investment required and its distribution over time with respect to revenues and available financing

Figure 4. Share of private finance in co-financed projects



Note: The Figure shows 3-year moving averages, except for marine and geothermal with 5-year moving averages due to small sample sizes.

The empirical analysis is done in a restricted sample due to the availability of policy data. The estimation sample used in section 3 and 4 covers 5267 deals financing over 2446 projects in six renewable energy sectors (wind, solar, biomass, small hydropower, marine and geothermal), in 87 countries, over the 2000-2011 time-span.

2.2. Renewable energy policies

A wide variety of policy instruments have been used, varying across countries, over time and across renewable resources. To study the role of policy instrument choice for private investment we construct policy variables using two sources of data – an updated version of the OECD-EPAU Renewable Energy Policy Database (2013) and the IEA/IRENA (2013) inventory of renewable energy policies.

First, continuous variables are constructed for selected policy instruments based on the OECD Renewable Energy Policy Database (OECD-EPAU 2013) – an update and extension of the dataset originally used in Johnstone et al. (2010). We construct continuous measures of feed-in tariffs (average tariff in USD per kWh using 2011 prices) and renewable energy quotas (percent limits) for the 12-year period of the study. In countries where such policies are introduced at the regional level, the average level weighted by electricity generation is used.

Overall, there are 47 countries with one of the two instruments in place in at least one year during 2000-2011 and at least one of the sectors. There is considerable variation in countries' experience as they experimented with various combinations of approaches at different points in time. While some countries have had feed-in tariffs (FIT) in place continuously throughout the entire 2000-2011 period (e.g. Germany, Spain, Portugal, China, Argentina, India), others have only introduced them recently (e.g. Indonesia, Uruguay, Malaysia, Japan, Finland). Similarly, renewable energy quotas (REQ) have been in place in the USA throughout the time period, while introduced in India and Spain only recently. Finally, while some countries initially introduced feed-in tariffs and later switched to quotas (e.g. Sweden, Italy), there are others where quotas were later complemented with feed-in tariffs or premiums (e.g. Australia, India, Italy, Poland, UK, Japan, Spain, and USA).

Second, binary variables are constructed indicating the presence of a policy instrument or measure, by country, year and sector, based on information obtained from the Policies and Measures Database maintained jointly by the International Energy Agency and the International Renewable Energy Agency (IEA/IRENA 2013). The IEA and the IRENA maintain an inventory with information on more than 1300 renewable energy policies in 92 countries, classified with respect to the targeted sector (e.g. biofuels for transport, biomass for power), the policy type and its status (described below). The policy instruments and measures are constructed for each of the six renewable energy sectors. Ideally, the "policies" included in the database would describe a specific policy instrument or measure targeting selected sectors. Converting such records into binary variables is straightforward. However, the difficulty arises when records represent broader policies (e.g. strategies, programmes, initiatives) and thus are potentially applicable to multiple sectors and policy types, or when policies are not coded at a sufficiently detailed level in the database. Records that are classified as applicable to multiple renewable energy sectors are, most often, programmes that truly have implications for many renewable energy sectors (e.g. Norway's CO2 tax on mineral products). In this paper some of those entries are considered – those applicable to "all" sources and to "power" – to generate our policy dummies. It is investigated separately whether our findings vary from those when such records are not included, concluding that this has no significant impact on our results.

The inventory presents information from 92 countries. While most records in the database represent national policies (60%) there are a large number of "supranational" policies (35%) – e.g. multilateral technology platforms and EU-level policies to be implemented by individual member states. In this paper, such records are excluded because individual countries may choose to employ different policy instruments to achieve the same objectives (concerning the six policy types used in this paper, this effectively amounts to excluding only four records). The remaining records (5%) represent "state/regional" policies and clearly the coverage of state/regional policies in the IEA/IRENA database is much less complete than for national policies. It is tested whether inclusion of such policies affects our findings compared to those when such records are not included and we conclude that this is indeed the case. For this reason, in this paper such state/regional policies are not considered. Our policy dummies thus represent "national" policies. Finally, for each policy, its current implementation status is reported ("planned", "in force", "ended", "and superseded"). This status is then used to attribute a start / end date of a policy, allowing us to validate its existence over time.

This paper focuses on those policies that have a potential to provide significant investment incentives, including tax relief/credits, support programmes for technology deployment and diffusion, and support for technology demonstration projects.[5] The variables are constructed for each of the six renewable energy sectors, by year and country.

[5] Demonstration projects are part of the pre-commercial stage of technology development, they are usually large single events (projects) intended to 'demonstrate' the mitigation potential of a technology (not necessarily its commercialization potential). On the other hand, technology deployment and diffusion are generally programmes directed to households and firms to encourage adoption of new technologies (the commercialization stage).

Overall, there are 36 countries with support in one of the selected 3 policy instruments in at least one year during 2000-2011 and at least one of the six sectors. Support for technology demonstration/ Tax Relief are among the most common (27 and 23 countries, respectively), followed by Technology Deployment and Diffusion (11).

2.3. Capital market imperfections

Capital market imperfections hamper the ability of firms to raise private finance for investment in renewable energy. In an attempt to evaluate the effect of such imperfections on private investment and understand their role in policy instrument choice, the "credit depth of information" is used as a proxy to capture the magnitude of such imperfections. The index, developed by the World Bank, measures the rules affecting the scope, accessibility and quality of credit information available through public registry or private bureau. The index ranges from 0 to 6, with higher values indicating availability of more credit information in a given country. It is expected to find a positive sign of this variable because higher levels of credit information will generally facilitate attracting private investment. The index was first introduced in 2004 and in order to cover the entire time-frame of this paper missing values were extrapolated backwards using the last available value.[6] For the countries included in our analysis the average CMDI index has risen from 3.44 in 2004 to 4.9 in 2011. Moreover, higher income countries have on average more credit information (index = 5.4) whereas middle and low income countries have an index between 2.6 and 4.

3. ESTIMATION METHODOLOGY AND SAMPLE STATISTICS

3.1 Model

Financial transactions are classified as private or public according to the ownership status of the organisations that provided the debt or equity financing. Deals are classified as "public" if the funds are provided via direct government spending or state-owned enterprises; they are classified as "private" if the funds are provided by family-controlled enterprises, quoted companies, joint ventures, consortia, partnerships, pre-institutional funding[7], special purpose vehicles, individual/angel network, subsidiaries and firms funded with private equity or venture capital.[8] The amount of private finance funds in a deal is then obtained as the disclosed transaction value of a deal coming from private providers of debt or equity. To explain the variation of the amount of private finance in a deal, we specify the following equation:

[6] We explore additional sources of data: i) the World Bank's indicator of "ease of doing business"; ii) IMF's "number of other depository corporations" such as commercial banks, credit unions, etc.; iii) "number of branches" (by the IMF) that includes all units of each type of reporting institution that provide financial services to customer; and iv) "interest rate spread" by the IMF. Unfortunately, due to many missing values and limited country and time coverage we are not able to incorporate most of these variables in the analysis.

[7] Defined as companies that have been set up, usually to commercialise intellectual property or technology, but are either at a very early stage or have not yet risen funding from an incubator, venture capital, private equity company or corporate venturer. They may be spin-outs from a university, company or other organisation, or they may have just been founded by an entrepreneur to exploit a market need (BNEF 2012).

[8] Two organisation types – charity/non-profit association and defunct – are excluded from the classification. They concern a very small share of organisations – 0.51% of debt providers and 1.74% of equity providers. Their volumes of finance cannot be attributed to a private or public classification.

$$PrivateFinance_d = \beta_0 + \boldsymbol{\beta_1'}\boldsymbol{DEAL}_d + \boldsymbol{\beta_2'}\boldsymbol{PROJECT}_d + \boldsymbol{\beta_3'}\boldsymbol{ORG}_d + \boldsymbol{\beta_4'}\boldsymbol{POLICY}_d + \epsilon_d \qquad [1]$$

where d (=1,…, D) indexes the financial deals. As explanatory variables we include vectors (shown in bold) of attributes that describe the deal itself, the related projects and organisations, as well as the policy conditions.

