AHP analysis to explore relative significance of foreign direct investment in renewable energy sectors in developing countries

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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, with a numerous developing countries placing various measures to attract FDI in renewable energy sector. This paper clarifies the relative significance of the determinants behind the location decisions of foreign renewable energy investors by using analytical hierarchy process. In total of 18 determinants that are categorized into macroeconomic environment, institutional environment, natural conditions, and renewable energy policies categories are used for the analysis. The results show that, adding to the traditionally argued determinants of FDI including macroeconomic environment, institutional environment, and natural conditions, renewable energy support policies have equivalent or stronger influence as location determinants of FDI. The paper also points out that some of the traditionally argued determinants such as exchange rate volatility, access to land, and administrative procedure also hold very strong influence as determinants of FDI in renewable energy. Driving from the results of this study, policy implications are made especially focusing on the determinants of FDI in renewable energy with high importance. The relative significance of the determinants clarified through this study offers criteria for prioritizing policies and actions for policy makers.

Keywords—

Renewable energy; AHP analysis; Foreign direct investment; Determinant; Policy intervention

1 INTRODUCTION

According to the latest figure provided by FDiintelligence (2017), renewable energy sector is the third largest sector with regard to the amount of foreign direct investment (FDI)[1], attracting around one-tenth of the total green-field FDI, which reached around 77 billion US dollars. Being 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, a lot of developing countries[2] are increasingly facilitating renewable energy development. At "the 21st Conference of the Parties of the United Nations Framework Convention on Climate Change", the importance of private finance for developing countries, especially FDI was strongly recognized (McInerney and Johannsdottir, 2016). For a lot of developing countries, FDI not only serves as an important source of capital, but also as a valuable channel to transfer more productive and innovative technology and techniques. In the midst of transition toward cleaner energy system occurring worldwide, enhancing the enabling environment for FDI in renewable energy could greatly facilitate the proper competition in electricity market, and advance the transition in a safe and efficient way. In order to do so, understanding the location determinants of FDI in renewable energy in developing countries, and clarifying their relative significance would offer criteria for prioritizing policies and actions for policy makers. Therefore, by developing on the preceding studies on this topic, this study aims to clarify the relative significance of the determinants of FDI in renewable energy in developing countries.

Despite of the increasing FDI in the renewable energy sector, and growing interests in the effectiveness of various policies aiming to attract investment in the sector, the number of studies clarifying the determinants of FDI in the sector is still very limited. Furthermore, most of the existing studies use econometric approaches to answer what the important determinants are. For example, the study conducted by Eyraud et al. (2013) use a panel-data approach in order to identify the determinants of green investment (includes both FDI and domestic investment), which they define as investment in selected energy-efficient technologies, renewable energy, and research and development in green technologies. The study points out the importance of the determinants such as interest rates, growth of gross domestic product, and renewable energy policies. Keeley and Ikeda (2017), by using structural equation

[1] FDI refers to investment to build new facility and/or to obtain lasting management interest in an enterprise of host countries.
[2] In this paper, the term "developing countries" indicates countries listed as developing countries on the International Monetary Fund's World Economic Outlook Report (2017).

modeling, investigate the determinant of FDI in wind energy in developing countries. Their results show the strong impact of renewable energy policies as determinants of FDI, especially highlighting the importance of regulatory policies. Murovec et al. (2012) also use structural equation modeling to clarify the determinants of environmental investments, which includes investments in the renewable energy sector. They highlight that tax measures and financial incentives are some of the determinants that have high impact on location decisions. Although these econometric approaches provide important empirical evidences, there are also some limitations. First limitation lies in the resolutions of the factors considered in the analyses. Most of these analyses show the strong impact of renewable energy support policies as determinants of FDI, which include different kinds of support policy (ex. feed-in tariff, renewable portfolio standards, renewable energy certificates, competitive bidding, and tax-incentives). However, in these econometric approaches, such different support policies' impacts are not individually tested. This limitation is due to the availability of data and the condition that a lot of countries implement more than one support policies in parallel, which makes it hard to clarify the impact of each policy.

Another limitation lies in the selection of variables considered in the studies. The econometric studies select variables based on literature review and availability of data. Painuly (2001) stresses 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 reflecting expert opinions more to identify some other omitted factors in the preceding studies, and clarify the relative significance of determinants of FDI.

