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Relative significance of determinants of foreign direct investment in wind and solar energy in developing countries – AHP analysis

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ABSTRACT

The importance of foreign direct investment (FDI) for the development of renewable energy in developing countries has been increasingly recognized. Numerous countries have created various measures to attract FDI in the renewable energy sector. This paper uses the analytical hierarch process to clarify the relative significance of the determinants in the location decisions of foreign wind and solar energy investors. A total of 18 determinants that are categorized into the macroeconomic environment, institutional environment, natural conditions, and renewable energy policy categories are used for the analysis. The results show that adding to the traditional determinants of FDI, including the macroeconomic environment, the institutional environment, and natural conditions, renewable energy support policies have the same or stronger influence as location determinants of FDI. The paper also points out that some of the traditional determinants, such as exchange rate volatility, access to land, and an efficient and transparent administrative procedure, are also very important as determinants of FDI in wind and solar energy. Policy implications focus on the determinants of FDI in wind and solar energy. The relative significance of the determinants clarified through this study offers criteria for prioritizing policies and actions for policy makers.

1. Introduction

According to the latest figures provided by FDintelligence (2017), the renewable energy sector is the third largest sector regarding the amount of foreign direct investment (FDI),[1] attracting around one-tenth of the total green-field FDI, which totaled USD 77 billion. Under pressure to rapidly increase energy generation capacities to address growing demand, to meet energy access challenges, and to foster economic development in a sustainable manner, many developing countries[2] are increasingly facilitating the development of renewable energy. The development of renewable energy is mainly led by the wind and solar energy sectors, which accounted for 68% of the total renewable energy installed worldwide between 2011 and 2016 (IEA, 2017).

At the 21st Conference of the Parties of the United Nations Framework Convention on Climate Change, the importance of private financing for developing countries, especially FDI, was recognized (McInerney and Johannsdottir, 2016). For many developing countries, FDI serves not only as an important source of capital but also as a valuable channel for transferring more productive and innovative technology and techniques. In the midst of the transition to cleaner energy systems that is occurring worldwide, enhancing the enabling environment for FDI in renewable energy, in particular wind and solar energy, two of the renewable energy sources attracting the majority of investment worldwide, could greatly facilitate competition in the electricity market, and advance the transition safely and efficiently. To do so, understanding the location determinants of FDI in wind and solar energy in developing countries and clarifying the determinants' relative significance would provide criteria for prioritizing policies and actions for policy makers. Therefore, by extending previous studies on this topic, this study aims to clarify the relative significance of the determinants of FDI in wind and solar energy in developing countries.

Despite the increasing FDI in the renewable energy sector, and

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[1] FDI refers to investment to build new facilities and/or to obtain lasting management interest in host countries' enterprises.

[2] In this paper, the term "developing countries" indicates countries listed as developing countries in the IMF's 2017.
World Economic Outlook Report.

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growing interest in the effectiveness of various policies aiming to attract investment in the sector, the number of studies clarifying the determinants of FDI in this sector is still very limited. Furthermore, most studies used econometric approaches to find the important determinants. For example, Eyraud et al. (2013) used a panel-data approach to identify the determinants of green investment (including FDI and domestic investment), which they defined as investment in selected energy-efficient technologies, renewable energy, and research and development in green technologies. The study pointed out the importance of determinants such as interest rates, growth of the gross domestic product, and renewable energy policies. Keeley and Ikeda (2017), using structural equation modeling, investigated the determinant of FDI in wind energy in developing countries. Keeley and Ikeda's results, which emphasized the importance of regulatory policies, showed the impact of renewable energy policies as determinants of FDI. Murovec et al. (2012) also used structural equation modeling to clarify the determinants of environmental investments, including investments in the renewable energy sector. Murovec et al. emphasized that tax measures and financial incentives are determinants that have a high impact on location decisions. Although these econometric approaches provided important empirical evidence, there are also some limitations. The first limitation is in the resolution of the factors considered in the analyses. Most of these analyses showed the impact of renewable energy support policies as determinants of FDI, which included different kinds of support policies (e.g., feed-in tariff, renewable portfolio standards, renewable energy certificates, competitive bidding, and tax incentives). However, in these econometric approaches, the impacts of the different support policies were not individually tested. This limitation is due to the availability of data and because many countries implement more than one support policy in parallel, which makes it hard to clarify the impact of each policy.

Another limitation lies in the selection of the variables considered in the studies. The econometric studies selected variables based on a literature review and the availability of data. Painuly (2001) stressed that interaction with experts in the field through structured interviews and/or questionnaires is “very crucial to identification of the barriers as the perception of stakeholders on barriers may reveal the lacunae in existing policies and help in identification of measures to overcome the barriers.” This highlights the importance of expert opinions to identify factors omitted in previous studies and clarify the relative significance of the determinants of FDI.

Therefore, to overcome these limitations, and to verify and complement the econometric studies, this paper aims to clarify the relative significance of the determinants based on questionnaires conducted with experts active in FDI in solar and wind energy in developing countries. The relative significance of the determinants is clarified by analyzing the data using the analytical hierarchy process (AHP). Clarifying the relative significance of the determinants provides criteria for prioritizing policies and actions that can enhance a country's attractiveness for FDI in wind and solar energy, and further shows the importance of renewable energy sector–specific policies. This study is one of the first attempts to clarify the relative significance of the determinants of FDI in wind and solar energy by employing a mix of qualitative and quantitative approaches.

The rest of the paper is structured as follows. Section 2 explains the methods employed in this paper. Section 3 presents the determinants of FDI in wind and solar energy through shedding light on previous studies. Section 4 provides the results of the AHP and clarifies the relative significance of the determinants. Finally, based on the results, Section 5 presents conclusions and policy implications for some of the most important determinants of FDI in wind and solar energy sector in developing countries.

2. Methods

To set the priorities among the determinants that have been identified, experts in decision-making positions in companies that have conducted FDI in solar and wind energy in developing countries were asked to fill out questionnaires formulated to provide input for the prioritization process (see Appendix). The responses were analyzed using the AHP to finalize the prioritization process. The AHP is a tool used for decision making and determining the significance of a set of criteria and sub-criteria of multi-criteria problems. The AHP was developed by Thomas Saaty in 1980. Lee and Chan (2008) highlighted the strength of the AHP, asserting it “is very suitable for complex social issues in which intangible and tangible factors cannot be separated.” The AHP has been applied in various fields, and it has been employed in a number of cases related to renewable energy (Kambezidis et al., 2011; Kaya and Kahraman, 2010; Keeley, 2017; Matsumoto et al., 2017; Nigim et al., 2004; Nikolaev and Konidari, 2017).[3] Most of the literature that applied the AHP to cases related to renewable energy used the method to determine the best renewable energy to deploy in a certain region or environment. Few cases applied the AHP to examine the relative significance of determinants of FDI in wind and solar energy, which is another originality of this paper.