$DEAL_d$ is a vector of deal characteristics such as "date of close" (year), deal status (announced, completed, abandoned) and investment type (new build, acquisition, refinancing). A variable is included to measure the "gearing ratio", defined as the share of debt on the total value of the deal (debt + equity). The gearing ratio is a measure of exposure to debt, and as such, it is used as a measure of exposure to financial risk.[9] The expected sign of this variable is negative. Also, we include variables describing the term in years of the long-term debt (Tranche A Tenor) and the associated interest rate to be paid measured as spread in basis points over the interbank rate (Tranche A Pricing). A variable is included that measures the generation capacity (in megawatts) financed by the deal. This is a control variable to capture the effect of scale, and the expected sign is thus positive.

Finally, as mentioned above, in some cases a deal provides financing for multiple projects. We would expect such deals to have greater value due to greater diversification of project risk and expect the sign to be positive.

$PROJECT_d$ is a vector of characteristics of the project being financed by deal d, such characteristics are the physical location (country) and the generation technology (sector). ORG_d is a vector of characteristics of the organisations associated with the deal such as the number of debt-providers and the number of equity-providers. $POLICY_d$ is a vector of variables representing the various policy instruments and measures aimed at encouraging investment in renewable energy projects. Although the deals included in our sample span a certain window, they were "closed" at a given date and thus can be associated with a policy framework that was in force in that year, country and sector. We include continuous variables of feed-in tariffs (FITs) and renewable energy quotas (REQs) and binary variables of tax relief/credits, support programmes for technology deployment and diffusion, and support for technology demonstration projects.

In addition, we also test other alternative variables. Namely, we run model specifications including proxies for credit market imperfections, such as credit depth of information (index from 0 to 6), ease of doing business (ranking of countries), interest rate spread, the number of depository corporations per capita, and the number of branches of financial corporations per capita. Many missing values and high correlation between these variables make it difficult to incorporate most of these variables in the model.[10] As a result, we only include the Credit Market Depth of Information (CMDI). The index is expected to have a positive impact on private finance.

Turning back to equation [1], we also include country, year and sector dummies in order to isolate specific contextual effects. With the estimation of this model, we wish to explain the variations in the amount of private finance provided. Consequently, all deals that comprise the estimation sample receive a positive amount of private financing. We use ordinary least squares with robust standard errors to estimate the model. The remaining variation in the dependent variable is consequently represented as an error term (ϵ_d), assumed to be normally distributed. All variables that

[9] Financial risk refers to the risk of default on borrowed funds. This is different from risk of an investment (or "project risk") that does not depend on the way it is financed.

[10] For example, there are very few observations for number of ODCs and branches, reducing the estimation sample by 75%. The ease of doing business rank is highly correlated with credit depth of information and interest rate spread, causing collinearity in the model. Finally, concerning interest rate spread there are no data for the key countries, such as the United States, the United Kingdom, and other European countries which are not covered after year 2003.

are spanned on large scales and exhibit high skewness (financial amounts, generation capacity) are rescaled using, as discussed and motivated below, the Inverse Hyperbolic Sine (IHS) transformation instead of a classic logarithmic transformation.

The deal level is appropriate to examine the role of public policy on private finance. However, recognising the potentially endogenous role of public finance in inducing private financial investment we undertake further analysis. In order to model private and public finance simultaneously the analysis is undertaken at the level of the project. This approach is adopted because multiple deals might be used to finance a single project, but public financing might not be involved in every single deal. Moreover, public funding agencies might be interested in securing the completion of projects as a whole, and not just in the characteristics of a specific deal. For these reasons, the analysis of the effect of public finance on private investment in renewable energy should be conducted at the project level, controlling for the effect of other policy instruments (e.g. FITs).

In order to generate our dependent variables, a measure of the private finance allocated at the level of the project, $PrivateFinance_p$, is constructed by aggregating across all deals associated with a given project as shown in [2]. This variable is the sum of the private finance transaction values of all deals associated with project p, $PrivateFinance_d$, where d (=1,…,D^p) indexes the deals associated with project p:

$$PrivateFinance_p = \sum_{d=1}^{D^p} PrivateFinance_d \qquad [2]$$

The measure of public finance, $PublicFinance_p$, directed towards a project is calculated in a similar manner as the total disclosed transaction value of finance originating from public sources in all deals associated with project p. Thus, the sum of these two variables equals the total value of the project (valued in terms of investment costs).

Thus, as mentioned above, we expect $PublicFinance_p$ to be endogenous with respect to $PrivateFinance_p$ and similarly, $PrivateFinance_p$ to be endogenous with respect to $PublicFinance_p$. Presumably investors will strive to secure the total financing of a project before closing the first deal[11], implying that private and public decisions of investment occur contemporaneously in the financing process. Thus, a correct specification is one that allows for simultaneity and two-way causality:

$$\begin{aligned} PubFinance_p &= \gamma_1 PrivFinance_p + \alpha_{1,0} + \boldsymbol{\alpha'_{1,1} POL_p} + \boldsymbol{\alpha'_{1,2} PROJ_p} + \boldsymbol{\alpha'_{1,3} ORG_{1,p}} + \boldsymbol{\alpha'_{1,4} GOV_p} + u_{1,p} \\ PrivFinance_p &= \gamma_2 PubFinance_p + \alpha_{2,0} + \boldsymbol{\alpha'_{2,1} POL_p} + \boldsymbol{\alpha'_{2,2} PROJ_p} + \boldsymbol{\alpha'_{2,3} ORG_{2,p}} + u_{2,p} \end{aligned} \qquad [3]$$

where i (=1,2) indexes equations and p (=1,…,P) indexes projects. Construction of variables in the POL_p and $PROJ_p$ vectors is the same as discussed in the deal-level analysis above.[12] Concerning the ORG_p vector, we include the *percentage of local developers*, the *average number of past projects*

[11] We only include projects for which all the deals were for "new build" and whose status is "completed", excluding projects with deal status abandoned, planned and refinancing deals.

[12] Assignment of policy variables to projects could be problematic because we aggregate different deals that may have occurred at different dates. However, 77% of the projects are financed by deals closed in the same year and 20% more are financed by deals closed over a 2 or 3 year time span; thus, taking into account the financing year of the project does not present major concerns to our assumptions on the policy framework.

handled by developers and the *owner(s)' average exposure to 'new energy' projects*[13], such organisational characteristics are expressed in percentage terms as there might be multiple organisations listed as project owners or developers.

In addition, GOV_p is a vector that captures some of the budget constraints faced by public entities as a determinant of public investment.[14] We use the World Bank database to construct lagged *government surplus* and current *government expenditures*, both expressed as a percentage of GDP. We expect a positive impact on both the decision to invest in a given project and the size of public investment. Availability of such data is rather limited and this restricts our estimation sample considerably. For example, we must exclude most projects carried out in China since public surplus and expenditure data are only available for years 2003 and 2004.

Recall that the aim is to analyse the impact of private finance on public finance and reciprocally the impact of public finance on private finance. Estimation of the simultaneous equations model [3] allows to do this, provided that the sets of explanatory variables are different in the two equations (identification condition). Estimation is consistent and unbiased under the assumption that explanatory variables are uncorrelated with the residual u_i. Finally, residual U is assumed to follow a bivariate normal distribution that allows for correlation between its two univariate components u_1 and u_2[15].

Moreover, as all projects do not receive both public and private financing, a problem of censoring in the dependent variables has to be addressed. Indeed, zeros (no financing) have a fundamentally different meaning than positive levels of financing. Following the work by Tobin (1958), we address censoring by the use of a Tobit estimation procedure[16]. Tobit comprises a probit analysing the determinants of the investment decision, and an ordinary least squares of the determinants of the investment volume.

