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The Role of Policy Driven Incentives to Attract Ppps in Renewable-Based Energy in Developing Countries

A Cross-Country Analysis

Maria Vagliasindi

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Abstract

This paper presents new global evidence on the key determinants of public-private partnership investment in electricity generated by renewable energy based on a panel data analysis for 105 developing countries over a period of 16 years from 1993 to 2008. It aims to identify the key factors affecting the private investor's decision to enter renewable-based energy generation, through a probit analysis and the amount of investment sunk in this market segment, based on Heckman's sample selection analysis. One of the key results of the paper is that the market for renewable-based energy is strongly driven by supportive policies. Support policies serve not only to attract the entry of private investors, but also to determine the level of investment. In the latter case, its impact is less significant, suggesting the need over time to revisit the power of the incentive schemes, as well as the implied allocation of risks between the public and private sector to ensure that feed-in tariffs produce the desired amount of investment. In contrast, broader economy-wide governance factors, including control for corruption and degree of political competition, are considered by private investors mainly for taking the decision to enter into renewable-based generation. This reinforces the expectation that private investors seem to be adequately protected against their risks, so that once they have entered the market, they can accommodate the governance environment. Private investors in renewable-based energy also require technical and regulatory certainty about the availability of renewable-ready transmission resources, if they are to finance investments. Private investors entering the market look more at the size of the market rather than the income level, whereas when determining the level of investment they assess both the size and "affordability" level. This raises some concerns on the sustainability of support mechanisms and their financing, particularly when the incremental costs implied by renewable-based generation are passed through to consumers.

This paper is a product of the Energy Unit, Sustainable Energy Department. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at mvagliasindi@worldbank.org.

The role of policy driven incentives to attract PPPs in renewable-based energy in developing countries*

*A cross-country analysis***

Maria Vagliasindi

JEL: L1, L51, Q48

Energy and Mining (EM) Sector Board

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**Maria Vagliasindi, Lead Economist, Energy Unit, Sustainable Energy Department, World Bank

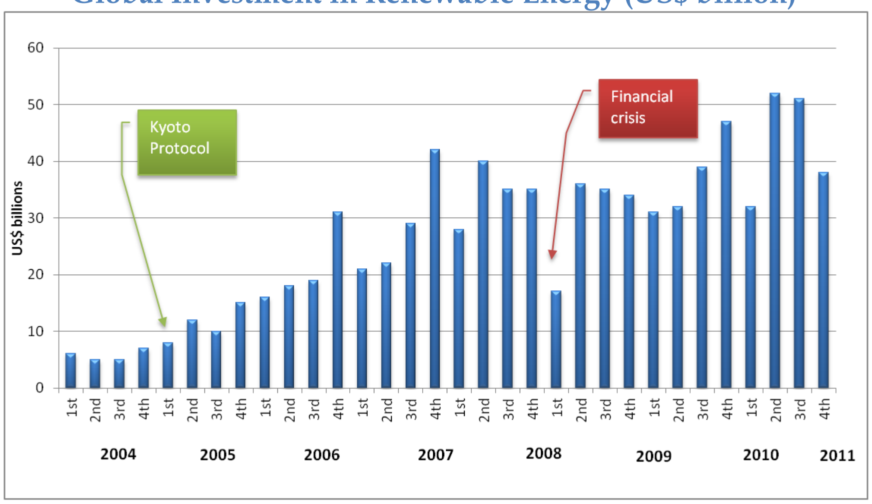
1. Introduction

1.1 The acceleration of investment in renewable energy

Rapid urbanization and economic growth, demographic trends, and climate change are challenges that require developing countries to accelerate public and private investments in renewable energy.

As shown in Fig. 1, the years following the adoption of the Kyoto Protocol marked the start of a period of strong exponential growth in mainstream renewable energy investment internationally. In 2008, for the first time, renewable energy including large hydropower attracted globally more power sector investment than fossil fuel based technologies (UNEP *et al.*, 2010). This growth followed from an alignment of global factors: rapid growth in energy demand from emerging economies such as China and India; increased competition for energy resources; geopolitical tension and energy security concerns; rising oil and gas prices; as well as the entry into force of the Kyoto Protocol in early 2005, and the rise of climate change up the political agenda more generally. At the same time, renewable technologies built up a commercial track record and renewable energy technology manufacturing became a globalized industry. Fig. 1 also shows strong signs of recovery after a sharp drop in the fourth quarter of 2008 and the first quarter of 2009, in the aftermath of the global financial crisis to reach a peak of US$ 173 billion in 2011.

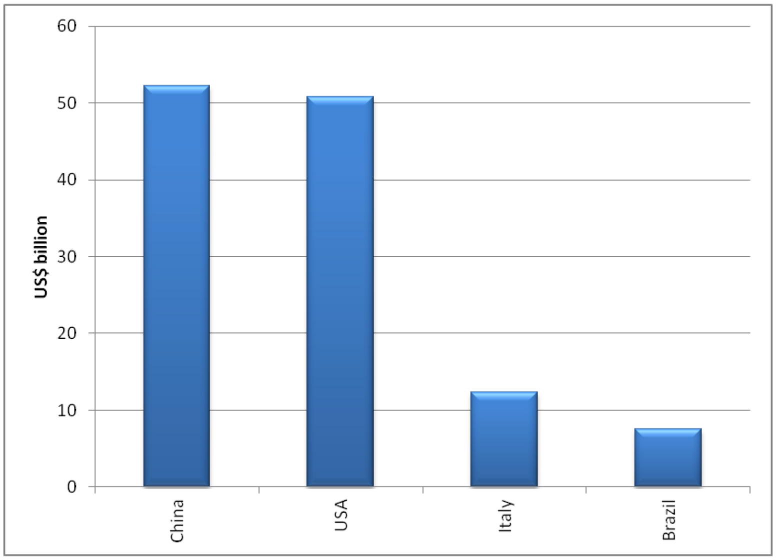
Fig. 1
Global Investment in Renewable Energy (US$ billion)



Source: Bloomberg New Energy Finance

With renewable energy investments amounting to US$ 34.6 billion in 2009, China took the lead for the first time. Overall, around $257 billion was invested globally in renewable energy in 2011. Of that, China led the way (for the third consecutive year) with new financial investments of $52 billion (Figure 1.8). Ambitious, mandatory targets for wind and solar power and the ample availability of credit in China have been the primary engines of that nation's clean energy growth. The United States came in second at about $50 billion,and Italy managed a distant third, thanks to a newly designed solar feed-in tariff and a major IPO by Enel Green Power, which raised $0.5 billion in 2010. Among developing countries in top world positions, Brazil and India stand out. Whereas in the case of Brazil renewable investments were characterized by subdued performance mainly due to consolidation underway in the biofuel segment, India renewable investment grew strongly supported by an accelerated depreciation tax break (which is expected to be reformed in 2012), the new solar mission and the launch of the Renewable Energy Certificates. Mexico's renewable investments increased fourfold compared to 2009, reaching more than US$ 2.3 billion, thanks to the new funding secured for wind projects. Egypt, the top country in the MENA region, achieved renewable investments over US$ 1.3 billion, due to large solar thermal and wind projects. In the case of Kenya, the top performing country in Sub-Saharan Africa, investment rose from virtually zero to over US 1.3 billion from a diversified basis, including wind, geothermal, small hydro and biomass.

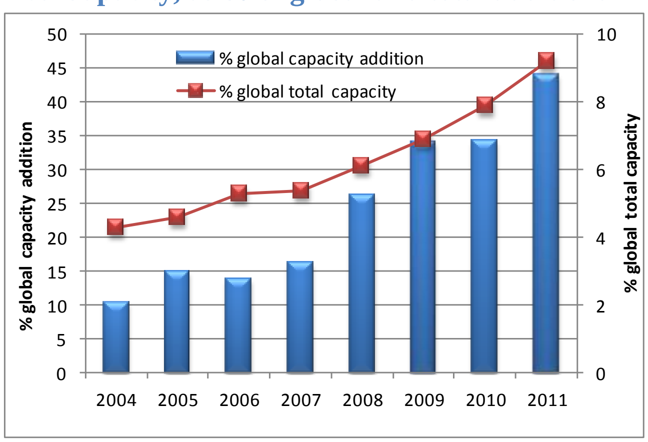
Fig. 2
New Financial Investment in Renewable Energy, 2011 (US$ billion)



Source: Bloomberg New Energy Finance

At this point renewables still represent a marginal percentage of the world's generation mix as measured in terms of global installed capacity about 9 percent as of 2011 (excluding large hydropower), up from around 5 percent in 2004 (Fig. 3). But its share in total new capacity additions (including hydropower) has grown exponentially, from 10 percent in 2004 to 44 percent in 2010.