Therefore, in order 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 the field of FDI in solar and wind energy in developing countries. The relative significance of the determinants is clarified by analyzing the data obtained through the questionnaires using analytical hierarchy process (AHP). Clarifying the relative significance of the determinants offers criteria for prioritizing policies and actions that can lead to enhancement of a country's attractiveness for obtaining FDI in renewable energy, and further shows the important of renewable energy sector-specific policies. This study is one of the first attempts to clarify relative significance of the determinants of FDI in renewable 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 renewable energy through shedding light on preceding studies. Section 4 provides the results of the AHP analysis and clarifies the relative significance of the determinants. Finally, based on the results of this paper, section 5 presents conclusions and policy implications focusing on some of the most important determinants of FDI in renewable energy sector in developing countries.

2. METHODS

In order 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. The responses are analyzed using the AHP to finalize the prioritization process. 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 method was developed by Thomas Saaty in 1980 (Saaty, 1980). Lee and Chatt (2008) highlights the strength of the AHP method, asserting the AHP method "is very suitable for complex social issues in which intangible and tangible factors cannot be separated". The AHP method has been applied in various types of fields, and it has been employed in 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). Most of the literature applying AHP to cases related to renewable energy are using AHP in order to determine the best renewable energy to be deployed in the certain region or environment. There are hardly any cases applying AHP in order to examine the relative significance of determinants of FDI in renewable energy, which is another originality of this paper.

In AHP, first the problem is structured in a hierarchical model by creating various levels of issues-categories parameters to achieve the desired goal. In our study, "enhancement of attractiveness for FDI in renewable energy in developing countries," is the top of the hierarchy, and below that are broad categories and the factors (sub-categories). Experts, then, systematically evaluate the factors through comparing them to one another two at a time regarding their influence on a factor above them in the hierarchy using 1-9 scale as proposed by Saaty (1980). These evaluations made by experts will be converted to numerical values to enable processing and comparing over the entire range of the problem. First, the pairwise judgments made by the experts will be converted into a pairwise matrix. The normalized matrix is gained by dividing each factor by the column-wise summation of the factors. The eigen-vector is, then, calculated by averaging the factor in rows. Each factor of this vector represents the weight of importance. In this study, the average of experts' evaluations is presented as relative significance of each factor. Next, consistency of each pairwise comparison matrix is checked to justify the evaluations made by the experts. "The oldest and most commonly used measures are the consistency index (CI) and consistency ratio (CR) (Brunelli, 2012)". CI is calculated based on the following equation proposed by Saaty (1980):

$$\mathrm{CI} = \frac{\lambda_{max} - \mathrm{n}}{\mathrm{n} - 1} \tag{1}$$

where n: number of evaluating factor and λ_{max}: the maximum eigen-value of the matrix.

CR is defined as:

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}} \tag{2}$$

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

If CR = 0, then the answers of the respondent is completely consistent; if CR = 1, then the answers are completely inconsistent. In general, based on Saaty's suggestion, answers within CR ≤ 0.1~0.15 are considered consistent enough to be acceptable (Saaty, 1980). When CR is above 0.15, it is recommended to repeat the evaluation till it reaches the acceptable consistency. However, in real practice, a comparison matrix often has poor consistency and repeating the evaluation for numerous times are practically difficult. Bhushan and Rai (2007) suggest that for very abstract parameters, CR up to 0.2 should be allowed. In fact, a large number of preceding studies used 0.2 instead of 0.1 as 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 CR ≥ 0.2 were excluded as inconsistent. Next, following the steps proposed by Goepel (2013), by using eigenvector method, all of the pairwise comparisons that meet the consistency defined above are combined into 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 matrices factors, the pairwise N×N comparison matrix A = $a_{ij(k)}$, is used with the each experts' weight (ω_k), which is expressed as the following equation:

$$C_{ij} = \exp \frac{\sum_{k=1}^{n} \omega_k \text{Ina}_{ij(k)}}{\sum_{k=1}^{n} \omega_k} \tag{3}$$

Through the above-mentioned process, a numerical weight (relative significance) is derived for each factor, which allows the factors to be compared with one another in a consistent and rational way.