Theoretically, the estimation of a simultaneous equation system on the full sample would require to fully account for the censoring of both public and private finance (tobit-tobit estimation). However, as 96% of the projects receive private financing[17], the probit step for the variable $PrivateFinance_p$ would not be robust. We therefore exclude projects that are solely funded through public channels and this eliminates the censoring in $PrivateFinance_p$. We thus consider the estimation of a simultaneous tobit-linear model[18] on the sample of projects with private participation i.e. 2357 projects in which every project receives a strictly positive amount of private finance ("private sample" hereafter). Our choice of model and our estimation procedure are derived from the contributions of Amemiya (1974 and 1979) and Nelson and Olson (1977) that extend the use of Tobit to simultaneous equations models.

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[13] According to BNEF metadata, exposure to new energy is itself measured by the percentage of funds raised by the organisation to be spent in "new energy" activities.

[14] Public finance may originate from other public entities than governments. The variables can thus be considered as proxies that measure public spending and public budget.

[15] See Greene (2008, 10.6: 314-336) for details on the identification condition or on the econometric analysis of simultaneous equation models.

[16] Tobit is formally based on the introduction of a latent variable for the dependent variable and on likelihood maximization.

[17] Our sample is composed of 2446 projects that fall into three different subsamples depending on the source of finance: 1933 projects that receive solely private financing (79%), 424 co-financed projects (17.4%), and 89 projects solely financed by public investors (3.6%).

[18] Estimations are carried out using aML software (Lillard and Constantijn 2003).

Furthermore, for a small subsample of projects, private and public financing are both strictly positive (i.e. there is no censoring). In this "co-financed sample" we are therefore able to estimate a simultaneous bivariate linear model. This subsample estimation is relevant for the analysis of the specific characteristics of such targeted projects and their differences with respect to the private sample. Reported estimation results are based on estimation using the full information likelihood (FIML) method in Stata.[19]

Wealth or investment data are often skewed, meaning that small values are more frequent than what would be the case under normal (Gaussian) distribution. Therefore, a common practice is the use of a log transformation to rescale variables and consequently reduce the skewness in the data. However, the presence of zeros renders impossible the use of a log transformation. In addition, low values (thus in the very steep part of the log function) imply that a log transformation might not be the best choice to reduce skewness. We therefore opt for the Inverted Hyperbolic Sine (IHS) transformation[20] which is defined for any positive values (zero included), and is equivalent to a log function for reasonable values[21]. Hence, it allows for similar interpretation as when using a log transformation (e.g. in terms of elasticity).[22] We apply the IHS transformation on three variables: Public Finance, Private Finance and Capacity. Public and private finance take on large values (refer to Table 3) when strictly positive, so the approximation holds. For the sake of parsimony we also apply the IHS transformation in deal-level estimations.[23]

[19] For FIML see Koopmans, Rubin, Leipnik (1950). An alternative estimation method is the three-stage least squares (3SLS), see Zellner and Theil (1962). Asymptotic equivalence of these methods under a set of assumptions has been established by Sargan (1964). Here, results of both methods are highly similar.

[20] The Inverse Hyperbolic Sine transformation is defined for positive values by:

$$ihs(y)=\ln(y+\sqrt{(1+y^2)}) \approx \ln(2y) = \ln(2)+\ln(y)$$

[21] Equivalence is already quite accurate for $y \geq 2$ and can be considered as very accurate for $y \geq 3$ since values differ by less than 1% after this threshold.

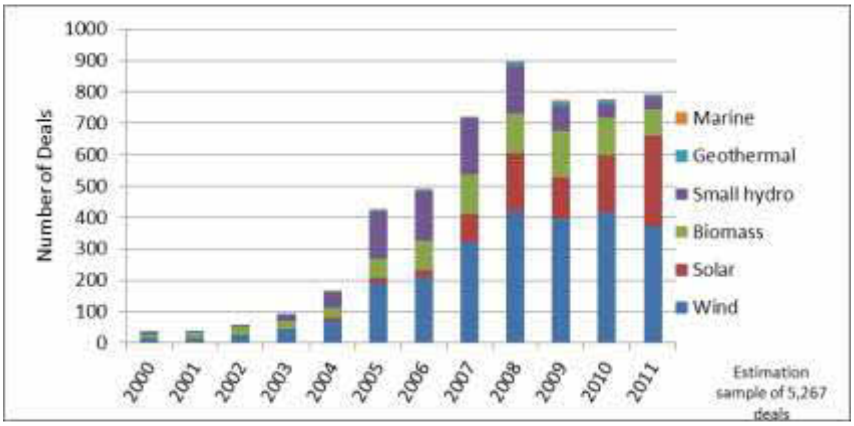
[22] See Burbidge et al. (1988) for a discussion of econometric properties. See Pence (2006) for an application to wealth data.

[23] Estimation results of the project-level analysis do not differ when using IHS or a log transformation – we refer to a translated log transformation: log (1+x).

3.2 Sample statistics

At the level of the deal, wind energy (47%) is the most frequent sector followed by solar (18%), biomass (17%), small hydro (16%), geothermal (1.6%) and marine energy (0.4%). Following a slow start, the number of deals increased substantially in 2005 to attain a maximum in 2008, and remained stable in recent years (Figure 5).

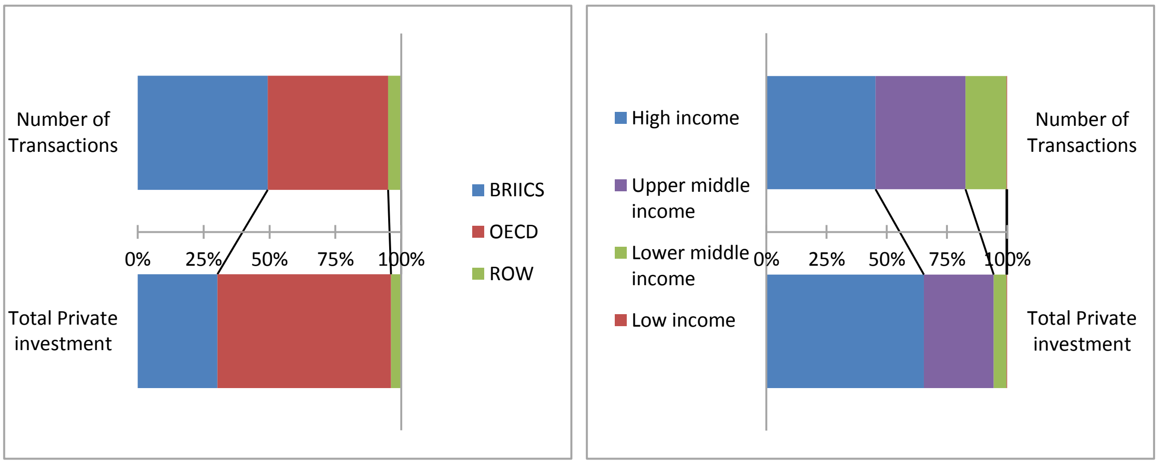
Figure 5. Sample statistics: Number of asset finance deals by year and sector



In total, 87 countries are represented, with China, India and the United States as the most frequent locations, followed by Spain, Germany, the UK and Brazil. Overall, almost half of the sample is located in Asia (48%), followed by Europe (29%), North America (14%) and the rest of the world. While BRIICS (Brazil, Russia, India, Indonesia, China, South Africa) countries dominate the sample in terms of number of deals (49% against 45% of transactions by OECD countries), OECD countries take the lead in terms of total volume of private investment (66% of private finance versus 30% in BRIICS countries)[24]. Fund providers from high-income countries represent 47% of the transactions in the sample and 65% of the total value of private investment (Figure 6).