Fig. 3
Renewable Installed Capacity, as % of global and total additional installed capacity



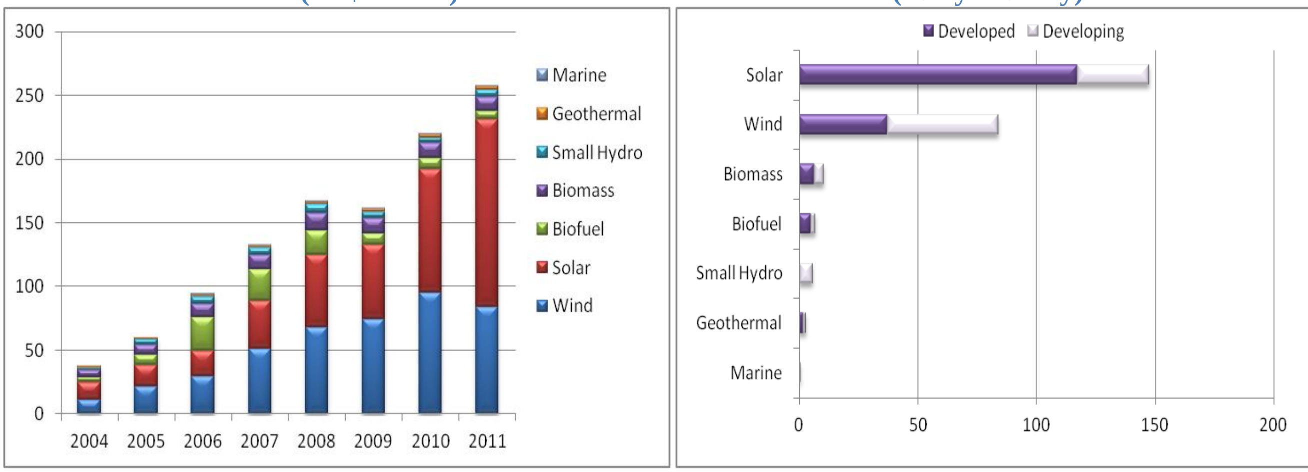
Source: Bloomberg New Energy Finance

Among grid-connected renewable energy, the key drivers of the exponential growth in diffusion of renewable installed capacity were solar, wind (on-shore and off shore), biomass, bioelectricity (cogeneration), landfill gas, small hydro power, and much more modestly solar (photovoltaic and concentrated solar power), and geothermal geothermal, and marine. (see Fig. 4).

New financial investment in solar after declineing from the pick recorded in 2008, also due to retroactive cuts in solar feed-in tariffs which occurred in a number of countries (such as Spain and Czech Republic) increased substantially in 2010 and 2011. Developed countries continued to be in the strong lead for solar technologies, with a fourfold level of investment than developing countries. New financial investment in wind grew at an exponential rate, mainly fueled by growth in developing countries, which recorded US 10 billion more investment than developed countries. Investment in biomass remained constant in US$ nominal terms at around US$ 11 billion since 2008, with developed countries leading with twice the volume of investments in 2010. Investments in small hydro declined after the pick of US$ in 2008, but developing countries recorded a twenty times higher level compared to developed countries.

Fig. 4

Investment in Renewable Energy, by source (US$ billion) **Investment in Renewable Energy (% by country)**



Source: Bloomberg New Energy Finance

1.2 Policy challenges to design effective support schemes to attract private investment in renewable energy

Changes in the level and composition of investment can be particularly drastic if a move toward low carbon solutions is implemented through an increasing proportion of renewable energy. Most renewable sources of energy cost more than energy from fossil fuels. In most cases this is because of higher capital costs for renewable-based energy, causing changes to the level and composition of investments.

Investments in renewable energy typically have higher upfront capital costs than conventional power generation, but lower operational costs (wind and solar, for example, do not have a fuel cost or fuel price volatility to manage). Before the global financial crisis, it was estimated that renewable energy project financing involved structures of 15 years or more to repay upfront loans, through income generated from the project's power generation. This makes renewable energy power projects exposed to longer-term risk, including the policy and regulatory incentive environment.

The higher costs and risk mean that companies particularly in the private sector will not be willing to undertake investments in renewable generation, unless they are required to or offered economic and financial incentives to do so. The price support mechanisms need to be structured in such a way as to reward the most efficient renewable energy suppliers and to give them an incentive to reduce costs as rapidly as possible. This has been extensively analyzed in the literature (see, e.g. O'Brien and Usher, 2004; more recently Ecofys 2008).

Policies that support renewable energy use either price or quantity setting instruments. Of the different options to support renewable energy, feed-in tariffs are increasingly seen as the "policy of choice" to attract private investment in renewable energy (Menanteau et al.; 2003, Mitchell *et al.*; 2006; Lipp, 2007; Lesser, 2008, Burer et al., 2009; REN 21, 2010, DB Climate Change Advisors, 2010). Under a feed-in tariff scheme, electric utilities are obliged to purchase renewable energy through long term contracts that guarantee access to the grid, at an enhanced price (the so called feed-in tariff). Feed-in tariffs, where renewable energy delivered to the grid receives a pre-set tariff, have a clear track record of delivering significant volume increases in its deployment. The stable revenue stream across a pre-established timeframe reduces risk around cash-flow. IEA analysis indicates that cost of capital will be higher in support schemes with traded obligations given the lack of certainty over the revenue stream.[1] Feed-in tariffs can be applied consistently and transparently and can be readily adapted to different specific power market structures. For instance, the incentive can also be offered as a premium in addition to the spot-market electricity price (Cory et al. 2009, Couture et al. 2010).

Box 1 Challenges for setting feed-in tariffs

Renewable energy support and incentive mechanisms are the most important factors that drive the growth of a market in renewable-based energy. Feed-in tariff (FIT), a price-based support, is in favor in majority of the European countries such as Germany and Spain. This system sets a guaranteed price for renewable energy generation or an addition to the prevailing market price. The feed-in tariff system is widely used in as well, and only few developing countries have implemented alternative solutions (see Box 2).

It is difficult to strike the right level of feed-in tariff. Low feed-in tariff may not trigger enough investment in renewable-based energy. High feed-in tariffs, though, also have a negative effect on cost reductions as they induce generators to choose high-cost sites and provide fewer incentives for cost cuts. This illustrates the importance of designing an efficient energy support system, which not only promotes diffusion but also provides continuous incentives for cost-reducing innovations. The rapid expansion of the Spanish solar PV and subsequent intervention to contract the market in 2008 (capping overall market size, alongside a 30% cut in the tariff) has been attributed as much to tariff design as to setting the tariffs at unsustainably high levels. In contrast, Germany prescribed stepped tariff reductions (degressions) and has produced steadier growth.

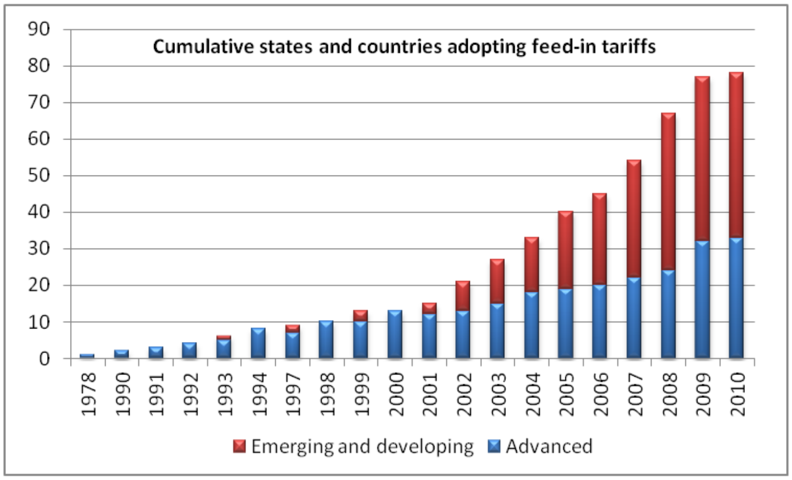
The effectiveness of the feed-in tariff policy has been well documented in Europe. A study comparing the effect of these policies to other policy mechanisms designed to support the spread of wind energy found that they resulted in 7-8 times as much installed wind capacity (European Commission, as reported by Thomas B. Johansson, Chair, Global Energy Assessment). The overall success of the German, Spanish, Danish and other national level feed-in programs has inspired similar initiatives in developing countries including China and, more recently, South Africa and India, as well as by regional and state governments in the UK, US, and Australia.

The feed-in tariff policy has already been implemented in about 80 states and countries around the world, more than half of which are developing economies (see Fig. 5 below). The most important element of these schemes is that they fully or partially remove the market risks of a project during a fixed period of time. The longer this period of guaranteed prices, the lower the cost of capital. Because of this, they are generally financed with a relatively large proportion of debt. In feed-in premium schemes, the risk of variations in electricity market prices is reflected by the tariff premium in the purchase power agreement (PPA). But private investors may struggle to acquire a PPA with a 15 to 20 year tenor at reasonable risk premium levels to cover this debt. A strong government commitment towards the scheme is essential in this respect. Changes in the

[1] IEA analysis indicates that a 2 to 30% cut in the cost of renewable energy can result from improved design of incentive or support schemes, with the higher end of this range linked to projects with higher project risk, such as offshore wind.

scheme can seriously affect the continuity of existing projects and have to be applied carefully. Increasing the economic lifetime, the contract period in the PPA, and the debt maturity will reduce the annual cost of debt service. This could be achieved through several means, such as by setting favorable conditions in loan guarantees, (low-interest) government loans and/or government participation. The government can also force parties to offer long-term contracts. This will be reflected in a risk premium, but – provided that a competitive market is functioning – this premium can be minimized. The main advantage is that the financing cost will be reduced due to the increased security.