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

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

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

where $H_{\alpha,\beta,\gamma}$: alpha (α), beta (β), gamma (γ), Shannon entropy for the priorities of all K respondents.

Shannon alpha entropy:

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

Shannon gamma entropy:

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

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

Shannon betta entropy:

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

The result of the consensus ratio is reported for each category and sub-category. AHP Excel spreadsheet developed by Goepel (2013) was used for the calculation of AHP.[3]

AHP is a subjective method that is not necessary to involve a large sample, but rather useful for research focusing on a specific issue where a large sample is not mandatory (Cheng and Li, 2002; Lam and Zhao, 1989). Thus, when only the relevant experts are selected as respondents, AHP analysis is suitable to be conducted with a small sample. For example, Cheng and Li (2002) used nine experts' answers to conduct AHP analysis in order to test comparability of critical success factors of construction partnering. Similarly, Lam and Zhao (1989) used eight experts' answers for AHP analysis 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 power plant database provided by GlobalData (2017), and only the companies who have been involved in wind and/or solar energy projects in developing countries with more than 1 MW capacity were selected in order to exclude small-scale investment that could have different characteristics. The questionnaire was sent to a total number of 86 companies, which the authors were able to contact experts in decision-making positions directly via email and/or phone, and 21 responses were obtained (the rate of collection was 24.4%). Through evaluating the consistency ratio of the collected questionnaires, 19 questionnaires showed to have acceptable consistency, and are used for the further analysis. A detailed description of the experts who provided responses to the questionnaire is provided in Table 1. 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 of oversea investment in renewable energy projects, around a three-fourth of the respondents being involved in both solar and wind energy.

[3] 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 1 Description of the respondents

Respondent	Headquarter	Sector
Respondent 1	United States	Solar and Wind
Respondent 2	France	Solar and Wind
Respondent 3	United States	Solar
Respondent 4	United Kingdom	Solar
Respondent 5	Egypt	Solar and Wind
Respondent 6	Japan	Solar and Wind
Respondent 7	Egypt	Solar
Respondent 8	Italy	Solar and Wind
Respondent 9	China	Solar and Wind
Respondent 10	Ireland	Solar and Wind
Respondent 11	Japan	Solar and Wind
Respondent 12	Japan	Solar and Wind
Respondent 13	France	Solar and Wind
Respondent 14	Egypt	Solar
Respondent 15	Germany	Solar and Wind
Respondent 16	Indonesia	Solar and Wind
Respondent 17	Japan	Solar and Wind
Respondent 18	Korea	Solar and Wind
Respondent 19	Japan	Solar and Wind

Table 2 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 finance***
		Exchange rate stability
		Labor cost
		Geographical 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 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.

3. DETERMINANTS OF FDI IN RENEWABLE ENERGY

Keeley and Matsumoto (2018) have conducted thorough literature review of the determinants of FDI in renewable energy sector in developing countries. They have looked into the determinants by first conducting literature review on both determinants of FDI in general and sector-specific determinants (such as renewable energy support policies). They have categorized the determinants, and further narrowed down the identified determinants based on expert opinions by conducting semi-structure interviews with experts who are in the decision making positions of the companies that have conducted FDI in the sector. Table 2 provides summary of the literature review conducted by Keeley and Matsumoto (2018).

Through the literature review, in total, 24 determinants are identified and they are categorized into four categories: institutional environment; macroeconomic environment; natural conditions; and renewable energy policies. The identified determinants are narrowed down to 18 determinants based on semi-structured interviews conducted with experts in the field. The 18 determinants identified by Keeley and Matsumoto (2018) are used in this study to further clarify the relative significance of the determinants. The sub-sections below provide brief explanations on the determinants used in this study for the AHP analysis. For more detail description on 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 efficient and transparent administrative procedure.

- *Political risk*: Political risk is 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 is 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*: Efficient and transparent administrative procedure refers to the transparency and efficiency of the administrative process for starting a company, and obtaining required permits and licenses that are required to develop renewable energy projects.