In AHP, first the problem is structured in a hierarchical model by creating various levels of issue or category parameters to achieve the desired goal. In the present study, “enhancement of attractiveness for FDI in wind and solar energy in developing countries” is the top of the hierarchy, and below that are broad categories and factors (sub-categories). Experts, then, systematically evaluated the factors by comparing them to one another two at a time regarding their influence on the factor above in the hierarchy using a 1–9 scale as proposed by Saaty (1980). The 1–9 scale is explained in more detail in Table 1. The evaluations are converted to numerical values for processing and comparison over the entire range of the problem. First, the pairwise judgments are converted into a pair-wise matrix. The normalized matrix is gained by dividing each factor by the column-wise summation of the factors. Then, the eigenvector is calculated by averaging the factor in rows. Each factor of this vector represents the weight of the importance. In this study, the average of the experts' evaluations is presented as the relative significance of each factor. Next, the consistency of each pairwise comparison matrix is checked to justify the experts' evaluations. “The oldest and most commonly used measures are the consistency index (CI) and consistency ratio (CR)” (Brunelli et al., 2013). The CI is calculated based on the following equation proposed by Saaty (1980):

$$\mathrm{CI} = \frac{\lambda\mathrm{max} - \mathrm{n}}{\mathrm{n} - 1}, \quad (1)$$

where n is the number of evaluating factors, and λmax is the maximum eigenvalue of the matrix.

The CR is defined as:

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}}, \quad (2)$$

where RI is the average value of the CI obtained from 500 positive reciprocal pairwise comparison matrices whose entries were randomly generated using the 1–9 scale (Peláez and Lamata, 2003).

Table 2 provides RI values for different n.

If the CR is 0, then the respondent's answers are completely consistent; if the CR equals 1, then the answers are completely inconsistent. In general, based on Saaty's suggestion, answers within the range of 0.1–0.15 are considered consistent enough to be acceptable (Saaty, 1980). When the CR is above 0.15, the evaluation should be repeated until it reaches the acceptable consistency. However, in real practice, a comparison matrix often has poor consistency, and repeating the evaluation numerous times are practically difficult. Bhushan and Rai

[3] The studies conducted by Kambezidis et al. (2011), Matsumoto et al. (2017), and Nikolaev and Konidari (2017) use the method called AMS, which is the combination of three standard multi-criteria methods including AHP.

Table 1
Analytic hierarchy measurement scale (Saaty, 1980).

Reciprocal Measure of Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance of one over another	Experience and judgment slightly favor one activity over another
5	Moderate importance	Experience and judgment strongly favor one activity over another
7	Strong importance	An activity is strongly favored, and its dominance is demonstrated in practice
9	Absolute importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between two adjacent judgments	When compromise is needed

Table 2
Values of the random index for different matrix orders (Saaty, 1980).

	Relationship between n and RI					
n	1–2	3	4	5	6	7
RI	0	0.58	0.90	1.12	1.24	1.32

(2007) suggested that for very abstract parameters, a CR up to 0.2 should be allowed. Numerous previous studies used 0.2 instead of 0.1 as the CR criterion (Regmi and Hanaoka, 2012; Thao et al., 2014). In this paper, a CR criterion of 0.2 was used, and answers (pairwise comparisons) with a CR greater than or equal to 0.2 were excluded as inconsistent. Next, following the steps proposed by Goepel (2013), by using the eigenvector method, all of the pairwise comparisons that meet the consistency defined above are combined into a consolidated decision matrix to obtain the aggregated result. The consolidated decision matrix C combines all k participants' inputs to obtain the aggregated group result (Goepel, 2013). The weighted geometric mean of the decision matrix factors, the pairwise N × N comparison matrix $A = a_{ij(k)}$, is used with each expert's weight (ω_k), which is expressed as the following equation:

$$C_{ij} = \exp\frac{\sum_{k=1}^{n}\omega_k \ln a_{ij(k)}}{\sum_{k=1}^{n}\omega_k}. \tag{3}$$

Through this process, a numerical weight (relative significance) is derived for each factor, which allows the factors to be compared with one another consistently and rationally.

The consensus ratio among the respondents is also calculated in addition to the weight of each factor by using the Shannon alpha and beta entropy. The consensus indicator ranges from 0% (no consensus between experts) to 100% (full consensus between experts; Goepel, 2013). The AHP consensus ratio S is calculated based on the following equation:

$$S = \frac{M - \exp(H_{\alpha min})}{\exp(H_{\gamma max})} / \frac{1 - \exp(H_{\alpha min})}{\exp(H_{\gamma max})} \tag{4}$$

$$\text{with } M = \frac{1}{\exp(H_\beta)}, \tag{5}$$

where H_α is the Shannon alpha entropy, H_β is the Shannon beta entropy, and $H\gamma$ is the Shannon gamma entropy for the priorities of all K respondents.

The Shannon alpha entropy is:

$$H_\alpha = \frac{1}{K}\sum_{j=1}^{K}\sum_{i=1}^{N} -p_{ij}\ln p_{ij}. \tag{6}$$

The Shannon gamma entropy is:

$$H_\gamma = \sum_{j=1}^{K} -\bar{p}_j \ln \bar{p}_j \tag{7}$$

$$\text{with} \bar{p}_j = \frac{1}{N}\sum_{i=1}^{N} p_{ij}. \tag{8}$$

The Shannon beta entropy is:

$$H_\beta = H_\gamma - H_\alpha \tag{9}$$

The result of the consensus ratio is reported for each category and sub-category. The AHP Excel spreadsheet developed by Goepel (2013) was used for the calculation of AHP.[4]

The AHP is a subjective method that does not require a large sample but is useful for research focusing on a specific issue where a large sample is not mandatory (Cheng and Li, 2002; Lam and Zhao, 1998). Thus, when only the relevant experts are selected as respondents, the AHP is suitable to be conducted with a small sample. For example, Cheng and Li (2002) used nine experts' answers to conduct the AHP to test the comparability of critical success factors of construction partnering. Similarly, Lam and Zhao (1998) used eight experts' answers for the AHP for a quality-of-teaching survey.

In this study, the questionnaire was sent to experts in decision-making positions in multinational companies that have conducted FDI in solar and wind energy. The companies were identified based on the power plant database provided by GlobalData (2017). To exclude small-scale investment that could have different characteristics, only companies that had been involved in wind and/or solar energy projects in developing countries with more than 1 MW capacity were selected. The questionnaire was sent to 86 companies, at which the authors were able to contact experts in decision-making positions directly via email and/or phone, and 21 questionnaires were returned (a response rate of 24.4%). Through evaluating the consistency ratio of the questionnaires, 19 were shown to have acceptable consistency (Table 3) and are used for further analysis. A detailed description of the experts who responded is provided in Table 4. The names of the respondents are kept anonymous in this study in consideration of the sensitivity of the subject. The respondents are all highly experienced experts on overseas investment in wind and/or solar energy projects, and around three-fourths of the respondents are involved in both solar and wind energy. The range of the average capacity of the wind and/or solar projects in which the respondents have been involved is also provided in Table 4, which varies from 1 to 10 MW to 10–100 MW for solar energy and 1–10 MW to 100–1000 MW for wind energy.