Fig. 5
Adoption of Feed-in Tariff Policies around the world



Source: REN2011

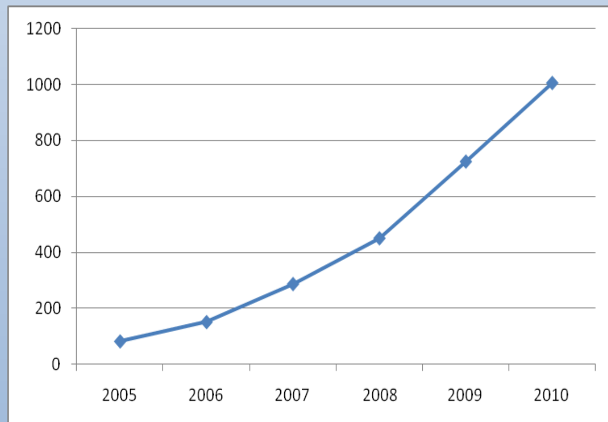
Reducing the risk premium in the cost of capital in quota obligation schemes can be achieved via various routes, but is not as easily done as with feed-in tariff schemes. The feed-in tariff system is widely used , and only few developing countries have implemented alternative solutions. Among support policies using quantity setting instruments, renewable portfolio standards are worth mentioning.

Renewable Portfolio Standards are fixed policy commitment mechanisms, which require utilities to supply a certain percentage from renewable energy by a given year. RPS policies have become widespread in the U.S. (in contrast to Europe and other countries, where FITs are more common). Renewable portfolio standards set a fixed quantity, and the market is expected to determine the price as utilities procure the lowest cost renewable energy sources available to them. Their use has developed extensive wind resources in the U.S. but has been criticized as being less effective for incentivizing nascent, higher-cost technologies or a stable investment environment for renewables. Few European countries have also used quantity based schemes (see Box 2 for examples in developing countries). Even though feed-in tariff schemes and renewable portfolio standards approaches are presented as alternatives (Mitchell *et al.* 2006; Rickerson and Grace 2007), these policies can also be used together with renewable portfolio standards prescribing how much customer demand must be met with renewable-based energy and feed-in tariff policies setting the right price and providing investor certainty (Cory *et al*, 2009).

Box 2 Quota systems for renewable generation: the case of Poland

The system of tradable certificates or the quota obligation framework, a quantity based system, has been adopted by Latvia, Poland and Romania. The Czech Republic adopted both systems. In 2000, the Polish government introduced a power purchase obligation for renewable energy sources, which was first amended in 2003, and again in August 2008. This requires energy suppliers to provide a certain minimum share of power generated by renewable sources (from 3.1% in 2005 up to 10.4% in 2010 and 12.9% in 2017). The electricity from renewable energy sources is purchased at a guaranteed price which is the median electricity price for the previous year. In 2010 this stood at 197.21 PLN/MWh. If a company does not fulfill its obligation according to the quota regulation, a penalty will apply that is equal to 248.46 PLN per MWh and an additional 30% fine cumulates to the initial fee if it is not duly paid. The European Commission's 2007 report found that fines were not enforced. In 2005, the Polish Law on Energy (1997) was amended to introduce an obligation for all renewable energy producers, regardless of the size of the installations, to obtain a license from the Energy Regulation Authority. Following this new requirement, more than 600 producers of renewable energy applied for and received licenses for producing electricity from renewable sources. The cumulative power installation moved from 83 in 2005 to about 1,000 in 2010.

Cumulative power installation in Wind generation (2005-2010), MW



Source	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Biogas	32.00	36.80	45.70	54.61	71.62	77.00
Biomass	189.80	238.80	255.40	232.00	252.49	252.49
Wind	83.30	152.00	287.90	451.00	724.68	1,005.00
Hydro	922.00	931.00	934.80	940.57	945.20	947.00
Total	**1,227.10**	**1,358.60**	**1,523.80**	**1 678.18**	**1 993.99**	**2 281.49**

The rest of the paper is organized as follows. Section 2 will highlight the key objectives of the papers and the data that is used to carry out the analysis. Section 3 introduces the theoretical hypotheses that will guide the empirical analysis. Section 4 reports the results of the regressions. Section 5 concludes and presents new directions for future research.

2. Analytical Approach and Data

This paper presents new global evidence on the key determinants of public-private partnership (**PPP) investment in electricity generated by renewable energy** (including hydro, wind, waste and geothermal) based on a panel data analysis for 105 developing countries over a 16 years period from 1993 to 2008.

The paper aims at determining the evidence of the effectiveness of sectoral support mechanisms such as feed-in tariffs for attracting private investment in developing countries. We divide the determinants of PPPs into three channels. These include (sectoral and economy-wide) governance variables and short and long run drivers, represented respectively by financial crises and climate change variables. We also control for macroeconomic, sectoral and regional variables.

Our study aims to identify the key factors affecting the private investor's decision to enter the renewable energy market and the amount of investment sunk in this market segment.

The analysis of the key determinants of the private investor's decision to enter is done using the probit model, where the dependent variable is a dummy equal to 1 if PPPs were introduced in the renewable energy market and 0 if not.

The treatment of the modeling of the key factors affecting the private investor's amount of investment sunk in the renewable energy market is based on Heckman's approach to sample selection. This distinguishes between (1) the decision on whether to enter the segment of the electricity market (selection equation), and (2) the decision on how much investment to commit to (investment equation).[2] Unlike the Tobit model, the factors that affect the two decisions need not be identical and, where identical, could even be different in the sign of their effect on the decisions. The selection equation relates the choice of whether to attract PPPs (via a zero/one dummy variable) as a function of the governance variables and the price of oil is estimated over the complete set of countries using a probit model. The second-stage equation, relating PPP investment to the full set of short run and long run variables described in Table 1, is estimated over the sub-set of countries. Because the group has been selected by the first-stage equation, the possibility of selection bias would be introduced if a standard regression were used at the second stage. This bias is related to the magnitude of the correlation between the errors (that include the omitted variables) in the selection and investment equations. Where there is no correlation between these errors, there is no selection bias. The direction of the bias depends on the sign of the inter-equation error correlation.

The condition for identification of the Heckman estimation procedure is that the selection equation contains a significant variable(s) not included in the investment equation. The significance of the Mills' ratio in the second stage indicates whether there would have been selection bias in its absence. If the Mills' ratio is insignificant, a simple regression of the quantity of investment on explanatory variables would be unbiased. The canonical Heckman model also assumes that the errors are jointly normal. If that assumption fails, the estimator is generally inconsistent and can provide misleading inference in small samples.

Data used in this paper are composed of both micro and macro level data. The micro, project-level data are from the Private Participation in Infrastructure (PPI)[3] database. The PPI database is managed by the World Bank and the Private-Public Infrastructure Advisory Facility (PPIAF). The data are collected at the project level for developing countries. The following information of each project recorded in the database is used in this

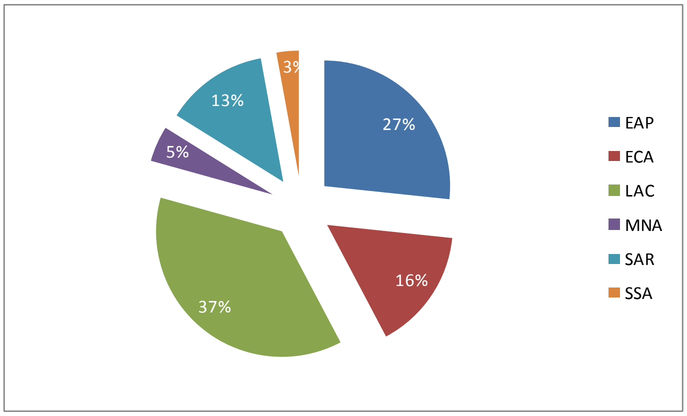
[2] The data on the dependent variable consist of observations related to the investment. This would be zero for countries that had not attracted PPPs, and positive for those countries that had decided to use it. This observation is split into two components: a zero or one variable indicating the lack of entry or entry of PPPs, and a variable measuring investment for the subset of countries that attracted PPPs.

[3] http://www.ppiaf.org/ppiaf/page/private-participation-infrastructure-database

paper: 1) country and region[4], 2) year of financial closure and total life period of the project, 3) total investment (in both monetary value and physical capacity), 4) sector, subsector, segment, and technology (fuel) of each project.[5] The database includes observations for 105 developing countries from 16 years from 1993 to 2008.