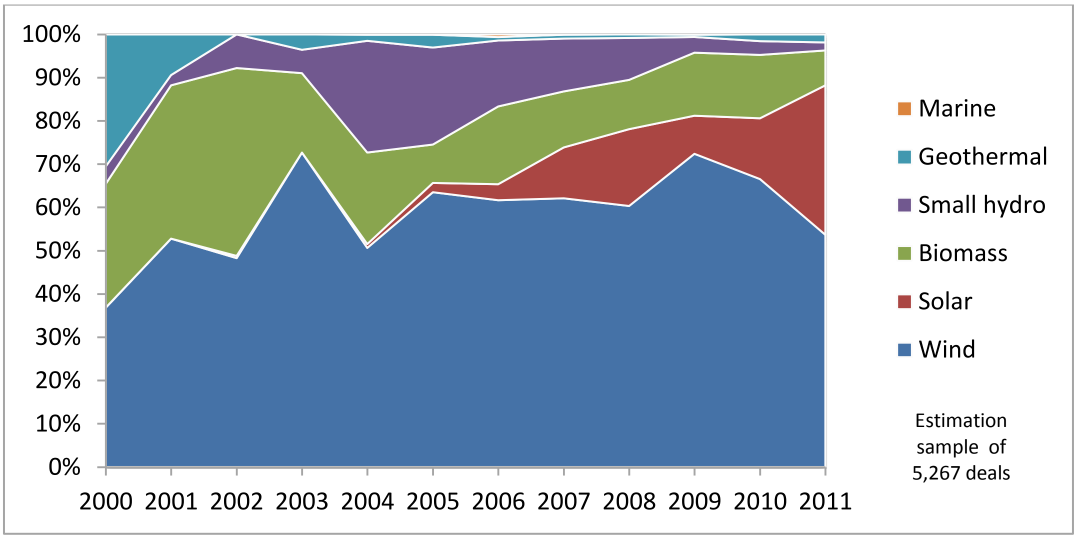
[24] The remaining countries represent 3.8% in terms of private finance volume, and 4.9% in terms of number of transactions.

Figure 6. Sample statistics: Number of transactions and volume of private finance by country and income group



In terms of their dollar value, about one half of all deals were in wind energy and this share has been more-or-less stable over 2000-2011. Biomass was the second most important sector in the first half of the decade, progressively replaced by solar energy towards the end of the decade (Figure 7).

Figure 7. Sample statistics: Share of sectors in total private investment on renewable energy



Based on the estimation sample, the average value of a (private) deal has risen over time starting from below USD 37 million in 2000 to almost USD 56 million in 2011 (in constant 2012 prices). On average, deal values are lowest in marine energy and highest in solar and wind energy, although in 2011 geothermal came first. Summary statistics for deal-level models are presented in Table 1.

Table 1. Summary statistics for deal-level models

Variable	N	Mean	Std. Dev.	Min	Max
PrivateFinance_Deal (million USD)	5267	72.35	150.43	0.1	2995
PrivateFinance_Deal (IHS transformed)	5267	4.04	1.41	0.1	8.7
CapacityFinanced_Deal (MW)	5267	45.78	92.45	0.002	2015
CapacityFinanced_Deal (IHS transformed)	5267	3.61	1.39	0.002	8.3
Deal Status – Announced	5267	0.0002	0.01	0	1
Deal Status – Completed	5267	0.99	0.1	0	1
Deal Status – Abandoned	5267	0.01	0.1	0	1
Transaction Type – New Build	5267	0.87	0.34	0	1
Transaction Type – Acquisition	5267	0.08	0.28	0	1
Transaction Type – Refinancing	5267	0.05	0.22	0	1
Gearing Ratio	5267	0.22	0.37	0	1
Tranche A Tenor	5267	1.62	5.48	0	40
Tranche A Pricing	5267	27.56	165.46	0	1525
Nb. of Debt Providers	5267	1.25	0.99	1	16
Nb. of Equity Providers	5267	1.15	0.46	1	8
Nb. of Projects Financed	5267	1.32	1.73	1	31
Policy variables (continuous)					
Feed-in Tariffs (USD)	5267	0.1	0.17	0	1.599
Renewable Energy Quotas	5267	0.02	0.03	0	0.182
Policy variables (binary)					
Tax relief/credit	5267	0.56	0.5	0	1
Technology Demonstration	5267	0.14	0.35	0	1
Technology Deployment & Diffusion	5267	0.35	0.48	0	1
Credit market imperfections					
Credit Depth of Information index	5264	4.67	1.04	0	6

Our project-level sample is composed by 2446 projects that fall into three different subsamples depending on the source of finance: 1933 projects that receive solely private financing (79%), 424 co-financed projects (17.4%), and 89 projects solely financed by public investors (3.6%). Summary statistics for project-level models are provided in Tables 2-3.

Table 2. Summary statistics – sample of private projects

Private projects	N	Mean	Std. Dev.	Min	Max
Dependent variables					
PubFinance (million USD)	2357	9.48	54.18	0	1200
PubFinance (IHS transformed)	2357	0.70	1.57	0	7.78
PrivFinance (million USD)	2357	69.22	125.12	0.13	1467.4
PrivFinance (IHS transformed)	2357	3.96	1.44	0.13	7.98
Project characteristics					
Capacity (MW)	2357	31.84	48.78	0.013	600
Capacity (IHS transformed)	2357	3.34	1.36	0.013	7.09
Project Status - Commissioned	2357	0.98	0.13	0	1
Project Status - Planned	2357	0.02	0.13	0	1
Organisations characteristics					
Owners' Exposure to New Energy	2357	0.67	0.16	0.093	0.75
Local developers share	2357	0.85	0.35	0	1
Developers Past Projects	2357	8.70	15.47	1	102
Developers Past Projects (log transformed)	2357	1.29	1.23	0	4.62
Policy variables (continuous)					
Feed-in Tariffs (USD)	2357	0.13	0.20	0	1.60
Renewable Energy Quotas (% limit)	2357	0.03	0.04	0	0.18
Policy variables (binary)					
Tax relief/credit	2357	0.49	0.50	0	1
Technology Demonstration	2357	0.21	0.41	0	1
Technology Deployment & Diffusion	2357	0.57	0.50	0	1
Public budget determinants					
Expenditures (% of GDP)	2357	27.98	9.76	10.45	52.09
Surplus (% of GDP)	2357	-2.66	3.48	-30.93	20.01
Regions					
OECD	2357	0.71	0.45	0	1
BRIICS	2357	0.25	0.43	0	1

Table 3. Summary statistics – sub-sample of co-financed projects

Co-financed projects	**N**	**Mean**	**Std. Dev.**	**Min**	**Max**
Dependent variables					
PubFinance (million USD)	424	52.69	118.60	0.225	1200
PubFinance (IHS transformed)	424	3.87	1.19	0.223	7.78
PrivFinance (million USD)	424	82.54	156.06	0.225	1467.38
PrivFinance (IHS transformed)	424	3.97	1.52	0.223	7.98
Project characteristics					
Capacity (MW)	424	43.04	55.18	0.02	420
Capacity (IHS transformed)	424	3.85	1.16	0.02	6.73
Project Status - Commissioned	424	0.99	0.08	0	1
Project Status - Planned	424	0.01	0.08	0	1
Organisations characteristics					
Owners Exposure to New Energy	424	0.62	0.20	0.093	0.75
Local Developers %	424	0.91	0.27	0	1
Developers Past Projects	424	7.39	11.69	1	80
Developers Past Projects (log transformed)	424	1.31	1.10	0	4.38
Policy variables (continuous)					
Feed-in Tariffs (USD)	424	0.06	0.16	0	1.60
Renewable Energy Quotas (%)	424	0.02	0.04	0	0.14
Policy variables (binary)					
Tax relief/credit	424	0.34	0.47	0	1
Technology Demonstration	424	0.19	0.40	0	1
Technology Deployment & Diffusion	424	0.42	0.49	0	1
Public budget determinants					
Expenditures (% of GDP)	424	27.10	7.19	10.45	49.79
Surplus (% of GDP)	424	-2.84	3.70	-30.93	20.01
Regions					
OECD	424	0.49	0.50	0	1
BRIICS	424	0.45	0.50	0	1

4. EMPIRICAL RESULTS

Several alternative model specifications are estimated based on equation [1]. Table 4 presents the estimated coefficients together with robust standard errors. We first estimate the base model (D1). The regression achieves a rather high goodness-of-fit (R-squared = 0.77) and results are consistent with prior expectations. For example, deals that finance projects with bigger generation capacity also tend to be bigger in dollar terms. Deals for "new build" tend to be bigger than acquisition or refinancing deals. Greater exposure to debt (gearing ratio) increases financial risk, and hence lowers the value of deals. Finally, deals that involve multiple providers of debt financing, or those that finance multiple projects, tend to be bigger in dollar value.