3. Determinants of FDI in wind and solar energy

Keeley and Matsumoto (2018) conducted a thorough literature review of the determinants of FDI in the wind and solar energy sector in developing countries. They looked at the determinants by first conducting a literature review of determinants of FDI in general and sector-

[4] The template can be downloaded from http://bpmsg.com/new-ahp-excel-template-with-multiple-inputs/. A detailed description of the template is provided in the following document: http://bpmsg.com/wp-content/uploads/2014/01/AHPcalc-v2013-12–24a.pdf.

Table 3
Consistency ratio values for the judgment matrices of each respondent.

Question	Respondent																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Categories	0.1	0.05	0.11	0.1	0.09	0.07	0.11	0.03	0.11	0.13	0.1	0.07	0	0.05	0.06	0.07	0.04	0.04	0.09
Institutional 0.14		0.03	0.09	0	0.04	0.14	0.02	0.09	0.08	0.14	0	0.14	0	0	0.01	0	0.02	0.02	0.12
Macroeconomic	0.01	0.07	0.14	0.12	0.14	0.1	0.03	0.06	0.1	0.14	0.14	0.06	0.14	0.14	0	0.12	0.06	0.14	0.14
Natural conditions	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Renewable policies	0.07	0.02	0.14	0.12	0	0.09	0.03	0.09	0.13	0.03	0	0.14	0.12	0.06	0.06	0.01	0.03	0.1	0.06
Renewable economic	0.01	0.12	0.01	0.12	0.1	0.11	0.02	0.12	0.11	0.11	0.02	0.1	0.13	0.09	0.09	0.1	0.01	0.07	0.11
Renewable regulatory	0.05	0.06	0	0	0.14	0.03	0.04	0.02	0.01	0	0	0	0.14	0	0.03	0.08	0.11	0.02	0.09
Renewable political	0.06	0	0.14	0.07	0	0	0.1	0.06	0.02	0	0	0.14	0	0.1	0	0	0.14	0.14	0.11

Table 4
Description of the respondents.

Respondent	Headquarters	Sector	Average capacity of the solar and wind energy projects
Respondent 1	United States	Solar and Wind	Solar (1–10 MW) Wind (10–100 MW)
Respondent 2	France	Solar and Wind	Solar (1–10 MW) Wind (10–100 MW)
Respondent 3	United States	Solar	10–100 MW
Respondent 4	United Kingdom	Solar	1–10 MW
Respondent 5	Egypt	Solar and Wind	Solar (10–100 MW) Wind (10–100 MW)
Respondent 6	Japan	Solar and Wind	Solar (1–10 MW) Wind (10–100 MW)
Respondent 7	Spain	Solar	10–100 MW
Respondent 8	Italy	Solar and Wind	Solar (1–10 MW) Wind (10–100 MW)
Respondent 9	China	Solar and Wind	Solar (10–100 MW) Wind (10–100 MW)
Respondent 10	Ireland	Solar and Wind	Solar (1–10 MW) Wind (10–100 MW)
Respondent 11	Japan	Solar and Wind	Solar (1–10 MW) Wind (10–100 MW)
Respondent 12	Japan	Solar and Wind	Solar (10–100 MW) Wind (100–1000 MW)
Respondent 13	France	Solar and Wind	Solar (1–10 MW) Wind (10–100 MW)
Respondent 14	Egypt	Solar	1–10 MW
Respondent 15	Germany	Solar and Wind	Solar (1–10 MW) Wind (1–10 MW)
Respondent 16	Indonesia	Solar and Wind	Solar (1–10 MW) Wind (1–10 MW)
Respondent 17	Japan	Solar and Wind	Solar (10–100 MW) Wind (100–1000 MW)
Respondent 18	Korea	Solar and Wind	Solar (10–100 MW) Wind (100–1000 MW)
Respondent 19	Japan	Solar and Wind	Solar (10–100 MW) Wind (10–100 MW)

Table 5
Summary of the determinants identified by Keeley and Matsumoto (2018).

Category		Factor
Institutional environment		***Political risk***
		Rule of law (effective law enforcement)
		Efficient and transparent administrative procedure
		Corruption
Macroeconomic environment		***Access to local financing***
		Exchange rate stability
		Labor cost
		Geographic proximity
		Market size
		Tax rate (corporate)
		Infrastructure
Natural conditions		***Natural resources (wind potential, insolation/sunshine duration)***
		Risk of disaster
		Access to land
Renewable energy policies	Economic support policies	***Feed-in tariff***
		Renewable portfolio standards and renewable energy certificates
		Auction/competitive bidding
		Tax incentives
	Regulatory support policies	***Priority/guaranteed access to the electricity grid***
		Technical standards (aligned with national standards)
		Absence of local content requirement
	Political support policies	***National renewable energy target***
		Well-structured renewable energy development plan
		Social acceptance

Note: Factors in bold and italic fonts are the factors that have been identified as important determinants.

specific determinants (such as renewable energy support policies). Keeley and Matsumoto categorized the determinants and narrowed them down based on expert opinions by conducting semi-structured interviews with experts who held decision-making positions at companies that conducted FDI in the sector. Table 5 provides a summary of the literature review conducted by Keeley and Matsumoto (2018).

Through the literature review, in total, 24 determinants were identified and then categorized into four categories: institutional environment, macroeconomic environment, natural conditions, and renewable energy policies. The determinants were then narrowed down to 18 determinants based on semi-structured interviews conducted with experts in the field. The 18 determinants are used in this study to further clarify the relative significance of the determinants. The sub-sections below provide brief explanations of the determinants used in this study for the AHP. For a more detailed description of each determinant, please refer to Keeley and Matsumoto (2018).

3.1. Institutional environment determinants

Institutional environment determinants consist of political risk, rule of law (effective law enforcement), and an efficient and transparent administrative procedure.

- *Political risk*: Political risk was defined by Edwards (1990) as "the probability of a change of government," and "the frequency of political assassinations, violent riots and politically motivated strikes."
- *Rule of law*: Rule of law was defined as "the extent to which agents have confidence in and abide by the rules of society" by Kaufmann et al. (2011).
- *Efficient and transparent administrative procedure*: An efficient and transparent administrative procedure refers to the transparency and efficiency of the administrative process for starting a company, and

obtaining permits and licenses that are required to develop wind and solar energy projects.

3.2. Macroeconomic environment determinants

Macroeconomic environment determinants consist of access to local financing, exchange rate stability, and labor cost.

- *Access to local financing*: Access to local financing refers to the ease of obtaining financing from the host country's financial market. A developed financial market for wind and solar energy projects enables foreign companies to make financing short- and long-term transactions with the local currency easier.

- *Exchange rate stability*: Exchange rate stability means less of a fluctuating exchange rate, which could reduce exchange rate risk.
- *Labor cost*: Labor cost refers to the cost of labor in the host country for installing, operating, and maintaining wind and solar energy power plants.