The macro data are collected from other central databases, including i) the *World Development Indicators (WDI) 2009* for macroeconomic variable and the *World Governance Indicators* and Polity IV to select a few indicators of governance ii) the *Energy Balances and Statistics 2009* of the International Energy Agency (IEA) to derive indicators of energy import dependence and per capita CO_2 emissions and the electricity databases of the Energy Information Agency (EIA) of Department of Energy (DoE) of the US government (Annex 1) to countries' total installed capacity and their composition, total electricity generation, consumption, net import, and distribution losses. Finally, we also use REN21 to compile the list of countries adopting feed-in tariffs and for publicly available information on the list of countries with an autonomous electricity regulator.

Fig. 6
PPP Investment in renewable-based energy, by region



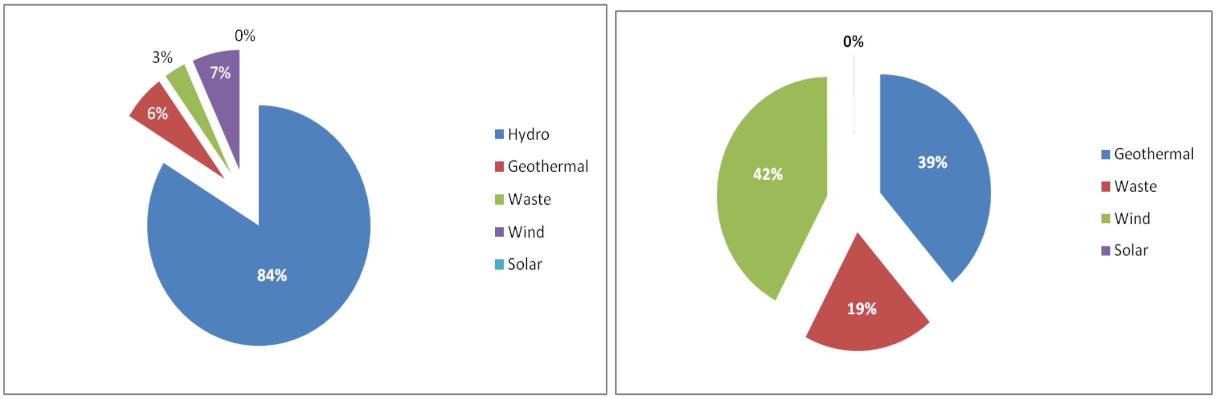
Source: World Bank/PPIAF PPI Database

The key summary statistics show PPP investment highly concentrated in few regions. As Figure 6 illustrates of all the PPP investment reported in the PPI data the large majority benefitted the LAC and EAP region (where investments are respectively just below 40% and above 30%). About 15% and 12% of investment in renewable took place respectively in the SAR and ECA region. Very little investments have been recorded in the MNA and SSA regions.

[4] The six regions are East Asia Pacific (EAP), East Europe and Central Asia (ECA), Latin America (LAC), Middle East and North Africa (MNA), South Asia Region (SAR), and Sub-Sahara Africa (SSA).

[5] The primary sector is energy, and the subsectors are electricity, natural gas, and other (road, telecom, or treatment plant). For the electricity subsector, the segment information tells whether it is a project for power generation, transmission, or distribution, or a combination of these. For power generation project, the technology (fuel) indicates what fuel (coal, oil, or natural gas etc.) or technology (hydro, wind, nuclear etc.) is used for the generation.

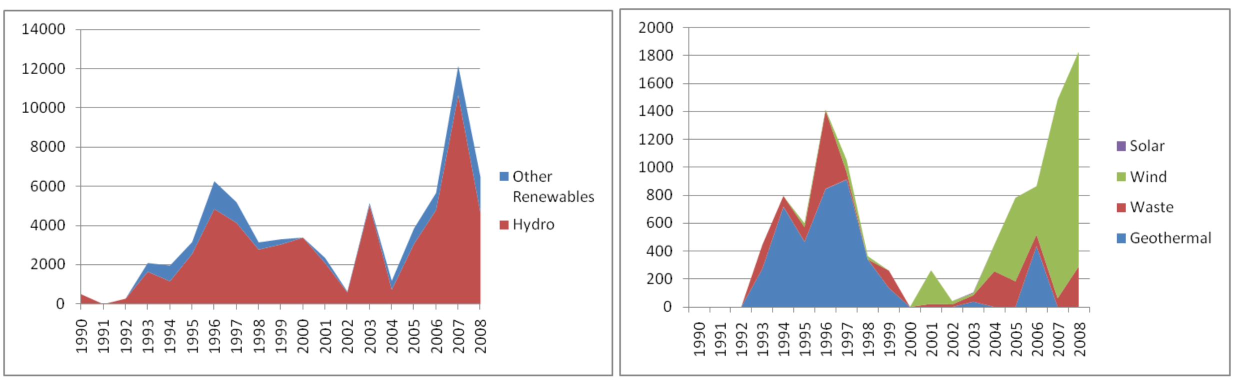
Fig. 7
PPP Investment in renewable-based energy, by energy source



Source: World Bank/PPIAF PPI Database

As Figure 7 illustrates, hydropower accounts for the lion's share of the investment in renewable-based energy. Excluding hydropower, wind and geothermal technologies have almost an equal share of 40% of the total investment in renewable-based energy, with waste limited to 20% of PPP investment.

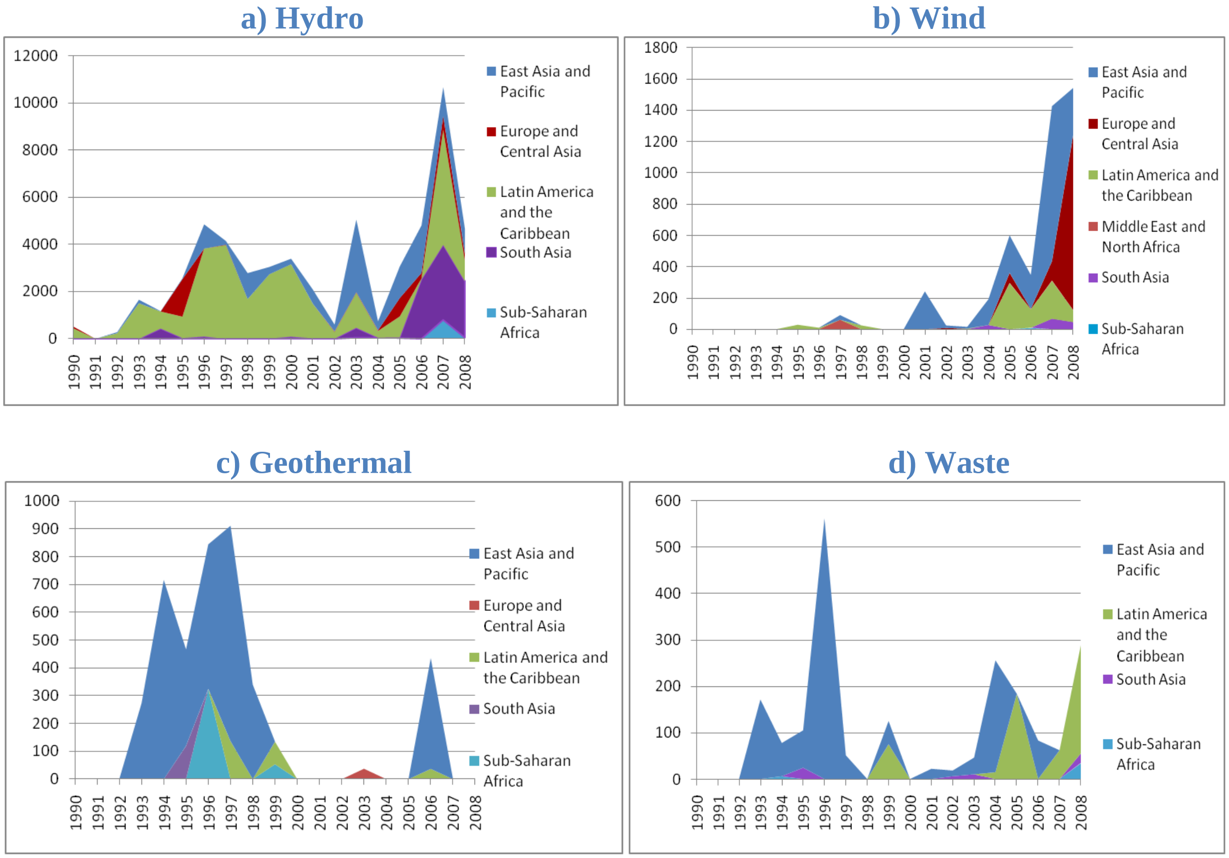
Fig. 8
PPP Investment in renewable-based energy, by energy source, over time



Source: World Bank/PPIAF PPI Database

The trends over time in PPP investment among developing countries confirms the exponential growth recorded at a global level following the adoption of the Kyoto Protocol and the introduction of support schemes, particularly feed-in tariffs. The past financial crises, notably the East Asian and Russian crises in 1997-1998, as well as the most recent Latin American crisis in 2001, negatively affected PPP investments.