3.2 Macroeconomic environment determinants

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

- *Access to local finance*: *Access to local finance refers to the easiness of obtaining finance from the financial market of the* host country. Developed financial market for renewable 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 fluctuating exchange rate, which could reduce exchange rate risk.
- *Labor cost*: Labor cost refers to the cost of labor in the host country for the installation and operation and maintenance of renewable energy power plants.

3.3 Natural conditions determinants

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

- *Natural resources*: Natural recourses refer to natural resource endowment in the host country. In the case of solar and wind energy projects, it refers to solar radiation level, and wind speed.
- *Access to land*: Access to land indicates the easiness to acquire required lands to develop renewable energy projects. In some countries, land contract is hard to make especially in rural areas where the ownerships of lands are unclear, and in some countries land-purchase restrictions are placed for foreign investors, which makes it hard to acquire land required lands.

3.4 Renewable energy policies determinants

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

3.4.1 Economic support policies

Economic support policies 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 purchase of electricity by utilities that is generated by renewable energy with guaranteed price for a fixed long-time period contracts ranging from 10 to 25 years.
- *Renewable energy certificates and renewable portfolio standards (REC&RPS)*: RPS is a policy that obliges electricity producers and/or distributors to either buy or produce fixed amount of electricity generated with renewable energy. REC allows competition between renewable producers since the price of certificate depends on supply and demand of certificates (Abdmouleh et al., 2015). These two policies are often conjointly implemented, referred as REC&RPS.
- *Auction/competitive bidding*: Auction refers to a call for running competitive bidding for renewable energy projects under long-term power purchase agreements, with 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 policies

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

- *Priority/guaranteed access to grid*: Priority/guaranteed access to electricity grid refers to guaranteed, transparent and straightforward access to the electricity grid for the renewable energy power producers, which enables smooth and secured project development.
- *Technical standards*: Technical standards indicate the existence of technical standards that are aligned with international standards. In some countries, technical standards that only benefit domestic firms are placed.

- *Absence of local content requirement*: local content requirement (LCR) is a policy measure that require companies to use the host country's manufactured goods and/or services to operate in the country. For foreign companies, LCR often reduces the freedom of selection, and increases the development cost and operation cost.

3.4.3 Political support policies

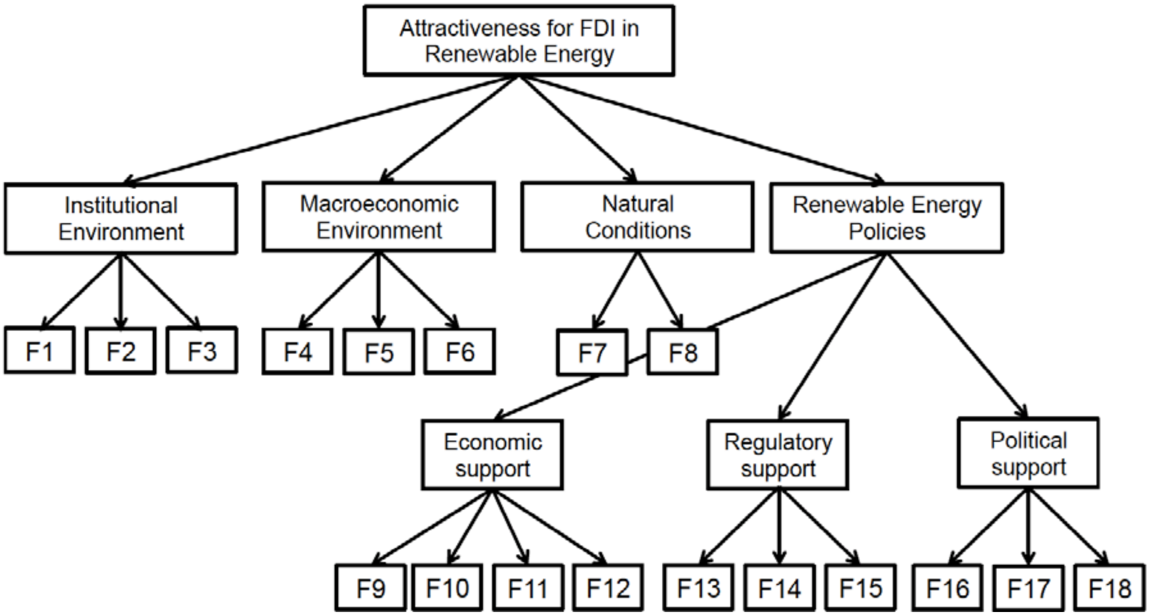
Political support policies determinants consist of national renewable energy target, well-structured renewable energy development plan, and social acceptance.