3.3. Natural conditions determinants

Natural conditions determinants consist of natural resources and access to land.

- *Natural resources*: Natural resources refer to natural resource endowment in the host country. In the case of solar and wind energy projects, this term refers to the solar radiation level and wind speed.
- *Access to land*: Access to land indicates the ease of acquiring the land required to develop wind and solar energy projects. In some countries, a land contract is a difficult transaction especially in rural areas where the ownership of land is unclear, and in some countries, land-purchase restrictions are placed on foreign investors, which makes it hard to acquire required land.

3.4. Renewable energy policy determinants

Renewable energy policy determinants are further divided into three sub-categories: economic support policies, regulatory support policies, and political support policies.

3.4.1. Economic support policy determinants

Economic support policy determinants consist of feed-in tariff, renewable energy certificates and renewable portfolio standards, auction/competitive bidding, and tax incentives.

- *Feed-in tariff*: Feed-in tariff is a policy that ensures the purchase of electricity by utilities that is generated by renewable energy with a guaranteed price for fixed long-term contracts ranging from 10 to 25 years.
- *Renewable energy certificates and renewable portfolio standards (REC& RPS)*: RPS is a policy that mandates electricity producers and/or distributors either buy or produce a fixed amount of electricity generated with renewable energy. REC allows competition between renewable producers because the price of the certificate depends on the supply and demand for the certificates (Abdmouleh et al., 2015). These two policies are often jointly implemented, referred to as REC &RPS.
- *Auction/competitive bidding*: An auction refers to a call for competitive bidding for renewable energy projects under long-term power purchase agreements, with the quantity (capacity) predetermined by the government of the host country.
- *Tax incentives*: Tax incentives for renewable energy projects include tax exemptions or reductions, which “come in the form of capital- or production-based income tax deductions or credits, accelerated depreciation, property tax incentives, sales or excise tax reductions, and value-added tax reductions” (Keeley and Matsumoto, 2018).

3.4.2. Regulatory support policy determinants

Regulatory support policy determinants consist of priority/guaranteed access to the electricity grid, technical standards, and the absence of a local content requirement.

- *Priority/guaranteed access to the electricity grid*: Priority/guaranteed access to the electricity grid refers to guaranteed, transparent, and straightforward access to the electricity grid for wind and solar energy power producers, which enables smooth and secure project development.
- *Technical standards*: Technical standards indicate the existence of technical standards that are aligned with international standards. In some countries, technical standards that benefit only domestic firms are in place.
- *Absence of a local content requirement*: Local content requirement (LCR) is a policy measure that requires companies to use the host country's manufactured goods and/or services to operate in the country. For foreign companies, the LCR often reduces the freedom of selection and increases the development and operation costs.

3.4.3. Political support policy determinants

Political support policy determinants consist of national renewable energy target, a well-structured renewable energy development plan, and social acceptance.

- *National renewable energy target*: The national renewable energy target is a target set by the host country government. The target could be “laid out both for long term as well as for short term based on the needs and feasibility in each country, which could be an indicator for investors regarding the degree of commitment of government” (Keeley and Matsumoto, 2018).
- *Well-structured renewable energy development plan*: A well-structured renewable energy development plan refers to a consistent and stable strategic framework that encourages investment in renewable energy for the long term (Foxon and Pearson, 2008).
- *Social acceptance*: Social acceptance refers to acceptance by the citizens of the host country and/or the residents in the project sites of wind and solar energy projects.

4. Results and discussion

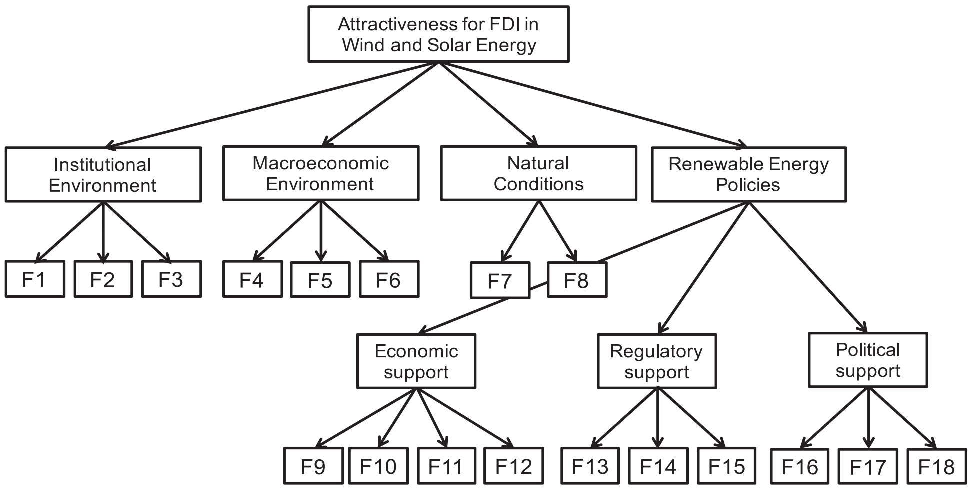
4.1. Hierarchy structure

To conduct the AHP, the hierarchy is created with the broad categories, sub-categories, and determinants that were clarified through the literature review and the semi-structured interviews with the experts (see Section 3). At the top of the hierarchy is the theme of the analysis: “Attractiveness for FDI in Wind and Solar Energy,” and broad categories (macroeconomic environment, institutional environment, natural conditions, and renewable energy policies) come below. Sub-categories come under the broad category of renewable energy policies. Last are the 18 determinants. The hierarchy is depicted in Fig. 1.

Respondents were first asked to evaluate the relative significance of four broad categories (institutional environment, macroeconomic environment, natural conditions, and renewable energy policies). Then the sub-categories were evaluated, and the determinants. Finally, the relative significance of each determinant is calculated using the evaluations obtained through this process.

4.2. Relative significance of the broad categories

The four broad categories were evaluated by the experts. The results (see Fig. 2) show that wind and solar energy policies are the most important determinants (40%). Macroeconomic environment and natural



F1: Political risk	F10: Auction
F2: Administrative procedure	F11: Tax-incentives
F3: Effective law enforcement	F12: REC&RPS
F4: Exchange rate volatility	F13: Priority access to grid
F5: Access to local finance	F14: Absence of LCR
F6: Labor costs	F15: Technical standards
F7: Natural resources	F16: Renewable target
F8: Access to land	F17: Development plan
F9: Feed-in tariff	F18: Social acceptance

Fig. 1. Hierarchy of the determinants.

conditions, at 25% and 21%, respectively. Institutional environment was evaluated as the least important determinant (14%). The consensus ratio is 68%, which indicates moderately high consensus among the respondents.

4.3. Relative significance of the institutional determinants

Next, the relative significance of the institutional determinants is presented in Fig. 3. An efficient and transparent administrative procedure is perceived as being the most important as a location determinant of FDI in wind and solar energy in developing countries (46%). The development of wind and solar energy projects requires various permits and licenses, involving various ministries and stakeholders, such as local communities. Obtaining permits and licenses can be a slow and unclear process especially in some developing countries, which is why transparent and smooth administrative procedures are deemed an important determinant. Political risk and effective law enforcement follow at 30% and 23%, respectively. The consensus ratio is moderately high at 66%.