Fig. 9
PPP Investment in renewable-based energy by source of energy and region, 1990-2008



Source: World Bank/PPIAF PPI Database

Each region has attracted investment in renewable energy based on its energy endowment and untapped potential. East Asia leads in geothermal (attracting more than 80% of PPP investment by this fuel), waste (accounting for about 70% of PPP investment) and wind (with total investment just below half of the total PPP investment). Latin America has attracted by far the most investment in hydropower, accounting for more than half of the total share. ECA experienced the most impressive exponential growth in wind (bringing the total investment to about 30%) and South Asia in hydropower (reaching just below 20%). These trends are shown in Fig. 9.

Hydropower Brazil alone in LAC attracted more than 35% of the PPP hydropower investment in developing countries. Chile and Argentina follow with more than 5% of investment in hydropower. India accounted for more than 15% of investment and China for about 10%. Specific risks for hydropower investment arise for project financing, such as hydrological uncertainty, construction cost overruns and schedule slippage, power demand uncertainty. Such concerns need to be mitigated to attract private finance.

Geothermal EAP hosts some of the largest resources of geothermal energy in the world. As much as 40% of the world's geothermal potential is found in Indonesia alone. The Philippines is one of the highest producers of the energy source, and both Indonesia and the Philippines have each announced intentions to become the world leader in geothermal production. PPP investments in Indonesia account for 40% of the total PPP geothermal investment in developing countries. The Philippines follows Indonesia's lead with one third of the total PPP geothermal investment. Geothermal energy is a key resource for Sub Saharan African countries along the East African Rift Valley System, a volcanic region with an estimated 7,000 MW of electricity-generating potential. The Democratic Republic of Congo accounts for about 8% of the total PPP geothermal investment, followed by Kenya which attracted about 1% of PPP investment in this sub-segment of the market. An abundant resource base combined with the desire to increase energy security and address climate change throughout the region have led to the continued development of Central America's geothermal resources. Costa Rica has been producing geothermal electricity from units located in the foothills of the Miravalles volcano since 1994. Studies of Guatemala's geothermal resource indicate that the country has up to 4,000 MW of geothermal potential, of which a small portion has already been developed for electricity production. Two geothermal power plants currently operate in Guatemala provide a combined 52 MW of geothermal energy to Guatemala's electricity grid. The majority state-owned company, LaGeo, operates the two plants which have a cumulative installed capacity of above 200 MW, making El Salvador the largest producer of geothermal energy in Central America. Investment in geothermal has significant upfront costs that must be spent prior to determining the viability of the resource basin. This investment requirement raises the upfront investment cost against (1) the short-term, up-front geological risk of exploration drilling, and/or (2) the long-term geological risk of developing and producing a geothermal reservoir with a lower-than-estimated temperature, higher than estimated mineralization, or difficulty with injection of geothermal fluids back into the subsurface.

Wind China alone attracted more than 50% of PPP investment in wind. Not surprisingly, China is listed as the top country in the world in terms of wind power added capacity in 2009, ahead of the United States, Spain, Germany, and India and the second country after the United States in terms of existing capacity. Poland has been a fast mover, attracting since 2005 15% of the overall investment. Bulgaria is following the lead by Poland attracting cumulatively more than 8% of the total investment. It is also worth noting the effort by Turkey and India in attracting private investment in wind which account for about 3% of the total PPP investment. The risk of lower revenue from a wind project due to lower than expected wind speeds is a major factor affecting the finance terms and conditions of wind farms. For wind as for other grid-connected renewable-based energy, long lead times and administrative process may be needed to ensure grid reinforcements or additional investment necessary in the distribution or transmission system. Regulations requiring the project developer to pay the grid cost only up to the nearest grid connection point (the so called "shallow" grid connection charges) minimize the risks for the project developers, but they increase the burden on the network operator.

Waste Thailand alone accounts for 50% of the total PPP waste investment in developing countries. Biomass is by far the largest single contributor to power generation with most of the successful larger projects integrated into the rice and sugar mills. This is because of the large quantities of rice husk and bagasse produced by the mills that provide electricity for the milling process with additional electricity produced for export to the Electricity Generating Authority of Thailand (EGAT). Biomass from waste streams created during the processing of cassava and palm oil is the second largest source of renewable energy. Municipal solid waste projects have been proposed but only infrequently implemented. Privately owned renewable energy projects that produce electricity under the Small Power Producer (SPP) and Very Small Power Producers are eligible for special regulations and additional payment are available where the projects replace electricity generated from diesel fuel. Box 3 reports some of the challenges for SPP based from the pioneering experience in Thailand and Sri Lanka and the most recent experience in the first Sub Saharan country, Tanzania. Brazil has attracted more than 20% of the total PPP waste investment. Brazil has over 4.8 GW of biomass cogeneration plants at sugar mills, which generated more than 14 TWh of electricity in 2009; nearly 6 TWh of this total was excess that was fed into the grid. China accounted for 12% of total PPP investment in this subsegment of the market and its capacity rose further by 14 % in 2009 to 3.2 GW, and the country plans to install up to 30 GW by 2020. India generated 1.9 TWh of electricity with solid biomass in 2008. By the end of 2009, it had installed 835 MW of solid biomass capacity fueled by agricultural residues (up about 130 MW in 2009) and more than 1.5 GW of bagasse cogeneration plants (up nearly 300 MW in 2009, including off-grid and distributed systems); it aims for 1.7 GW of capacity by 2012.

Box 3 Small Power Producers and light handed regulation

Small Power Producer (SPP) regulations enable expansion of renewable generated electricity through model power purchase agreements, standardized tariffs, and streamlined interconnection and licensing requirements. The regulations provide the legal basis for customers to self-supply with small clean renewable energy or cogeneration generators, and to export excess power (up to 10 MW) to the national utility (either the national grid, or mini-grids). SPPs will only develop if the prices that they receive for their electrical output exceed their own costs of production. For example, where main grid connected SPPs can sell at an administratively set price of about US $.10/kwh, the only SPPs that are commercially viable are cogenerators, some biomass generators and some mini-hydro generators with well-endowed sites. Solar and wind generators are generally not viable at this price level. In Tanzania in some cases (as reported in Graecen, Kahyoza and Mbawala (2010), SPPs will replace some or all of the production of existing diesel generation of mini-grids operated by TANESCO (the national government-owned utility). In other cases, it will bring electricity to communities without electricity. EWURA, the Tanzanian electricity regulator, has made a conscious effort to employ "light handed regulation" in its regulation of SPPs. "Light handed regulation" means first, minimizing the amount of information that is required; second, minimizing the number of different regulatory requirements and decisions; and third, relying to the extent possible on related reviews by other Tanzanian government entities. An example of the first is that annual reporting requirements for SPPs are a fraction of those required by TANESCO or larger IPPs. An example of the second is that projects under 1 MW are exempt from EWURA licensing, and the SPP program relies on standardized documents as much as possible to minimize the need for case-by-case negotiation. An example of the third is that EWURA has proposed to rely, to the maximum extent possible, on the economic and technical reviews undertaken in electrification grant reviews by the Tanzania Rural Energy Agency (REA). Tenenbaum and Graecen (2010) also provides a typology of SPPs, presents a more detailed and nuanced discussion of the different dimensions of regulation vis-a-via SPPs and, perhaps most importantly, concludes with a several page checklist of real world implementation issues for regulators and government officials who wish to promote SPPs, Thailand and Sri Lanka both have similar SPP regulations in place, and both have encountered – to a certain extent – problems in which companies apply for PPAs with the intention of selling these PPAs at a profit. For example, in Thailand one company accounts for 445 MW of signed PPAs for grid-connected solar PV. None of these projects have yet to be built. Similarly, in Sri Lanka companies have tied up key micro-hydro sites with PPAs that have failed to develop into projects even after a number of years. To discourage this form of 'PPA speculation' EWURA's license approvals 'expire' after two years, thus giving other developers the chance to move in and develop the site.

Source: Greacen Kahyoza and Mbawala (2010), Tenenbaum and Greacen (2010)

3. Theoretical hypotheses

The key determinants of PPPs in renewable-based energy, measured as the existence and amount of investment, are divided into three channels, reported in Table 1. These include (sectoral and economy-wide) governance variables and short and long run drivers, represented respectively by financial crises and climate change variables. We also control for macroeconomic, sectoral and regional variables.

The hypotheses that we are going to test are reported below. Each of the hypothesis is divided in two parts (part A and B), taking into account respectively the key factors affecting the private investor's decision to enter the renewable energy market and the amount of investment sunk in renewable energy, because of the different modeling that will be used (as described in Section 3).