Our interest is primarily directed at the results related to our principal research questions – the role of public policy. The coefficient estimates of both feed-in tariff and of tax relief/credit measures are positive and highly statistically significant, while the effect of renewable energy quotas is statistically insignificant (model D1).[25] Similarly, neither of the technology support variables is significant.[26]

What is the rationale to explain these findings? There are two elements to the answer – how governments address the environmental externality and what is done to alleviate the additional capital market imperfections. First, it is possible that different types of instruments might not generally be of an equivalent degree of ambition in achieving environmental objectives, for instance, with quota schemes likely to be less ambitious than many feed-in tariff schemes. This might be due to differences in countries' underlying environmental policy objectives, but equally important there might be differences in the suitability of an instrument as a means to overcome political obstacles and gain public acceptance for ambitious policy objectives. Second, some policy instrument types might be better suited to deal with the specific capital market imperfections relevant for renewables projects (see discussion in the Introduction). For example, feed-in tariff or tax credit schemes might provide a more predictable revenue stream for project owners and developers, in contrast to alternative instruments such as the various quota-based schemes, that might be more illiquid and opaque (e.g. over-the-counter transactions) making it difficult for investors to assess future revenue streams.

The sample statistics suggest a certain dominance of China in our sample. To test for the robustness of our results we estimate the same specification as in D1 on a sample excluding China (model D2). Policy and control variables keep their sign and significance; the only noteworthy change is a positive and significant correlation of technology demonstration with private finance.

[25] These findings are robust to exclusion of potential outliers. To test this, the first and the last percentile of observations are excluded from the sample (and also the first 5% and the last 5%) and the results are qualitatively the same for feed-in tariffs and tax relief (not reported here).

[26] In an alternative specification, we also test inclusion of a variable representing the growth in a country's electricity consumption as a measure of changing market opportunities. We do not report the results because the variable is never statistically significant.

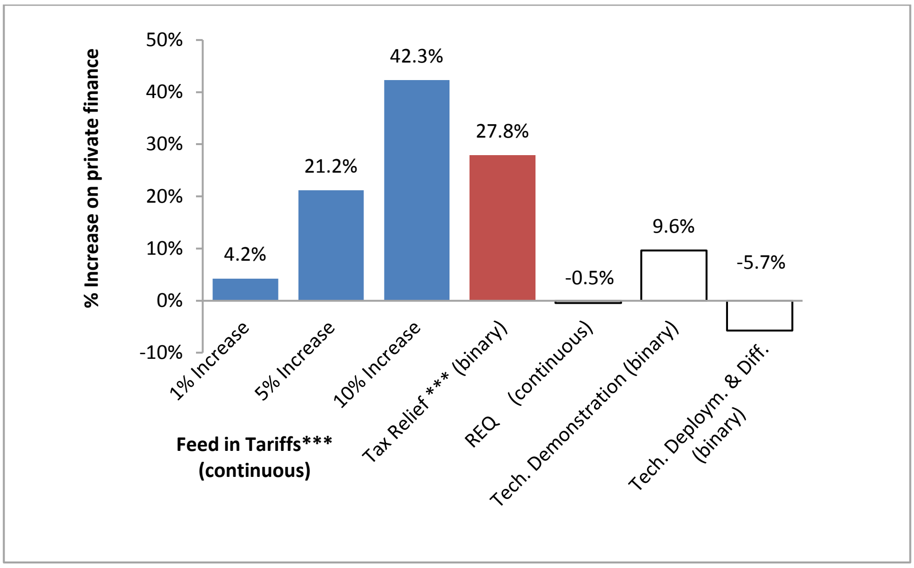
Table 4. Deal-level regression estimates – base model specification

Dependent variable: PrivateFinance_Deal (IHS transformed)	(D1)	(D2) excl. China	(D3) with CMDI
Capacity Financed (IHS transformed)	0.8584***	0.8499***	0.8584***
	[0.0119]	[0.0130]	[0.0119]
Deal Status – Completed	(base)	(base)	(base)
Deal Status – Announced	0.1405***		0.1402***
	[0.0285]		[0.0286]
Deal Status – Abandoned	0.0019	0.0748	0.0016
	[0.1122]	[0.1219]	[0.1121]
Transaction Type – New Build	(base)	(base)	(base)
Transaction Type – Acquisition	-0.9412***	-0.8962***	-0.9411***
	[0.0646]	[0.0669]	[0.0646]
Transaction Type – Refinancing	-0.5987***	-0.5816***	-0.5988***
	[0.0638]	[0.0656]	[0.0638]
Gearing Ratio	-0.0733*	-0.0629	-0.0734*
	[0.0384]	[0.0393]	[0.0385]
Tranche A Tenor	0.0107***	0.0107***	0.0107***
	[0.0026]	[0.0028]	[0.0026]
Tranche A Pricing	-0.0001	-0.0001	-0.0001
	[0.0001]	[0.0001]	[0.0001]
Nb. of Debt Providers	0.0579***	0.0620***	0.0578***
	[0.0106]	[0.0106]	[0.0106]
Nb. of Equity Providers	-0.0825***	-0.0634**	-0.0824***
	[0.0254]	[0.0308]	[0.0254]
Nb. of Projects Financed	0.0167**	0.0172**	0.0167**
	[0.0079]	[0.0080]	[0.0079]
Feed-in Tariffs (continuous)	0.4190***	0.4408***	0.4183***
	[0.1139]	[0.1405]	[0.1139]
Tax Relief (binary)	0.2784***	0.1493**	0.2802***
	[0.0484]	[0.0610]	[0.0488]
Renewable Energy Quotas (continuous)	-0.254	0.5336	-0.2297
	[0.9369]	[1.1078]	[0.9409]
Tech. Demonstration (binary)	0.078	0.0930*	0.0754
	[0.0535]	[0.0553]	[0.0547]
Tech. Deployment & Diffusion (binary)	-0.0591	-0.0356	-0.0636
	[0.0671]	[0.0688]	[0.0696]
Credit Market Depth of Information			-0.0066
			[0.0189]
Country dummies	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
Sector dummies	Yes	Yes	Yes
Nb. of Observations	5267	3706	5264
Adjusted R-squared	0.7679	0.7667	0.7731

Note: * 10%, ** 5%, *** 1% significance levels. Robust standard errors presented in brackets. For categorical variables "base" indicates the reference level.

So far we have discussed statistical significance of the explanatory variables. However, what can we say about the magnitude of the effects? The estimated elasticities from model D1 (Figure 8) tell us that a 1% increase of the feed-in tariff offered to investors induces, on average, 4.2% more private finance investment. Moreover, the introduction of a tax relief/credit scheme induces on average 27.84% more private investment. Combining both results we infer that the introduction of tax relief for renewable energy investments is, on average, equivalent to a 6.6% increase in a feed in tariff.[27]

Figure 8. Effect of the policy instrument choice on private investment – model D1



Note: * 10%, ** 5%, *** 1% significance levels. For binary policy variables the value indicates the average effect of the inclusion of a policy on private finance. Empty bars indicate no statistical significance at 10%.

Finally, we take the base model and include the credit depth of information index (model D3). However the estimated coefficient of this variable is not significant, suggesting that our proxy for capital market imperfections does not have an appreciable effect on private investment in renewables overall. As explained above, we are not able to find more suitable data to measure such imperfections. Below, we return to this subject using sector-specific regressions, and we see that under certain conditions the availability of credit market information has a significant impact on private investment.