4.4. Relative significance of the macroeconomic determinants

The results for the relative significance of the macroeconomic determinants are presented in Fig. 4. The experts view exchange rate volatility as the strongest determinant among the macroeconomic determinants, with a weight of 60%. This is because of the long-term payback period for wind and solar energy projects, and the role of wind and solar energy investment as a low-volatility investment in many companies' investment portfolios.

Access to local financing and labor costs are much less important compared to exchange rate volatility, 26% and 14%, respectively. The consensus ratio is moderately high, 68%.

4.5. Relative significance of the natural conditions determinants

Fig. 5 shows the relative significance of the natural conditions determinants. Natural resources and access to land are very important, 42% and 58%. The consensus ratio is moderately high, 65%, but the lowest among all evaluations. This is partly due to differences in experiences regarding land acquisition for the projects. Depending on the type of renewable support policy, governments often offer support for

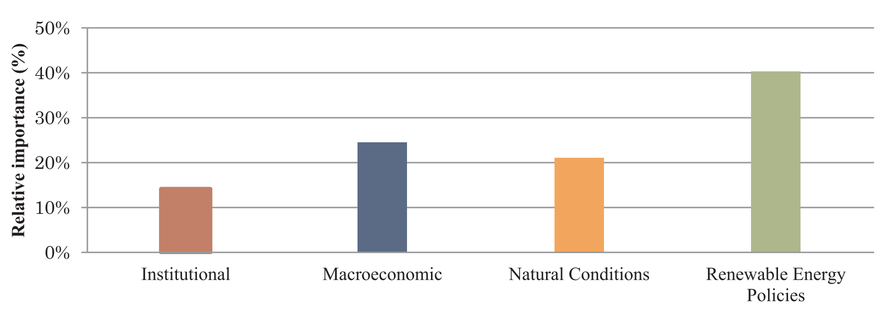


Fig. 2. Relative significance of the broad categories.

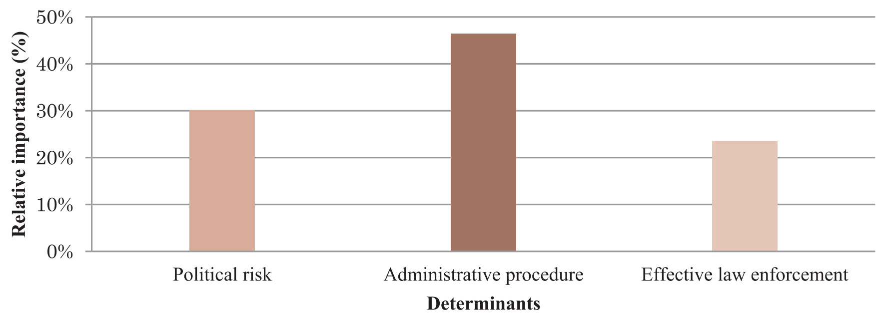


Fig. 3. Relative significance of the institutional determinants.

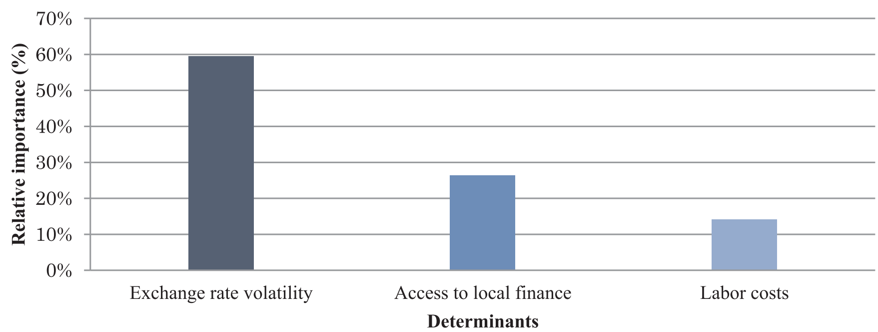


Fig. 4. Relative significance of the macroeconomic determinants.

the land acquisition process so that the projects can be smoothly implemented with a lower risk being hampered by land issues, which is often seen in projects implemented under competitive bidding. This different view of the importance of access to land was also observed in the semi-structured interviews with experts (Keeley and Matsumoto, 2018).

4.6. Relative significance of the wind and solar energy policies

As presented in Fig. 6, the results for wind and solar energy policies show that regulatory support policies and economic support policies are very important, 44% and 36%, respectively. Political support policies are perceived to have the least important role, 20%. The consensus ratio is 70%, indicating high consensus.

4.7. Relative significance of the economic support policies for wind and solar energy

Fig. 7 presents the results for the wind and solar energy economic support policies. Feed-in tariff, which is the most frequently used policy in developing countries, is evaluated as having the most significance, 46%. Auction, which has also been increasingly employed in many developing countries, including South Africa and Mexico, follows at 27%. Tax incentives and REC&RPS are less important, 15% and 11%, respectively. The consensus ratio is high, 70%.

4.8. Relative significance of the regulatory support policies for wind and solar energy

The results for regulatory policies for wind and solar energy show that priority access to the electricity grid is by far the most important determinant among the regulatory support policies with a weight of 63% (Fig. 8). LCRs, which could greatly affect the profitability and operational risk of wind and solar energy projects, are surprisingly less important with a weight of 25%. This could be partly because for small-scale energy projects, the logistics and cost of connecting to the electricity grid can drive up the cost of the projects much more than LCRs do. Although the significance is lower than priority access to the electricity grid, when a country has limited technological capacity, the existence of LCRs greatly reduces the freedom of selection of a reliable supplier, and increases the cost and operational risk of the projects. The consensus ratio is very high, 78%.

4.9. Relative significance of political support policies for wind and solar energy

Fig. 9 shows the results for the relative significance of political support policies for wind and solar energy. Having a well-structured

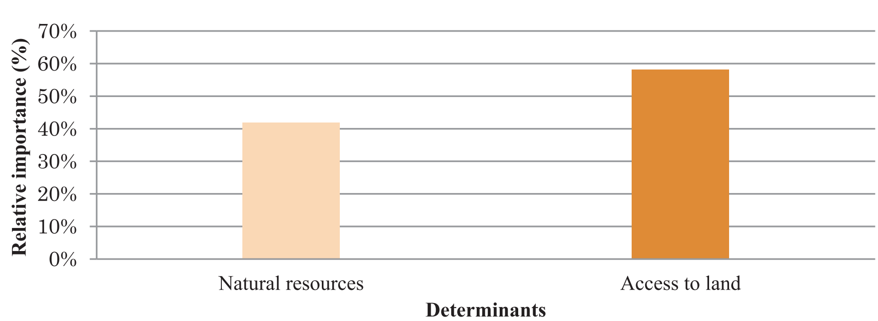


Fig. 5. Relative significance of the natural conditions determinants.