Table 1 Dependent and Explanatory Variables Influencing Private Investment in Renewable-based Energy

Variables	Definition	Exp. Sign
	SECTORAL GOVERNANCE VARIABLES	
Introduction of feed-in tariffs *FIT*	= 1 since the year of establishment of a feed-in tariff system = 0 otherwise	+
	ECONOMY WIDE GOVERNANCE VARIABLES	
Control of Corruption	= measures the perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests. (Kaufmann and Kray World Governance Indicator)	+
Degree of democracy *Polity2*	= Revised Combined Polity Score (Polity 2): This variable is a modified version of the POLITY variable to facilitate the use of the POLITY regime measure in time-series analyses. It ranges from +10 (strongly democratic) to -10 (strongly autocratic), based on 6 indicators.	+
	SHORT RUN FINANCIAL CRISES	
East Asian and Russian Crisis *d_FC1*	= 1 for the 3 years after 1997 = 0 otherwise	-
Latin American Crisis *d_FC2*	= 1 for the 3 years after 2001 = 0 otherwise	-
	LONG RUN ENVIRONMENTAL SUSTAINABILITY FACTORS	
Price of oil	= value of the international price of oil	+
Kyoto Protocol	= 1 for the years after 2005 = 0 otherwise	+
PPP Transmission investment	= investment in transmission committed by the private sector in (US$)	+
	LONG RUN ECONOMIC FUNDAMENTALS	
GDP *ln_GDP*	= GDP, PPP terms (constant 2005 international $)	+
Population *ln_Pop*	= total population	+

Sectoral and Economy-Wide Governance

Hypothesis 1A The likelihood of attracting private investors to provide electricity from renewables is higher in countries where support mechanisms, including feed-in tariff, have been put in place.

Hypothesis 1B The level of investment in renewable-based energy is expected to be higher in countries using such incentives.

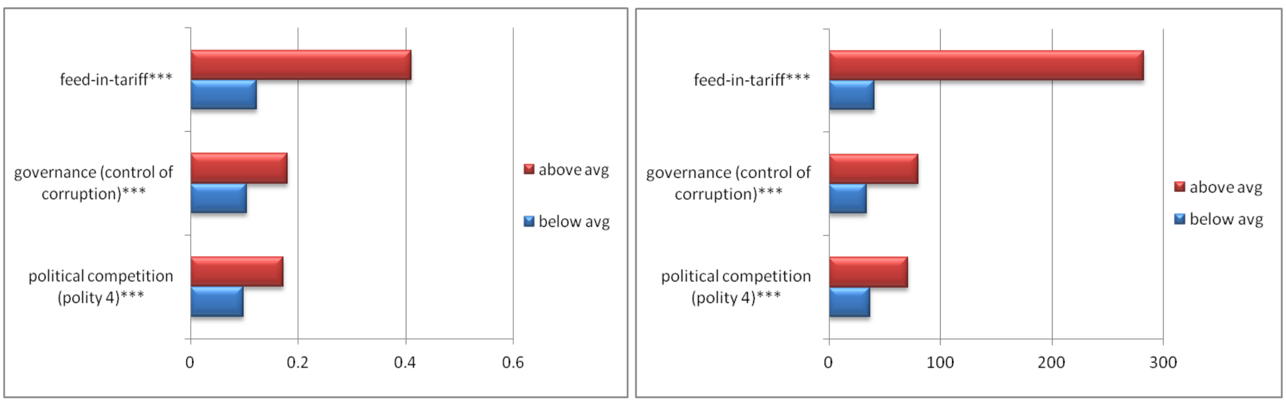
Private investors are more likely to choose to invest in renewable energy if the country offers sufficient incentives from the regulatory side. This is because most renewable sources of energy produce electricity at a higher cost than electricity from conventional sources, and they also typically entail higher upfront capital costs. After recouping the capital cost, private investors can benefit from the lower operational costs of generation from renewables. This is because, for instance, producers of electricity from wind and solar do not have to manage fuel cost or fuel price volatility.

To get an initial indication of whether the data confirm these hypotheses we can calculate the two means between different groups (e.g. the proportion observation where feed-in tariffs have been used and the one where they were not) and compare them to see if one is greater than the other, and by how much. The significance of differences between two sample means can be assessed using the t-statistic calculated as part of the t-test. The t-statistic may be thought of as a scaled difference between the two means, where the absolute difference between means is rescaled using and estimate of the variability of the means. Such tests will be performed for each of the following hypotheses.

The data reported in Fig 10 shows that countries that have introduced a feed-in tariff are almost four times more likely to attract private investment in renewable-based energy and about seven times more investment than countries where such support mechanisms have not been introduced. Both differences in the proportion (and total investment) of countries who have used (or not) feed-in tariffs are highly significant at 1% confidence level.

Fig. 10
Links between Investment in Renewable-based energy and Governance

a) Likelihood of PPPs in renewable-based energy (proportion) | *b) Investment in PPP renewable-based energy (average investment,US$ million)*



Source: World Bank/PPIAF PPI Database
Note: *, **, *** indicate significance of the t test of the difference between the two pair means respectively at 10%, 5% and 1% confidence level.

Hypothesis 2A The likelihood of attracting private investors to provide electricity from renewable-based energy is higher in countries characterized by higher standards of economy-wide governance and a higher degree of political competition.

Hypothesis 2B The amount of private investment in renewable-based energy generation is higher in countries characterized by higher standards of economy-wide governance and a higher degree of political competition.

Countries that score above average on economy wide indicators in terms of control of corruption and political competition are twice as likely to attract private investment and to get about twice the volume of investments.

Short run crises and economic fundamentals

Hypothesis 3A Countries facing severe financial crises are less likely to attract new PPPs.

Hypothesis 3B Countries facing severe financial crises are less likely to receive PPP investment from existing PPPs in the years immediately following the crises.

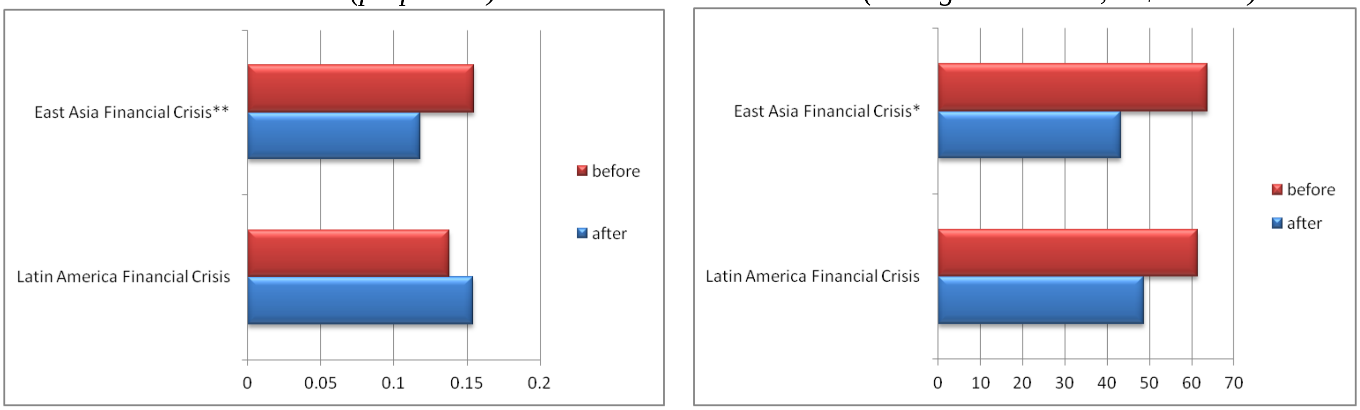
The likelihood of attracting investment declined by 10% after the East Asian financial crisis, but marginally increased, but not significantly so, after the Latin American financial crisis. Investment dropped by 30 and 20 percent after the East Asian and Latin American financial crises. Not surprisingly, the impact of the first financial crisis was significant both in terms of likelihood and extent of reduction of investment.

Fig. 11

Links between Investment in Renewable-based energy and Financial Crises

a) Likelihood of PPPs in renewable-based energy (proportion)

b) Investment in PPP renewable-based energy (average investment,US$ million)



Source: World Bank/PPIAF PPI Database

Note: *, **, *** indicate significance of the t test of the difference between the average respectively at 10%, 5% and 1% confidence level.

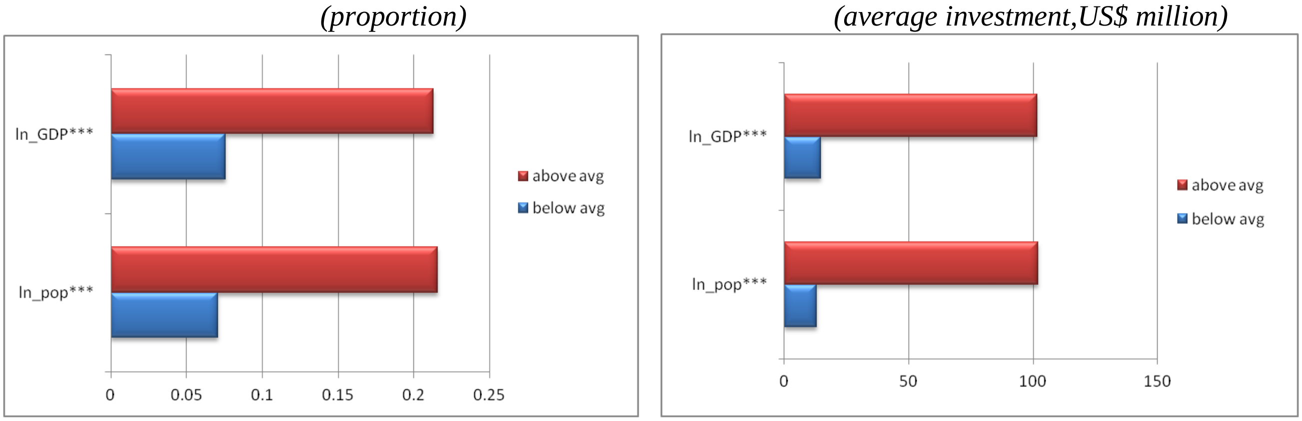
Hypothesis 4 Countries characterized by higher income and size of the market are more likely to attract PPPs and a higher volume of investment.