A concern with our base model specification could be the potential endogeneity of the policy variables with respect to private finance. For instance, awareness of environmental issues could be at the origin of greater private investments as well as greater support of public policies to promote green investments. If this were the case, then, estimates presented would be biased. Therefore, a two-stage least squares (2SLS) regression is implemented by instrumenting the continuous policy variables for FIT and REQ (using model D1 from Table 4). We follow the work of Nicolli and Vona (2012) to specify the determinants of environmental policy instrument choice, such as GDP per capita (level and square term), government expenditures and surplus (as a percentage of GDP). Restricted data availability of such indicators means that the 2SLS estimation is based on a subsample of countries. We also test for the inclusion of credit market proxies (credit depth of information index and ease of doing business index) because existence of credit market imperfections might motivate the introduction of renewables policies. Both, the first- and the second-stage regressions achieve a

[27] For an accurate interpretation of the results, the coefficient of dummy variable has been corrected following the work of Halvorsen and Palmquist (1980).

satisfactory goodness of fit (R^2 of 87% and 90%), results of the 2SLS estimation (not reported) do not greatly differ from those of the base model (D1 in Table 4) estimated on the same subsample. This would suggest that FITs and REQs are exogenous. This is confirmed by a Hausman test for endogeneity.

Next, we take the base model (D1) and we study the effect of renewable energy policies by groups of countries as the impact of renewables policies on private finance might vary by country context. The estimates of group-specific effects of policy variables are reported in Table 5.[28] We find that higher feed-in-tariffs are correlated with larger amounts of private finance in OECD countries (1% significance level), but not elsewhere in the world. Conversely, it is in BRIICS countries where we find a positive and significant correlation between the introduction of tax relief policies and private investment in renewable energy. For quota schemes, there is no evidence of an effect in either of the country groups.

Table 5. Deal-level regression estimates with country group-specific effects

Policy × Country group	OECD	BRIICS	ROW
FIT (continuous)	0.4045***	-0.47985	-1.3009
	[0.1141]	[0.3229]	[1.1055]
Tax Relief (binary)	-0.1305	0.4211***	0.2840
	[0.1101]	[0.0543]	[0.2680]
REQ (continuous)	-2.504	0.6569	n.a.
	[1.6250]	[1.0068]	
Tech. Demonstration (binary)	0.1114**	n.a.	0.0685
	[0.0552]		[0.5861]
Tech. Deployment & Diff. (binary)	0.0003	n.a.	-0.0294
	[0.0664]		[0.7660]

Note: * 10%, ** 5%, *** 1% significance levels based on robust standard errors. Key control variables included as in model D1, not reported here. "n.a." indicates either that no observations matched the criteria or that variable was "omitted" because of multicollinearity.

A possible explanation of this interesting result is related to the underlying differences between the characteristics of the two policy instruments – tax relief and feed-in tariff schemes. Tax relief is a "one off" measure directed at alleviating the initial investment costs during the construction stage of the project, whereas feed-in-tariff schemes provide a "stream" of payments that materialize after the project is commissioned and affecting mainly the variable costs of operation. The different results may be explained by the perceived viability of the instruments in the two country groupings, with investors in OECD countries having greater confidence in the continued existence of the FIT over time. The results may also reflect the fact that OECD countries have on average higher labour and maintenance costs relative to investment costs, conversely BRIICS countries tend to have a lower ratio of variable to fixed costs.[29]

The impact of renewable energy policies on private finance may vary across generation technologies, depending on the characteristics and design of a given policy instrument. To examine this question, we include in the base model interaction terms between policies and sectors. The results of the sector-specific estimates (Table 6) suggest that this might indeed be the case. While feed-in tariffs have a positive and significant effect on finance towards solar and biomass projects, quota schemes are significant for small hydro. This is consistent with the degree of maturity of the

[28] Results for the other control variables hold the sign and significance of D2 and are not reported for brevity. Estimation done on a sample of 5267 observations obtaining $R^2 = 0.7750$

[29] On a similar specification (not reported), we study the effect of policies by each of the income groups, we follow the classification of the World Bank, finding consistent results with those presented in Table 4.

respective technologies and their distance from the market. A utility facing a quota, which is not sector-specific, will choose the lowest-cost option (e.g. hydropower) to meet the requirements.[30] This finding is broadly consistent with those of Johnstone et al. (2010) found in the area of technological innovation.

Table 6. Deal-level regression estimates with sector-specific effects

Policy × Sector	Wind	Solar	Biomass	Small Hydro
FIT (continuous)	0.333	0.2490*	0.7165*	-5.5644**
	[0.3497]	[0.1413]	[0.4350]	[2.4623]
Tax Relief (binary)	0.1971***	0.0412	0.2113***	0.0453
	[0.0689]	[0.0914]	[0.0638]	[0.1742]
REQ (continuous)	0.1243	-0.633	-0.0804	14.4523***
	[1.0258]	[1.1751]	[1.6438]	[2.4228]
Tech. Demonstration (binary)	0.0785	-0.087	0.3280***	-3.5815***
	[0.0660]	[0.1112]	[0.1229]	[0.6429]
Tech. Deployment & Diff. (binary)	-0.1238*	0.0459	0.1405	2.5073***
	[0.0740]	[0.0897]	[0.1274]	[0.2119]

Note: * 10%, ** 5%, *** 1% significance levels based on robust standard errors. Key control variables included (as in model D1) are not shown here for brevity. However, significance and sign hold. Estimation done on 5267 deals obtaining an R-sq. of 0.78. While the models are estimated on the full interacted sample, including deals for geothermal and marine energy, these are not reported because there are only less than 100 observations in these two sectors, compromising the reliability of the sector-specific estimates.

As discussed above, one of the possible explanations for a positive effect of renewables policies is not only their implicit environmental ambition (and thus level of support), but also their ability to overcome any imperfections in a country's credit markets. While the initial investigation did not find any evidence of renewables policies supplementing such capital market imperfections (model D3), here we examine this question in greater detail. In particular, we ask whether technology maturity plays a role since capital markets may have more difficulty assessing risks associated with less mature technologies.

The data allow us to distinguish various "sub-sectors" of technologies, some of which can be considered more mature (e.g. onshore wind) than others (e.g. solar PV, offshore wind). However, in the underlying data the sub-sector information is available only at the project level, not the deal level, and we must therefore restrict our sample only to those deals that have a one-to-one relationship with projects (a single deal financing a single project).

We run subsector-specific regressions[31] and split the effect of policy instruments by including a triple interaction effect between a policy instrument, Credit Market Depth of Information (CMDI) index, and sub-sector dummies. Our aim is to understand the role of policies at different levels of credit information for different sub-sectors of the same renewable resource.

We find (Table 7) that for onshore wind the effect of FIT is positive and statistically significant at low levels of credit market information (index=0) and insignificant at high levels of credit market information. On the contrary, the effect of REQ is found to be positive and statistically significant at a

[30] The degree of intermittency (capacity ratio) might play a role as well.

[31] We run these regressions for wind and solar sectors. There are 1581 transactions financing wind projects, and 670 transactions financing solar projects. The remaining four renewable energy sectors could not be studied in this exercise either due to a low number of observations (geothermal; marine) or the lack of information in our dataset on the subsectors (small hydropower; biomass and waste).

high level of credit market information (index=5).[32] For solar PV, a less mature technology, there is no evidence of an effect of REQ, while FIT is positive and significant even in a well-functioning credit market. Taken together these results imply that if credit markets are functioning well, a FIT will induce private finance for solar PV, while a REQ will induce private finance in wind power. However, if credit markets are not functioning well only a FIT will have an effect on private finance flows, and only for the case of onshore wind power.