- *National renewable energy target*: National renewable energy target is a target set by the host country government. It 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*: 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 of citizens of the host country and/or the residents in the project sites toward renewable energy projects.

4 RESULTS AND DISCUSSION

4.1 Hierarchy structure

In order to conduct the AHP analysis, the hierarchy is created with the broad categories, sub-categories, and the determinants that have been clarified through the literature review and the semi-structured interviews with the experts as presented in the previous sub-sections (see Section 3). The top of the hierarchy is the theme of the analysis: "Attractiveness for FDI in Renewable Energy," and broad categories (macroeconomic environment, institutional environment, natural conditions, and renewable energy policies) come below that. Sub-categories come under the broad category of renewable energy policies in the hierarchy. Lastly, the identified 18 determinants come under them. The hierarchy is structured as depicted in Figure 1.



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

Figure 1 Hierarchy structure of the determinants.

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

4.2 Relative significance of the broad categories

First, the four broad categories (i.e., macroeconomic environment, institutional environment, natural conditions, and renewable energy policies) were evaluated by the experts.

The result (see Figure 2) show that renewable energy policies work as the strongest determinants with the weight of 40%. Macroeconomic environment and natural conditions follow renewable energy policies with the weight of 25% and 21%, respectively. Institutional environment was evaluated as the least important determinant with the weight of 14%. Consensus ratio shows 68%, which indicates moderately high consensus among the respondents on the evaluation.

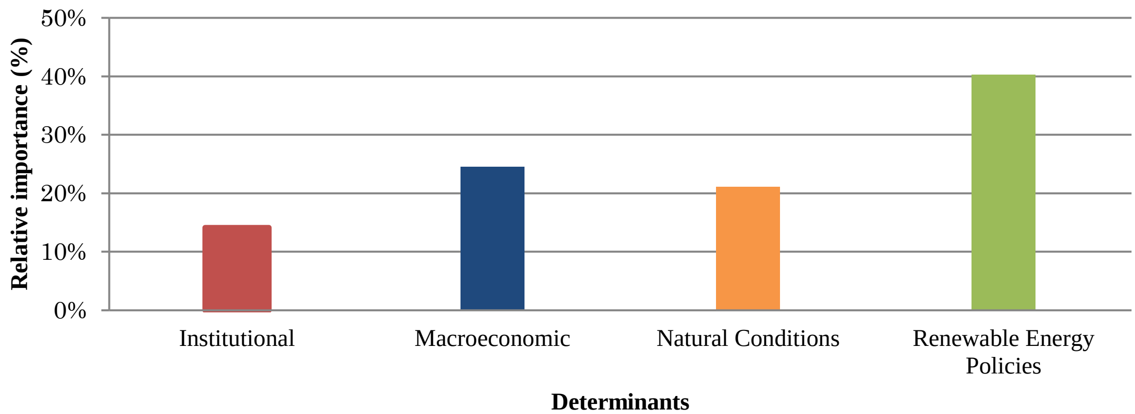


Figure 2 Relative significance of the broad categories

4.3 Relative significance of the institutional determinants

Next, the relative significance of the institutional determinants (i.e., political risk, administrative procedure, and effective law enforcement), is presented in Figure 3. Administrative procedure is perceived to have the strongest importance as a location determinant of FDI in renewable energy in developing countries with the weight of 46%. Renewable energy project development require various permits and licenses, involving various ministries and stakeholders such as local communities. Obtaining permits and licenses could be slow and unclear process especially for some developing countries, which is why transparent and smooth administrative procedure is deemed as an important determinant. Political risk and effective law enforcement follow this with the weight of 30% and 23%, respectively. Consensus ratio is moderately high with 66%.