Fig. 12

Links between Investment in Renewable-based energy and GDP per capita

a) Likelihood of PPPs in renewable-based energy (proportion)

b) Investment in PPP renewable-based energy (average investment,US$ million)



Source: World Bank/PPIAF PPI Database

Note: *, **, *** indicate significance of the t test of the difference between the average respectively at 10%, 5% and 1% confidence level.

Fig. 12 shows that countries with above average GDP and population are o are three times more likely to attract private investment in renewable-based energy. Countries with above average GDP and population growth are respectively seven and eight times more likely to attract more investment than countries whose population is increasing below the average.

Long run Environmental Sustainability Drivers

Hypothesis 5A Developing countries are more likely to attract more investment in years following the entry into force of the Kyoto Protocol due to the rise of climate change up in the political agenda.

Hypothesis 5B Developing countries are more likely to retain more investment in years following the entry into force of the Kyoto Protocol due to the rise of climate change up in the political agenda.

Hypothesis 6A The likelihood of attracting and retaining private sector investment in renewable based generation is higher if the price of oil is increasing.

Hypothesis 6B The likelihood of attracting and retaining private sector investment in renewable based generation is higher if the price of oil is increasing.

Hypothesis 7A Countries that have attracted more private investment in transmission are also better prepared to integrate renewables in their system and hence more likely to attract private sector investors in renewables.

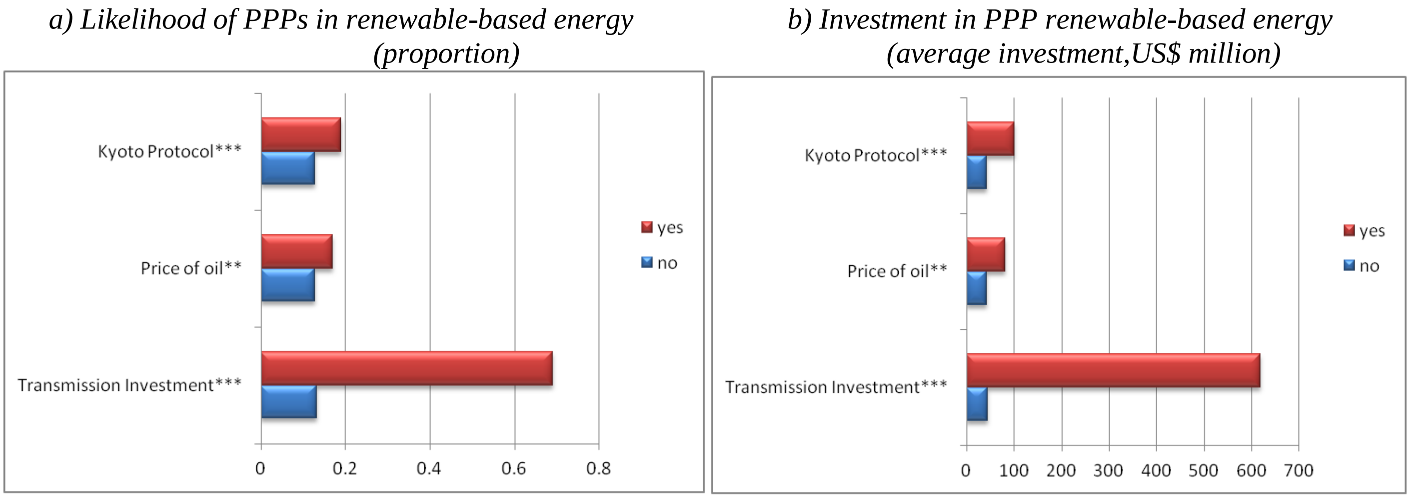
Hypothesis 7B Countries that have attracted more private investment in transmission are also better prepared to integrate renewables in their system and hence more likely to attract higher investment in renewables.

Fig. 13 shows that Hypotheses 5A and B are strongly reinforced by the data. After the entry into force of the Kyoto Protocol, developing countries became 30% more likely to attract PPPs in renewable-based energy. They also attracted more than twice the amount of investment in US$ terms in renewable generated energy.

Hypotheses 6A and B are also confirmed by the data. Countries with above average price of oil are 30% more likely to attract PPPs in renewable-based energy. They also attracted more than twice the amount of investment in US$ terms in renewable generated energy.

Hypotheses 7A and B found very strong confirmation in the data. Countries with above average private investment in transmission are 5 times more likely to attract private investment in renewable-based energy. They also attract almost 14 times the investment in US$. In other words, attracting additional private investment in renewable-based energy depends not only on policy and regulatory regimes, but also on several other factors including grid or infrastructure access and availability; the planning and approval process, given the potential for costly delays to construction which defer the point at which a project will start generating revenue; the power purchase agreements and so on – all aspects within the boundary of the project or that could affect the feasibility and profitability of PPPs in renewable-based energy (World Bank and E3 2010, Sovacool, 2009).

Fig. 13
Links between Investment in Renewable generated energy and *Environmental Sustainability Drivers*



Source: World Bank/PPIAF PPI Database
Note: *, **, *** indicate significance of the t test of the difference between the average respectively at 10%, 5% and 1% confidence level.

The result of the regressions will allow us to test the hypotheses and corroborate the robustness of these preliminary findings.

4. Regression Results

Table 2 reports the parameter estimates using the probit model, where the dependent variable is a dummy variable equal to 1 if PPP occurred for electricity renewable generation and 0 if not. This model aims at identifying the key factors driving the entry of new private investment in the renewable market.

Regression (1) reported in Table 2 represents the basic probit model introducing as explanatory variables the key sectoral and economy wide governance variables to test Hypotheses 1 and 2. Regressions 2 and 3 then extend the analysis to analyze the role of short run financial crises and long run climate change variables, controlling respectively for macroeconomic fundamental variables and sectoral and regional control. Regression 3 also allows for the introduction of investment in transmission and for the interaction between the price of oil and other selected variables.

Table 2 Key Determinants of the Introduction of PPP in Electricity Renewable Generation

	(1)	(2)	(3)
GOVERNANCE VARIABLES			
SECTORAL GOVERNANCE VARIABLES			
Introduction of feed-in tariffs *FIT*	0.802*** (0.146)	0.556*** (0.158)	0.407** (0.175)
ECONOMY WIDE GOVERNANCE VARIABLES			
Control of Corruption *wgi_cc*	0.445*** (0.092)	0.452*** (0.104)	0.456*** (0.106)
Degree of democracy *Polity2*	0.025*** (0.009)	0.021* (0.011)	0.020* (0.011)
GDP *ln_GDP*		0.039 (0.068)	0.020 (0.076)
Population *ln_Pop*		0.247*** (0.077)	0.271*** (0.035)
LONG RUN ENVIRONMENTAL SUSTAINABILITY FACTORS			
Price of oil			-0.011 (0.007)
Price of oil*Kyoto Protocol			0.011* (0.008)
Transmission investment			0.002*** (0.001)
REGIONAL CONTROLS			
Regional Dummies	Yes	Yes	Yes
Constant	-1.097*** (0.087)	-6.128*** (0.800)	-5. 570*** (0.838)
N	1185	1143	1143
Log likelihood	-444.67	-202.34	-391.75
χ^2	130.52***	202.34***	218.66***
Pseudo R^2	12.80	20.19	21.82

Note: *, **, *** indicate significance of the coefficient respectively at 10%, 5% and 1% confidence level.

In what follows the key results are highlighted, focusing on the specific hypotheses tested in each of the regressions.

Regression 1 confirms Hypothesis 1.A, namely the introduction of a feed-in tariff is positively and highly significantly associated to the introduction of PPPs in renewable electricity generation.

Hypothesis 2A is also confirmed, that a higher standard of economy wide governance is more likely to attract PPPs in renewable electricity generation. The result extends more broadly to all form of (price and quantity based) support to renewable-based energy. The results are presented only for feed-in tariff, as they represent the predominant support mechanism used in the developing countries sampled in our study.

Hypotheses 3A, related to short run crises, is not confirmed. Despite after the East Asian and Latin American crises PPPs declined substantially, the likelihood of attracting investor did not decrease substantially following periods of crises which go beyond the initially impacted region.

Hypothesis 4A is partly confirmed. Interestingly, countries characterized by higher income have a higher probability of attracting PPPs, but not significantly so. The size of the market instead has both a positive and highly significant relationship with the introduction of PPPs.