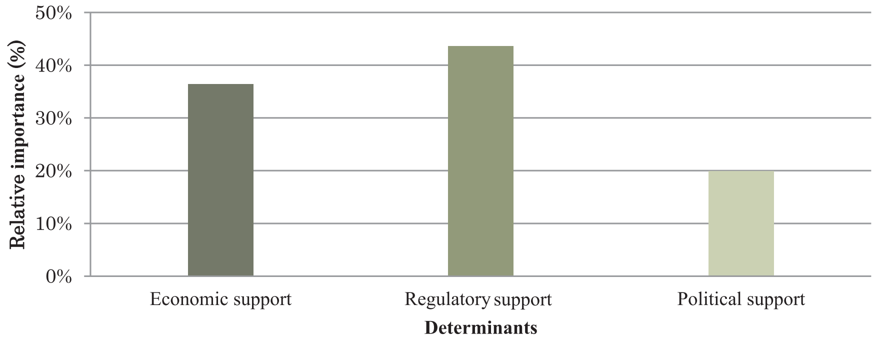


Fig. 6. Relative significance of the renewable energy policies.

development plan for wind and solar energy is perceived as having the most importance with a weight of 46%, followed by having a national renewable energy target, 34%. Under international pressure, many developing counties set high national renewable energy targets; as of 2017, targets are in place in 176 countries (REN21, 2017). However, the targets are frequently not well linked to known indigenous energy resources, expected costs of development and operation, local training needs, budgetary needs, and actions to achieve the goals, which makes the targets less reliable than a well-structured development plan. Social acceptance surprisingly has the least importance with a weight of 20%. As expressed in the NIMBY (not in my backyard) issue, in developed countries there are many cases in which wind and/or solar projects are hampered by local community resistance. As observed in the semi-structured interviews, for wind and/or solar projects in developing countries, objections from local communities are perceived to be less likely to happen compared to projects in developed countries (Keeley and Matsumoto, 2018).

4.10. Relative significance among all the determinants

Finally, through multiplying each determinant's weight by the weight of the category of the determinant, the relative significance of each determinant is calculated. For example, for the weight of political risk (30%) is multiplied by the weight of the institutional category (14%), which makes the relative significance of political risk 4% among all determinants.

Fig. 10 shows the final results for all the determinants. Exchange rate volatility has the highest weight among the determinants (15%), followed by access to land (12%), priority access to the electricity grid (11%), natural resources (9%), feed-in tariff (7%), and an efficient and transparent administrative procedure (7%). This final result highlights which factors are important for enhancing attractiveness for FDI in wind and solar energy, and the priorities (relative significance) between the determinants.

5. Conclusions and policy implications

This paper employed expert opinions and the AHP to identify the relative significance of the determinants of FDI in wind and solar energy in developing countries. The conclusions and policy implications are presented in this section.

5.1. Conclusions

Based on the questionnaires conducted with 21 experts active in the field of FDI in solar and wind energy, the relative significance of the determinants is clarified. For attracting FDI in wind and solar energy sectors, in addition to the traditional determinants of FDI (including natural conditions, an institutional environment, and a macroeconomic environment), renewable energy support policies have been shown to have equivalent or stronger influence on decision making regarding FDI, supporting the results of quantitative studies. This study breaks down the renewable energy support policies into more detail and provides experts' opinions on the relative importance of each policy (feed-in tariff, REC&RPS, auction, priority access to the electricity grid, etc.). The paper further sheds light on another important point that some of the traditional determinants (such as exchange rate volatility, access to land, and an efficient and transparent administrative procedure) also have very strong influence as determinants of FDI in wind and solar energy. The relative significance of the determinants clarified through this study offers criteria for prioritizing policies and actions for policy makers. There is a broad range of public interventions to reduce investment risks or increase investment returns. Furthermore, some of the traditional determinants, such as exchange rate volatility risk, can also be hedged through properly designed renewable energy support policies. The following sections focus on the key determinants for attracting FDI in the wind and solar energy sectors and provide policy implications that could be applied to various developing countries aiming to enhance the enabling environment for FDI.

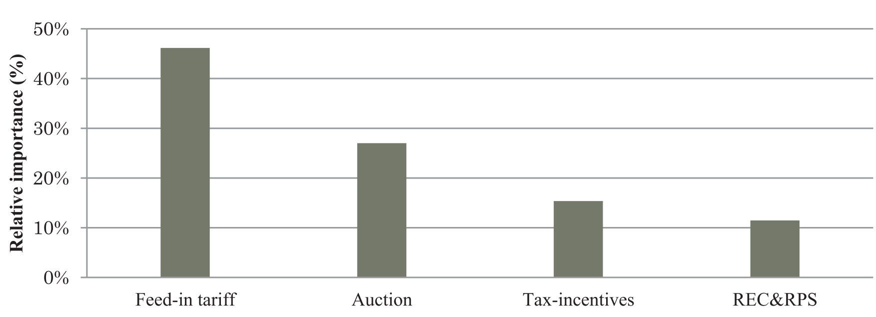


Fig. 7. Relative significance of the economic support policies.

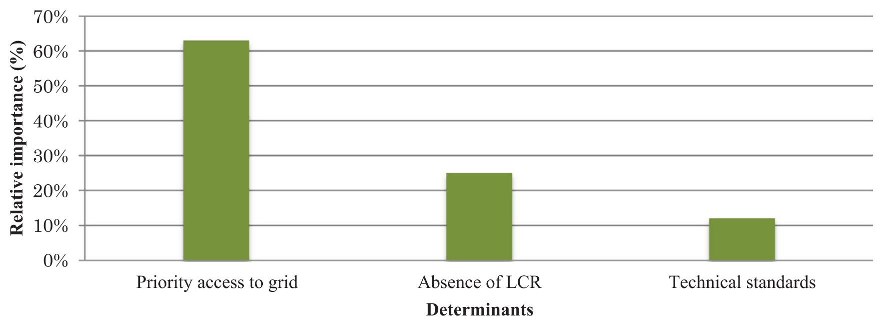


Fig. 8. Relative significance of regulatory support policies.

5.2. Policy implications

Through the AHP, this paper has shown that traditional FDI determinants (such as exchange rate volatility, access to land, and an efficient and transparent administrative procedure) and determinants specific to the wind and solar energy sector (including priority access to the electricity grid, feed-in tariff, and auction) are very important determinants behind the location decisions for FDI in wind and solar energy in developing countries. Focusing on the highly important determinants (exchange rate volatility, access to land, an efficient and transparent administrative procedure, priority access to the electricity grid, natural recourses, access to local financing, absence of LCR, feed-in tariff, and auction), this section provides policy implications that could contribute to enhancing the enabling environment for FDI in the wind and solar energy sectors.