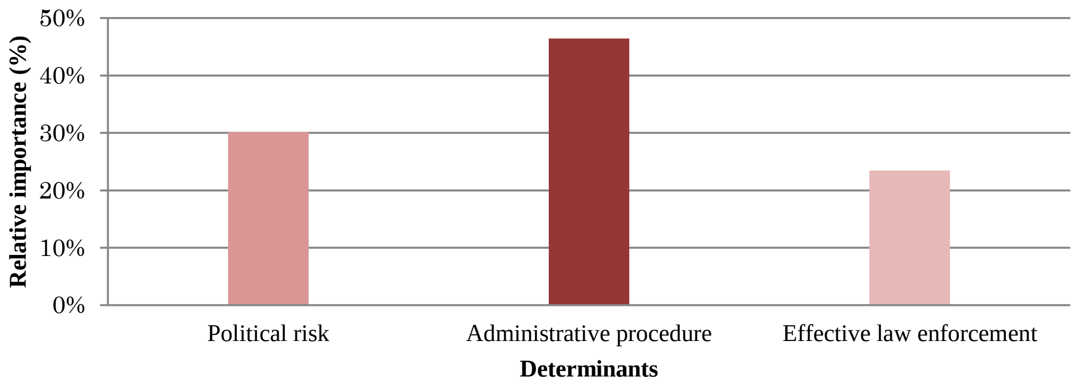


Figure 3 Relative significance of the institutional determinants

4.4 Relative significance of the macroeconomic determinants

The result of relative significance of the macroeconomic determinants (i.e., exchange rate volatility, access to local finance, and labor costs) is presented in Figure 4. The experts view exchange rate volatility as the strongest determinant among the macroeconomic determinants, with the weight of 60%. This is because of the long-term payback period of solar and wind energy projects, and the role of renewable energy investment as low-volatility investment in a lot of companies' investment portfolio.

Access to local finance and labor costs hold much weaker importance compared to exchange rate volatility with the weight of 26% and 14% respectively. Consensus ratio among the respondents is moderately high with 68%.

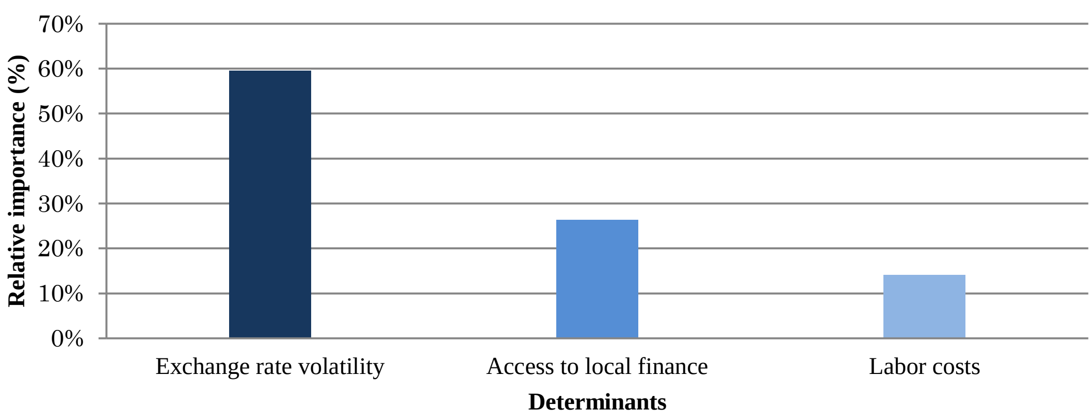


Figure 4 Relative significance of the macroeconomic determinants

4.5 Relative significance of the natural conditions determinants

Figure 5 shows the relative significance of the natural conditions determinants (i.e., natural resources and access to land). These determinants both have strong importance with the weight of 42% and 58%. Consensus ratio among the respondents is moderately high with 65%, but the lowest among the all evaluations. This is partly due to differences in experiences regarding land acquisitions for the projects. Depending on the type of renewable support policies prepared, governments often offer support for land acquisition process so that the projects can be smoothly implemented with lower risk of the projects being hampered by land issues, often seen in projects implemented under competitive bidding. This different view on the importance of access to land was also observed in the semi-structured interviews with the experts (Keeley and Matsumoto, 2018).