Table 7. Deal-level regression estimates by sector – policy interacted with information index

Policy × CMDI × Sub-sector	Wind		Solar	
	Offshore	Onshore	PV	Thermal
FIT (continuous) × CMDI (index=0)	n.a.	10.0939**	n.a.	n.a.
		[4.5433]		
FIT (continuous) × CMDI (index=1)	n.a.	n.a.	n.a.	n.a.
FIT (continuous) × CMDI (index=2)	n.a.	4.3394	n.a.	n.a.
		[3.2609]		
FIT (continuous) × CMDI (index=3)	n.a.	n.a.	n.a.	n.a.
FIT (continuous) × CMDI (index=4)	n.a.	0.4965	0.4328	0.5233
		[0.8402]	[0.5329]	[0.8371]
FIT (continuous) × CMDI (index=5)	3.3281	-0.3459	0.7790***	0.5185
	[5.6216]	[1.1970]	[0.2979]	[0.5930]
FIT (continuous) × CMDI (index=6)	-1.5571	-0.0146	1.0376***	0.58
	[2.7488]	[0.4318]	[0.4017]	[0.5262]
REQ (continuous) × CMDI (index=0)	n.a.	n.a.	n.a.	n.a.
REQ (continuous) × CMDI (index=1)	n.a.	n.a.	n.a.	n.a.
REQ (continuous) × CMDI (index=2)	n.a.	n.a.	n.a.	n.a.
REQ (continuous) × CMDI (index=3)	n.a.	n.a.	n.a.	n.a.
REQ (continuous) × CMDI (index=4)	1.4207	4.8509	34.833	n.a.
	[5.410]	[5.5977]	[28.808]	
REQ (continuous) × CMDI (index=5)	n.a.	2.6389**	2.5725	7.0569
		[1.3161]	[4.5085]	[8.251]
REQ (continuous) × CMDI (index=6)	-1.8980	-0.8002	5.8118	3.9456
	[11.803]	[1.7910]	[10.644]	[11.477]
Country dummies	Yes		Yes	
Year dummies	Yes		Yes	
Sub-Sector dummies	Yes		Yes	
Nb. of Observations	1581		670	
Adjusted R-squared	0.879		0.898	

Note: * 10%, ** 5%, *** 1% significance levels based on robust standard errors. Key control variables included as in model D1, not shown here. "n.a." indicates either that no observations matched the criteria or that variable was "omitted" because of multicollinearity.

So far we have studied the role of public policies in inducing private finance, however recall that 11% of the deals in our sample have some funds that originate from public sources. We

[32] The statistical insignificance of this triple interaction might be due to few observations with active REQ and high CMDI index (index=6).

investigate how this presence impacts on private finance – as a direct effect, by country group, and in interaction with policy instruments. A dummy variable representing the deals that are publicly financed (or co-financed) is included and interacted with country groups and policy variables. The results (Table 8) confirm our previous findings concerning the effects of policy instruments. Deals where at least a portion of financing originates from public sources tend to involve smaller volumes of private finance – the sign of the variable is negative and significant. Moreover, interacting policy variables with the public finance dummy (second column in table 8) suggests that FITs induce larger amounts of private finance only in the absence of public finance participation. This indicates a substitution between direct and indirect public support in the eyes of private investors (we return to this point below). A similar result is found for demonstration programmes indicating that, while such programmes might facilitate raising private finance, complementary provision of additional public finance might be counterproductive. We also find evidence that tax relief measures induce private finance regardless of public participation in project financing.

Table 8. Deal-level regression estimates with public finance participation

FIT (continuous)		0.3207***	
		[0.1108]	
Tax Relief (binary)		0.3079***	
		[0.0468]	
REQ (continuous)		-0.2538	
		[0.9184]	
Tech. Demonstration (binary)		0.0769	
		[0.0525]	
Tech. Deployment & Diff. (binary)		-0.0707	
		[0.0671]	
Public finance participation (binary)		-0.6230***	-0.6792***
		[0.0390]	[0.0631]
FIT (continuous) ×	No public finance		0.3587***
			[0.1088]
	With public finance		0.1005
			[0.2321]
Tax Relief (binary) ×	No public finance		0.3069***
			[0.0472]
	With public finance		0.3634***
			[0.0857]
REQ (continuous) ×	No public finance		-0.5174
			[0.9122]
	With public finance		1.7397
			[1.5713]
Tech. Demonstration (binary) ×	No public finance		0.0994*
			[0.0551]
	With public finance		-0.1143
			[0.1064]
Tech. Deployment & Diff. (binary) ×	No public finance		-0.0835
			[0.0687]
	With public finance		0.0134
			[0.1160]
Country dummies		Yes	Yes
Year dummies		Yes	Yes
Sector dummies		Yes	Yes

Nb. of Observations	5267	5267
Adjusted R-squared	0.7805	0.7809

Note: * 10%, ** 5%, *** 1% significance levels. Robust standard errors in brackets. Key control variables included as in model D1, not shown here.

As noted above, inclusion of a public finance variable in the model raises the concern that this variable might in turn be dependent on the level of private finance, and such reverse causality could potentially bias the results. Thus, we turn to the project-level analysis where we address this possibility explicitly using a simultaneous equation methodology, and distinguishing between those projects in which there is some public finance involved and those in which this is not the case. The estimation results are presented in Table 9.

We first summarise results concerning the determinants of private investment decisions (Table 9).[33] We find evidence of an apparent substitution effect of public financing on private investment, with a negative and significant coefficient.[34] In both OECD and BRIICS countries, co-financed projects are to a greater extent financed by private entities (positive coefficients) and to a lesser extent by public organisations (negative coefficients) relative to other countries. In line with the initial deal-level analyses, the generosity of feed-in tariff schemes is positively correlated with private finance while quota schemes play no role. Existence of technology demonstration programmes and support for technology deployment are also positively correlated with private finance. The only surprise is the negative correlation with the presence of a tax credit schemes. A possible explanation of this result is that the volume of tax credit/relief is typically subject to an upper limit, leading private investors to pursue smaller projects. Nevertheless, the tax credit estimate is positive and significant for the co-financed sample.

In contrast, using the co-financed sample we find evidence of a positive effect of public finance on private finance. A 1% increase in public investment implies a 0.7% increase in private investment. Furthermore, in this case it is important to note that the effects of renewable energy support policies (FIT and REQ) are insignificant. There is, therefore, a concern that in the absence of well-designed renewable energy support policies (including raising the price of carbon) governments wishing to secure project completion have no other choice than to support projects directly using public finance.

In both samples project size seems to be a major driver of the level of financing. Indeed, a 1% increase in generation capacity leads to a 1% increase in the amount of private financing[35]. The magnitude of the elasticity is lower for the co-financed sample. Commissioned projects and projects located in OECD countries tend to attract greater volumes of private funds. Being an owner or developer that is relatively new to the new energy business is correlated with greater volumes of private finance raised. While perhaps unexpected it is consistent with our results on public authorities' propensity to favour new entrants into the market (see below).

For completeness, we next summarise results concerning the determinants of public investment decisions (Table 9 cont.). Recall that results for the Tobit model can be interpreted both in terms of probability to invest as well as in terms of levels, provided a positive investment decision has been taken. Given that only 424 projects (18%) of the estimation sample are co-financed, the probabilistic

[33] This corresponds to the second equation in [3].

[34] While the magnitude of the coefficient is lower compared with the substitution effect of private on public (Table 9, cont.), recall that the estimation procedure is different (tobit vs linear) and so the coefficients are not fully comparable.

[35] This is particularly so in BRIICS countries and ROW, with a somewhat lower effect in OECD countries. The effect is highest for wind and solar, and lowest for geothermal and marine (based on model specifications with interactions; not reported in Table 9).

interpretation is of great relevance for the Tobit results.[36] Results of the tobit-linear model estimated on the private sample indicate that higher government expenditures imply a higher propensity to provide direct public financing for projects (the share of government expenditures on GDP is positive and significant). In other words, countries with high public spending levels are more likely to invest public funds in renewables projects. A similar result is found in the bivariate linear model estimated on the co-financed sample where the coefficient is also positive and significant.

As expected we find that higher generation capacity is positively correlated with the allocation of public funding for projects. However, while project size is a significant factor in the decision to invest public funds, it does not affect the volume of funds. Moreover, we find that public investors tend to favour projects by local developers and by newcomers (project owners with low exposure to 'new energy'), and they also tend to target projects that have already been commissioned rather than those that are only being planned. Finally, the recourse to public financing is more likely in no-OECD countries. This indicates a certain complementarity between direct public investment and more indirect support schemes and policy instruments. Indeed, since such policies have been more common in OECD countries. Moreover, a project located in OECD countries is not only less likely to obtain public funding (Tobit equation of Tobit-linear model), the investment is also generally less generous once obtained (linear equation of linear-linear model).