5.3. Exchange rate volatility risk and renewable economic support policies

Strong volatility in the exchange rate indicates a host country has an unstable currency, which was evaluated as the most important determinant influencing decision making for FDI in wind and solar energy in developing countries (see Fig. 10). Considering the long-term payback period for wind and solar energy projects, and the role of investment in wind and solar energy as a low-volatility investment in many companies' investment portfolios, a country with high exchange rate risk discourages foreign investors. Exchange rate risk not only affects the future return from a project but also raises the cost of financing. From the macroeconomic perspective, this implies that "host countries need to avoid over-valuation of the exchange rate for maintaining a stable economic environment" (Kiyota and Urata, 2004). However, several measures could be taken by policy makers to reduce exchange rate risk with the appropriate design of renewable economic support policies.

Two of the major economic support policies for wind and solar energy employed in many developing countries and deemed very important by foreign investors are a feed-in tariff and an auction or competitive bidding. Feed-in tariff and the auction system provide payments for electricity from renewable energy at a guaranteed price for a fixed long-term contract. One way to reduce the impact of exchange rate risk on FDI projects is to index a portion of the payments made under the feed-in tariff or auction system to a foreign currency (e.g., the US dollar). Paying renewable energy projects in tariffs indexed to US dollars or another relatively stable foreign currency could make the exchange rate risk incurred by the project developer minimal, and debt costs and project costs would fall. Although this means that the governments need to accept some exchange risk, through the enhanced competition and lowered levelized cost of energy of renewable energy projects, governments could potentially reduce the cost required for renewable energy policies. In many countries, commodities such as imported oil, coal, and natural gas are priced in US dollars, benefiting from access to capital in dollar terms. Although the host country's government needs to be willing to accept the full transfer of exchange rate risk from investors to themselves, the simplest but also more expensive option is to pay the tariff in US dollars. Countries such as Uganda pay the tariff in US dollars (ERA, 2016).

Another option for lowering exchange rate risk is to adjust the tariff rates in line with inflation. Inflation largely impacts exchange rate volatility, and according to Gatzert and Vogl (2016), inflation risk strongly affects the risk-return profile of renewable energy investments. Through adjusting the tariff rates in line with inflation, the impacts of the depreciation of a currency can be offset, and the interest rate effect on debt repayments can be counteracted. For example, the Philippines adopts this approach, annually adjusting tariff rates based on the national consumer price index for the entire contractual period.

In cases where the guaranteed revenue will be paid in US dollars, getting funding from the host country (i.e., access to local financing) is not that important. However, if the tariff is paid in domestic currency, access to local financing could be an important factor for the project developers. Furthermore, as described in Keeley and Matsumoto (2018), "obtaining funding from a local bank could enhance the credibility of the company in the country, and help the smooth implementation of the project." Thus, for host countries with less-developed financial markets, either facilitating the development of the financial market for wind and solar energy or paying the guaranteed revenue in US dollars could enhance the enabling environment for FDI in wind and solar energy.

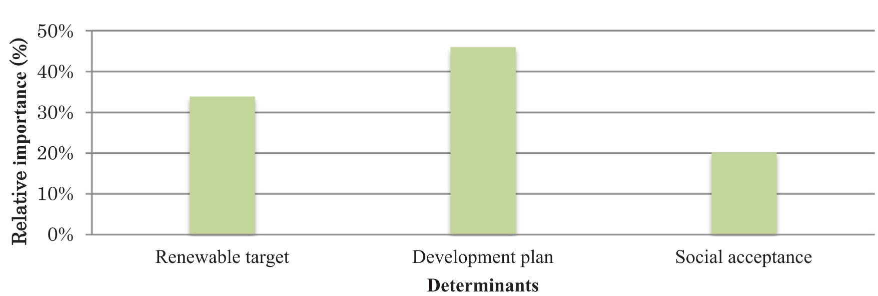


Fig. 9. Relative significance of the political support policies.

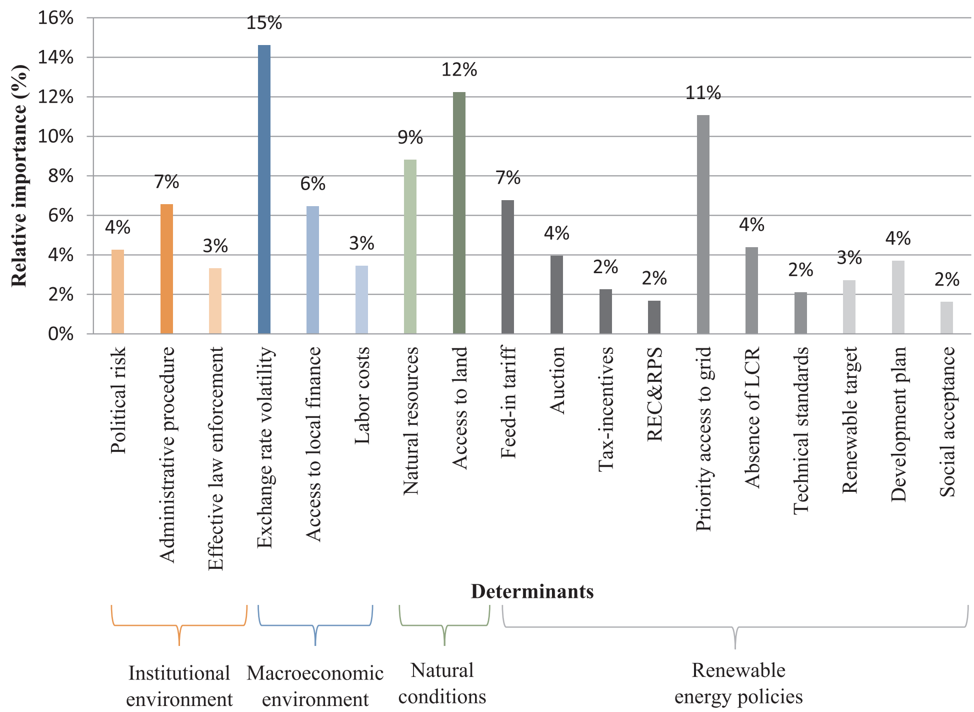


Fig. 10. Relative significance of the determinants.

5.3.1. Feed-in tariff vs. auction/competitive bidding

Feed-in tariff and auction are employed by many countries, and they are also perceived as two of the most preferred economic support policies by foreign investors based on the analyses presented in this paper (see Fig. 10). Although the effectiveness of feed-in tariff systems is well verified through experiences to expand renewable-based electricity in various countries, setting the right tariff can be challenging because of the fast-changing cost of wind and solar energy projects, and the information gap between policy makers and practitioners in young markets. Therefore, for a country that lacks the capacity to design feed-in tariff systems, implementing competitive bidding before adopting the feed-in tariff system could help find the appropriate tariffs for wind and solar energy projects. Competitive bidding systems are preferred by many developing countries partly because these systems can be controlled by the government. However, competitive bidding must also be designed carefully to make the system beneficial. First, the process must be clear and transparent, and second, the quality of the bid needs to be considered carefully in addition to price. To implement successful competitive bidding, ensure the realization of the target, and maintain efficiency, Kreiss et al. (2017) recommended high financial and adjusted physical pre-qualifications. The Organization for Economic Cooperation and Development (OECD, 2015) stated that “renewable energy projects involve complex technologies and contract relationships, experienced bidders are more likely to propose reliable prices, with lower risks of delays or failure to comply.” South Africa, which sets developers’ previous experience as one of the bidding criteria, is a good example among developing countries (IRENA, 2013). Although competitive bidding is an effective support policy, in the eyes of foreign investors, recent aggressive competition among project developers and often time-consuming bidding processes make it questionable whether competitive bidding is a long-term support policy that a country can maintain successfully. Including the design of a system, what measures to adopt depend on the conditions of a country (including the macroeconomic situation), overall currency and balance of payment exposure, and the state of the cost of wind and solar energy projects in the country.