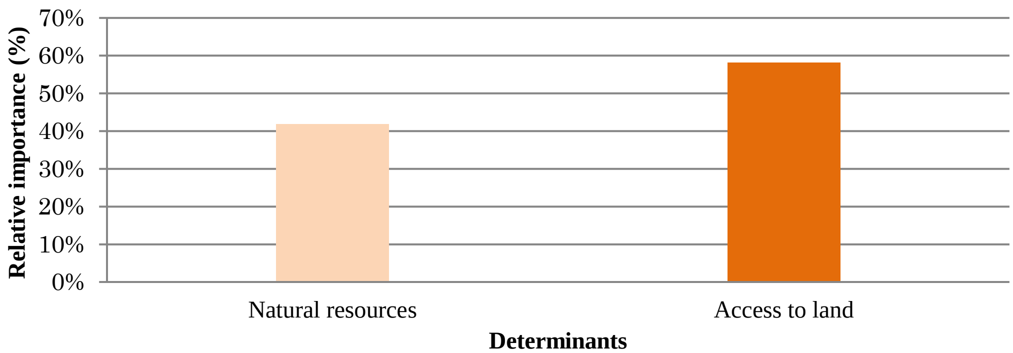


Figure 5 Relative significance of the natural conditions determinants

4.6 Relative significance of the renewable energy policies

As presented in Figure 6, the result in the cases of the renewable energy policies showed that regulatory support policies and economic support policies both hold strong importance with the weight of 44% and 36%, respectively. Political support policies are perceived to have the least important roles with the weight of 20%. Consensus ratio shows 70%, indicating high consensus among the respondents.

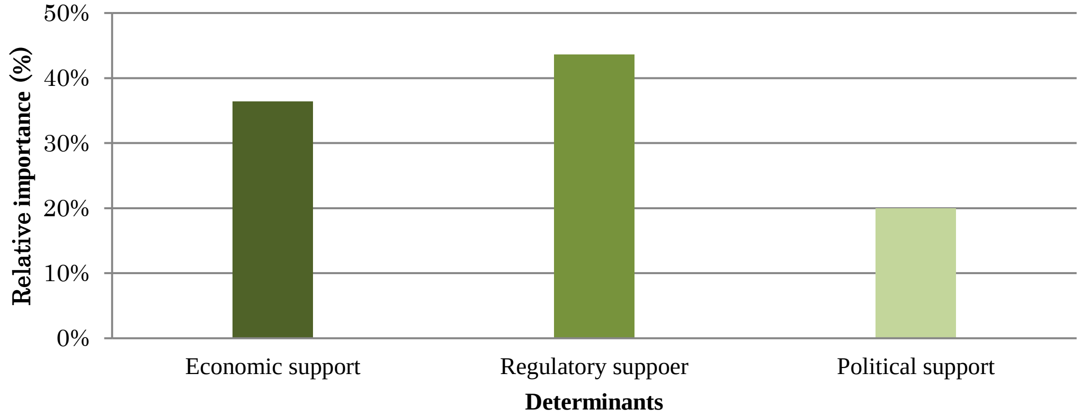


Figure 6 Relative significance of the renewable energy policies

4.6.1 *Relative significance of the economic support policies*

Figure 7 presents the result of the renewable economic support policies. Feed-in tariff, which is the most-used policy in developing countries, is evaluated to have the strongest significance, weight being 46%. Auction, which has also been increasingly employed in numbers of developing countries including South Africa and Mexico, follows this with the weight of 27%. Tax-incentives and REC&RPS hold weaker importance with the weight of 15% and 11% respectively. Consensus ratio among the respondents is high with 70%.