Concerning the policy variables, we find that favourable public finance decisions are more likely in countries pursuing demonstration projects, and less likely in countries that have tax relief (or tax credit) measures in place. Indeed, tax credits and public finance investment can serve as substitute incentives because both of these interventions have an incidence on the initial stage of the project. In the case of feed-in tariffs, although we find no effect on the decision to invest public funds, we do find a negative correlation with the volume of public funds invested (albeit only at 10% significance level). This indicates that when making investment decisions public authorities take into account the existence and generosity of such support schemes. Quota schemes (REQ) are the exception, as they do not seem to play a role in determining the likelihood and volume of public finance investment. Indeed, our results suggest that policies such as REQ and FITs do not substitute for direct provision of public financing.

[36] For the remaining three linear models the interpretation is standard.

Table 9. Project-level regression estimates

Estimation sample:	Private projects	Co-financed projects
Dependent: **PrivateFinance** (IHS)	(P1)	(P2)
	Linear equation	Linear equation
PublicFinance (IHS)	-0.1503***	0.6961***
	[0.0098]	[0.2746]
Capacity (IHS)	1.0334***	0.5792***
	[0.0225]	[0.2134]
Status – Commissioned	(base)	(base)
Status – Planned	-2.1008***	-2.5142***
	[0.2158]	[0.7661]
Owner exposure	-0.2582***	0.2958
	[0.0946]	[0.2882]
Developers past projects	-0.0609***	-0.0701
	[0.0109]	[0.0459]
FIT	0.3679***	0.5459 (p-value=0.14)
	[0.0923]	[0.3695]
Tax relief	-0.1771***	0.3353*
	[0.0388]	[0.1944]
REQ	-0.6786	-1.5379
	[0.4863]	[1.6447]
Tech Diffusion and Deployment	0.1067**	0.5938***
	[0.0471]	[0.1840]
Tech Demonstration	0.1278***	-0.2728*
	[0.04107]	[0.1609]
Region – OECD	0.2691***	0.7775***
	[0.0773]	[0.2179]
Region – BRIICS	-0.2293**	0.4791**
	[0.0724]	[0.1942]
Region – ROW	(base)	(base)

Note: * 10%, ** 5%, *** 1% significance levels. Robust standard errors in brackets. For categorical variables "base" indicates the reference level.

Table 9. Project-level regression estimates (cont.)

Estimation sample:	Private projects	Co-financed projects
Dependent: **PublicFinance** (IHS)	(P1)	(P2)
	Tobit equation	Linear equation
PrivateFinance (IHS)	-3.3548***	0.2923
	[0.1997]	[0.4277]
Govt Expenditures	0.1049***	0.0247**
	[0.0178]	[0.0123]
Govt Surplus	0.0041	0.0171
	[0.0494]	[0.0111]
Capacity (IHS)	4.6261***	0.4538
	[0.2423]	[0.4860]
Status – Commissioned	(base)	(base)
Status - Planned	-14.6125***	-1.1342
	[1.1759]	[1.7667]
Owner exposure	-5.3077***	-0.4015*
	[0.7613]	[0.2112]
Local Developers	1.2545***	0.0142
	[0.4648]	[0.1517]
FIT	-2.2339	-0.6481*
	[1.6120]	[0.3542]
Tax relief	-2.6285***	-0.3726***
	[0.4197]	[0.1409]
REQ	8.6636	1.7938
	[5.6637]	[1.5515]
Tech Diffusion and Deployment	-0.2229	-0.4630**
	[0.5521]	[0.2191]
Tech Demonstration	1.1641**	0.2345
	[0.42159]	[0.1508]
Region – OECD	-1.4885*	-0.7407***
	[0.7773]	[0.2101]
Region – BRIICS	0.0967	-0.4544***
	[0.7086]	[0.1539]
Region – ROW	(base)	(base)
Variance of residuals		
σ_1	4.2511***	0.4831***
	[0.1267]	[0.1171]
σ_2	0.6418***	0.6574***
	[0.0172]	[0.1654]
ρ	0.2967	-0.4365**
	[0.2029]	[0.2272]
Year dummies	Yes	Yes
Country dummies	No	No
Sector dummies	Yes	Yes
N	2357	424

Note: * 10%, ** 5%, *** 1% significance levels. Robust standard errors in brackets. For categorical variables "base" indicates the reference level.

5. CONCLUSIONS

This paper examines the effect of public policies on private finance flows towards renewable energy projects. Using historical data on financial transactions, it is found that policy instrument choice matters a great deal. In analyses undertaken at the level of the deal there is evidence that price-based instruments such as feed-in tariffs are positively correlated with the volume of private finance raised, while no such evidence is found for quota-based instruments. This result generally holds at the level of the project. It is hypothesised that this might be because feed-in payment schemes provide a more predictable investment incentive, similar to tax relief (tax credit) measures whose effect is also found to be positive.

A particularly important finding of the study is that in the absence of well-designed policy incentives to address the environmental externality associated with electricity generation, governments might have to resort to direct provision of public funding to support such investments. While evidence is found that direct provision of public finance towards a project is positively correlated with private finance raised for the targeted projects, the data also suggest that the characteristics of such projects are important. In fact, while finding evidence of a substitution effect of public finance, it is not adequate to interpret this as a 'crowding out' effect. This would require conducting analysis at a more aggregate level. Rather, the available evidence seems to indicate that public finance is perhaps used as a means to secure completion of projects that are unable to raise sufficient volume of private financing in the first place. This would explain why co-financed projects tend to be 27% more costly (per megawatt installed) than projects that rely solely on private finance.

Environmental policies also seem to affect both public and private investment levels in renewable energy. For instance, measures of tax relief (or tax credit) have a significant negative impact on the provision and level of public investment. Since tax relief can be considered to be an indirect way of providing public investment, through a diminished tax burden for beneficiaries, this substitution effect between public finance and tax relief is in line with prior expectations.

Interestingly, demonstration programmes appear as a complement of public involvement in projects. Additionally, even though technology deployment and diffusion programmes are negatively correlated with the level of public financing, such schemes seem to be an effective way to induce private financing. Moreover, the presence of renewable energy quotas does not seem to impact on either public or private investment. Last, our analysis also suggests that in the presence of public co-financing of a given project, public policy incentives (such as feed-in tariffs and tax relief) have a more limited impact on investors' ability to raise private finance, indicating that public policy measures and direct provision of public finance are substitutes for one another.

It is also found that generation capacity is a main driver of public investment decision suggesting that public authorities favour large projects. However, once a positive decision to invest has been taken, capacity does not seem to impact on the level of public finance allocated to the project. It can thus be argued that public funds are used only to pursue completion of projects, regardless of the size of the project but taking into consideration other characteristics such as availability of private financing.

These findings have important implications for policy design and policy instrument choice. Concerning policy design – differences across countries in environmental policy ambition certainly play a key role: a more ambitious policy mix will always provide a stronger signal to investors, independent of the choice of policy instrument through which this signal is transmitted.[37] However, in

[37] This statement holds in general. Whether or not an ambitious policy is viewed as being 'credible' will depend on the type of instrument and its design characteristics – as discussed below.

the presence of uncertainty over future policy actions or lack of commitment to a long-run policy objective, some policy instruments imply a greater degree of commitment on the part of the government.

Therefore – concerning policy instrument choice – some instruments might be better suited to alleviate the particular risk-return profile of renewable energy investments. In particular, policy instruments that provide a more predictable revenue stream (e.g. some types of feed-in tariff/premium schemes) might be more suitable than policy instruments whose support levels are more difficult to ascertain ex ante (e.g. certain designs of renewable energy credits traded in over-the-counter transactions). However, this comes at a cost – depending on future market conditions the government might find that it is bearing a higher level of risk than is required to meet its policy objectives. This is particularly true if public finance is used directly to support renewable energy projects.

This shortcoming arises in large part from the difficulties associated with using a single instrument to address two distinct failures in the market. The level of ambition associated with the measure is unlikely to be economically efficient with respect to both the internalisation of environmental externalities and the resolution of credit market failures. As such, if there is sufficient divergence between actual and expected outcomes over time then the government may choose to abrogate on its previous commitments. For instance, there have been cases in which feed-in tariff schedules have been changed retroactively. In due course this will affect investors' perception of the credibility of future "apparent" commitments. This perception can undermine policy credibility for many years.

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