Hypotheses 5A and 6A are partly confirmed. Regression 3 shows that higher international prices of oil do not significantly affect likelihood of attracting PPPs in renewable electricity generation, even not significantly so. Controlling for the interaction between the price of oil and the Kyoto protocol, environmental sustainable considerations affect the choice of introducing PPPs in renewable based generation. The positive sign of the interacted terms however implies that after the introduction of the Kyoto protocol countries became more likely to introduce PPPs in renewable based generation, also driven by the higher price of oil.

Regression 3 introduces an additional variable for the level of committed private investment in transmission. Hypothesis 7A is confirmed. Countries with higher private investment in transmission are positively and significantly associated with the introduction of renewable-based energy. This confirms the importance of including considerations related to access to the grid and development of the network so as to integrate renewable-based energy into the power system. Because of the potential concerns with endogeneity due to the fact that private investment in both segments of the power sector can be driven by similar factors, we also used instrumental variables, including the lagged variable of the transmission variables. The results are robust to the introduction of instrumental variables. In sum, Hypothesis 1.b on the links between better readiness of the transmission resources for renewables and higher investment in renewable generated energy is strongly confirmed by the regressions.

Regression 3 confirms the robustness of the previous results, controlling for regional dummies and for the interaction between the emission per capita and the GDP per capita of the country.

We can now move to determine which of the previous factors affect the private investor's decision to enter the market of renewable-based energy and the amount of investment sunk in the sector. Regressions (1) and (2) in Table 3 report the results of the two step Heckman model, introducing in the first stage as a dependent variable (reported in red) the likelihood of attracting private investment in renewable-based energy and as explanatory variables the key sectoral and economy wide governance variables. The second step of the model uses the logarithm of amount of private investment in renewable-based energy as the dependent variable, conditional on the decision to enter the renewable market, and as explanatory variables the broader model including the short run and long run variables described above. The final two regressions report the GLS model using as a dependent variable the logarithm of amount of private investment in renewable-based energy, which restrict the number of observations only to countries with a non-negative level of private investment in renewable-based energy.

Table 3 Key Determinants of PPP Investment in Electricity Renewable Generation

	Two step (1)	Two step (2)	(3)	(4)
SECTORAL GOVERNANCE VARIABLES				
Introduction of feed-in tariffs *FIT* *First step in red*	0.803*** (0.143)	0.681*** (0.150)		0.509* (0.318)
ECONOMY WIDE GOVERNANCE VARIABLES				
Control of Corruption *wgi_cc* *First step in red*	0.386*** (0.088)	0.372*** (0.088)		
Degree of democracy ***Polity2*** *First step in red*	0.023*** (0.008)	0.020** (0.009)		
ENVIRONMENTAL SUSTAINABILITY FACTORS				
Price of oil			0.011* (0.006)	
Kyoto Protocol		0.003*** (0.001)		
MACROECONOMIC CONTROL				
GDP *ln_GDP*	0.627*** (0.173)	0.541*** (0.174)	0.586*** (0.197)	0.628*** (0.192)
Population *ln_Pop*	0.345*** (0.171)	0.196 (0.170)	0.312 (0.213)	0.373* (0.209)
Constant	-6.998*** (2.412)	-5.466** (2.397)	-5.370** (2.345)	-5.109** (2.378)
N	1184	1184	189	189
Censored N	1002	1002		
Wald χ^2	32.85***	27.32***	23.80***	22.87***
Within R^2			7.88	7.20
Between R^2			17.92	20.29
Overall R^2			16.72	15.85

Note: *, **, *** indicate significance of the coefficient respectively at 10%, 5% and 1% confidence level.

Some interesting results are worth highlighting. In what follows we focus on the different factors that affect entry and the level of investment in renewables.

First, better control of corruption and higher degree of political competition are crucial in attracting the entry of private investors, but they do not affect the extent of investment in the presence of substantial sharing of risks between the public and private sector. The economy wide governance factors affect only the first step of the Heckman model, confirming the results of the probit model analyzed before. In other words, This suggest that the first generations of private investment in renewable-based energy have been developed on the basis of attractive feed-in tariffs and long term PPAs guaranteeing a fixed rate of return, through take-or-pay clauses and/or government guarantees, shifting most of the risks to the public sector.

Second, the sectoral support scheme, provided by feed-in tariffs, instead, affect both the entry and the level of investment in renewable-based energy, though they become much less significant when it comes to

determine the amount of investment. The result is easily explained, as investments in renewable-based energy depend crucially on the presence of support mechanisms. We found confirmation of an important result as before. Higher investment in transmission can be often an important prerequisite for attracting private investment in renewable-based energy.

Third, investment in renewable-based energy has been significantly affected by the signing of the Kyoto Protocol, proving also the importance of legal international commitment to further generate confidence and foster investment in the sector.

Other differences in results are more a question of nuances. In terms of economic fundamentals, whereas the level of entry was mainly affected by the market size (in terms of population), both income and population size affect the level of investment, highlighting the importance of affordability and sustainability of the support for renewable-based energy. Investment in transmission does not affect significantly the level of investment in electricity renewable generation.

5. Conclusions and Future Directions

Strong evidence is found in this analysis of the effectiveness of support mechanisms such as feed-in tariffs to attract private investment in renewable-based energy in developing countries, after controlling for several short and long run factors related to the presence of financial crises and trends in economic fundamentals. The key results of the paper are summarized below:

- **The market for renewable-based energy is strongly driven by supportive policies. Support policies serve not only to attract the entry of private investor but also to determine the level of investment**. In the latter case, its impact is less significant, suggesting the need over time to revisit the power of the incentive schemes, as well as the implied allocation of risks between the public and private sector to ensure that feed-in tariffs produce the desired amount of investment.

- **In contrast, broader economy-wide governance factors, including control for corruption and degree of political competition, are considered by private investor mainly for taking the decision to enter into renewable-based generation.** This reinforces our earlier suggestions that private investors seem to be adequately protected against their risks, so that once they have entered the market, they can accommodate the governance environment.

- **Private investors in renewable-based energy also require technical and regulatory certainty about the availability of renewable-ready transmission resources, if they are to finance investments.** The traditional reactive model of transmission regulation that has been used in the past, where transmission has been developed on a first-come, first-served is not conducive for renewable-based energy, as it introduces extensive regulatory and technical uncertainty about whether adequate transmission will be available once the resource is generated, and transmission distances for renewable-based energy can be large. Also in this case such factors do not affect the level of investment but only the decision to enter the market.

- **Private investors entering the market looks more at the size of the market rather than the income level, whereas when determining the level of investment they assess both the size and "affordability" level**. This raises some concerns on the sustainability of support mechanisms and their financing, particularly when the incremental costs implied by renewable-based generation are passed through to consumers.

- **Short run financial crises do affect neither the decision to enter the renewable market nor than the level of investment, proving the resilience of renewable-based energy to such shocks.**

In a nutshell, the policy and regulatory regime will be assessed across all aspects of the project, not just the support or incentive mechanism. This would include: the planning and approval process, given the potential for costly delays to construction which defer the point at which a project will start generating revenue; grid or infrastructure access and availability; power purchase agreements and so on – all aspects within the boundary of the project or that could affect company activity.

Moving this analysis forward, our future research aims to look at a more detailed analysis and policy recommendation on specific factors that could contribute to successfully attract investment in developing countries, by looking at the two issues reported below:

- **Incentive schemes.** What types of incentive schemes proved to be the most successful in attracting private investment in renewable generated electricity? The importance of details of feed-in tariff system design, which may include capping (government-established limit on installation); tariffs differentiated by technology; tariff inflation-indexation; duration. All of these design factors will make the business environment for renewable-based energy, or less, attractive to private investors. Further work is planned to look at to what extent the level of feed-in tariff vis-à-vis other characteristics (including the time duration and those mentioned above) affect private investment in renewable-based generation.

- **Financing and affordability issues:** Ultimately, financing choice rests between (today and tomorrow) users and (developing and developed countries') taxpayer (tomorrow's users, if financed through borrowing, developed countries' taxpayers if financed through ODA). Where feed-in tariffs have been employed in developing countries, they often have to be met by government budgetary allocations to cover the differential between the guaranteed price that the utility pays to the renewable energy suppliers, and the average rate that it is allowed to charge consumers for each kilowatt hour of electricity. This dependence on national budgets to cover the difference places a cap on the total expansion of renewable energy that can take place in a developing country, and thus creates a disincentive for expanded renewable energy investment. Within this context, alternative support schemes, including through a "global feed-in tariff", a payment-on-delivery mechanism, whereby funds flow only when electricity comes on line; that is, when real and tangible benefits are being provided. Whereas they have been cases where costs has been borne by the taxpayers, in most cases will be passed through consumers, raising formidable affordability issues. There are ways to protect poor consumers, but at the same time allowing for some partial pass through of feed-in tariffs. The incremental cost associated with renewable based generation can be, for instance, recovered for instance only through large customers.

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