5.3.2. One-stop agency for an efficient and transparent administrative procedure

Wind and solar energy projects require various permits and licenses, involving various ministries and stakeholders. Obtaining permits and licenses can be a slow and unclear process in some developing countries, especially for foreign investors considering the information asymmetry in relation to that of domestic companies.

The lengthy approval processes often arise from an over-complex set of administrative responsibilities for different sources of renewable energy, among and between authorities at several decision-making levels (national, provincial, and local). Resolving complex and inefficient administrative procedures would promote project implementation and enhance the enabling environment.

In Indonesia, about 14 permits and licenses are required to carry out wind and solar energy projects, of which nine need to be obtained at the local level.[5] Different notions among local authorities, and sometimes-unclear decision-making power distribution between different levels of authorities had been slowing down wind and solar energy development. To resolve the complex procedures, the Indonesian government established a one-stop agency, Badan Koordinasi Penanaman Modal (BKPM), an investment service agency of the Indonesian government. Such one-stop agencies are administrative entities that guide investors through all stages of the investment process, including planning, application for approval, approval procedure, and project implementation. These agencies contact the relevant authorities, submit the required documents, and function as a bridge between investors and the administrative system as presented in Fig. 11. One-stop agencies can simplify the exhausting process to obtain the required permits and licenses from different levels of authorities through creating common understanding between different authorities and making the procedure more transparent.

Making one-stop agency function well demands good awareness of

[5] Information obtained during an in-person interview with the Ministry of Energy and Mineral Resources, Directorate General of New, Renewable and Energy Conservation of the Republic of Indonesia, conducted from October 16–18, 2017, in Jakarta, Indonesia.

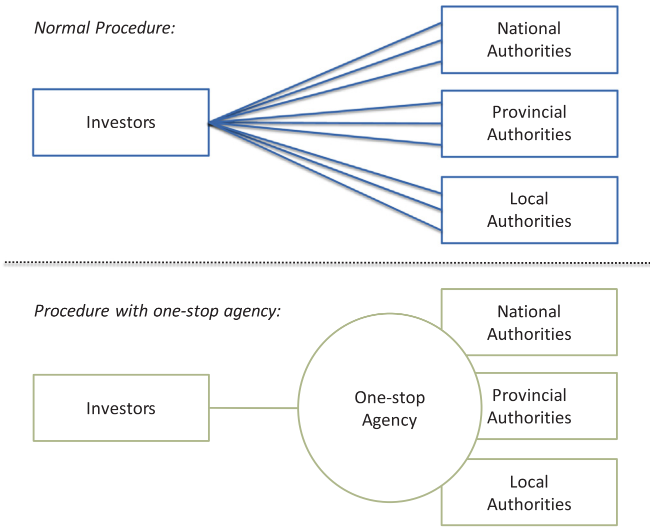


Fig. 11. The structure of a one-stop agency. The top panel shows the normal procedure for obtaining permits and licenses, while the bottom panel shows the procedure with a one-stop agency.

the bureaucratic barriers to investment, and most importantly, as also recommended by Maulud and Saidi (2012) in the facilitation of renewable energy in Malaysia, inter alia and intense collaboration between authorities at several decision-making levels. In addition, the one-stop agency must be approved and accepted at higher administrative levels (i.e., the national and provincial levels). Another important point is creating consistent and harmonized understanding among and between different authorities, which sends coherent signals to potential investors. Having a one-stop agency for renewable energy projects not only smooths the development of wind and solar energy but also works as a positive signal for foreign investors.

5.3.3. Wind and solar energy resource mapping and improving access to land

The availability of natural resources and access to land are very important determinants of FDI in wind and solar energy in developing countries (see Fig. 10). Mapping the potential for wind and solar energy production within a certain region or municipality could greatly enhance attractiveness for potential investors. Resource mapping provides insights into the economic viability of specific production sites and enables estimations for the initial feasibility study.

Another notable point is ease of access to land. For some developing countries, accessing land "may require engaging with actors who do not necessarily have formal property rights to the land that they occupy, particularly in remote rural areas" (OECD, 2015). Through resource mapping, coordination for land-use planning can be improved, and could help identify lands that need land-use adjustment to enable wind and solar energy project developments.

Detailed mapping of wind and solar energy potential and improving land access issues require comprehensive local and provincial coordination, and collaboration between different responsible units at the local level. Therefore, similar to the concept of one-stop agencies, a cross-departmental committee that coordinates and oversees the process could be an important success factor.

5.3.4. Access to the electricity grid and other regulations

Access to the electricity grid is another very important determinant of FDI (see Fig. 10). Considering that most of the wind and solar energy FDI projects are conducted with a project financing scheme, if there are any risks in grid connection that affect the future revenue of the project, the company would not be able to obtain financing for the project. In many developing countries, even after regulatory liberalization, especially foreign investors can find it difficult to secure access to the electricity grid in a timely manner. A study conducted by Araújo (2011) showed that "providing regulated third party access to the electricity grid can help increase investment in electricity infrastructure." Thus, ensuring guaranteed access to the electricity grid could greatly enhance the enabling environment for FDI.

Especially for foreign investors, other regulations can impose restrictions on implementing wind and solar energy projects, which include LCRs and import tariffs. If a strong LCR is set, it forces foreign investors to rely on the quality and capacity of the companies of the host country. This not only drives up the development cost and affects the quality of the facility but also can negatively affect the government of the host country through increasing the support required for the development of wind and solar energy projects. LCRs can also increase the technology risk that affects the developer and the electricity system with the limited capacity of the local supply chain. Furthermore, considering that a large part "of the value created (in USD/MW installed) in wind and solar energy is generated after the manufacturing phase" (CEEW; NRDC, 2012), LCRs can negatively impact host country from the value-added point of view.

There are other trade-related measures such as limiting equity in wind and solar energy projects for foreign investors to benefit from the feed-in tariff system. These "trade-related investment measures are now being challenged under World Trade Organization rules and can be subjected to substantial anti-dumping and/or countervailing duties" (OECD, 2015). These measures could discourage investment. Thus, they should be carefully treated to avoid missing the opportunity to embrace the capital and innovative potential FDI can bring to host countries.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.enpol.2018.08.055.

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