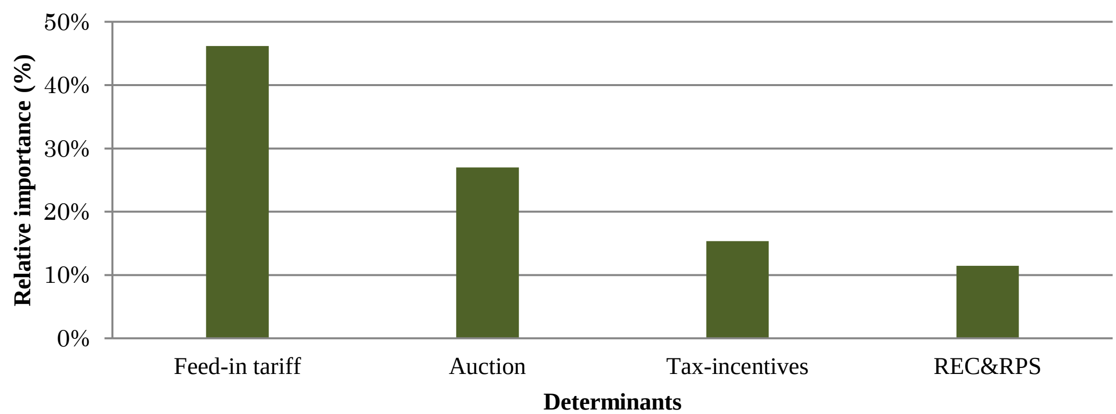


Figure 7 Relative significance of the economic support policies

4.6.2 *Relative significance of the regulatory support policies*

The result of case of the renewable energy regulatory policies (i.e., priority access to grid, absence of LCR, and technical standards) shows that priority access to grid is by far the most important determinant among the regulatory support policies with the weight of 63% (Figure 8). LCRs, which could greatly affect profitability and operational risk of renewable energy projects, hold surprisingly weaker importance compared to priority access to grid with the weight of 25%. This could be partly because for small-scale energy projects, the logistics and cost of grid connection can significantly drive up the cost of the projects more than LCRs do. Although the significance is lower than priority access to grid, when a country has limited technological capacity, the existence of LCRs greatly reduces the freedom of selection of a reliable supplier, and increases both cost and operational risk of the projects. Consensus ratio among the respondents is very high with 78%.

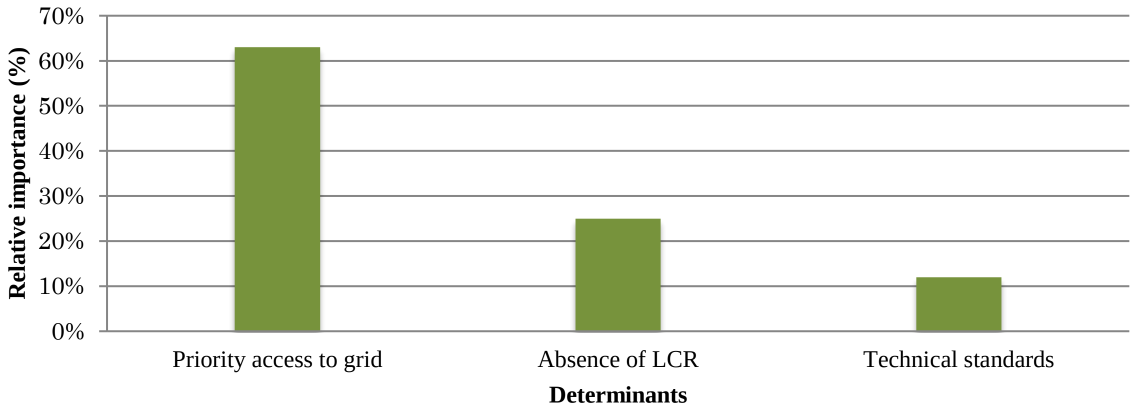


Figure 8 Relative significance of the regulatory support policies

4.6.3 Relative significance of the political support policies

Figure 9 shows the result of relative significance of the renewable political support policies: renewable energy target, development plan, and social acceptance. Having well-structured renewable energy development plan is perceived to have the strongest importance with the weight of 46%, followed by having national renewable energy target with the weight of 34%. Under the international pressure, a lot of developing counties set high national renewable energy targets, with targets being in place in 176 countries as of 2017 (REN21, 2017). However, those 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 it less reliable than well-structured development plan. Social acceptance surprisingly holds the lowest importance with the weight of 20%. As expressed in NIMBY (not in my backyard) problem, in developed countries there are a lot of cases that wind and/or solar projects get hampered because of resistance of local communities. As it was observed in the semi-structured interview, for conducting wind and/or solar projects in developing countries, the objections from local communities are perceived to be less likely to happen compared to projects in developed countries (Keeley and Matsumoto, 2018).

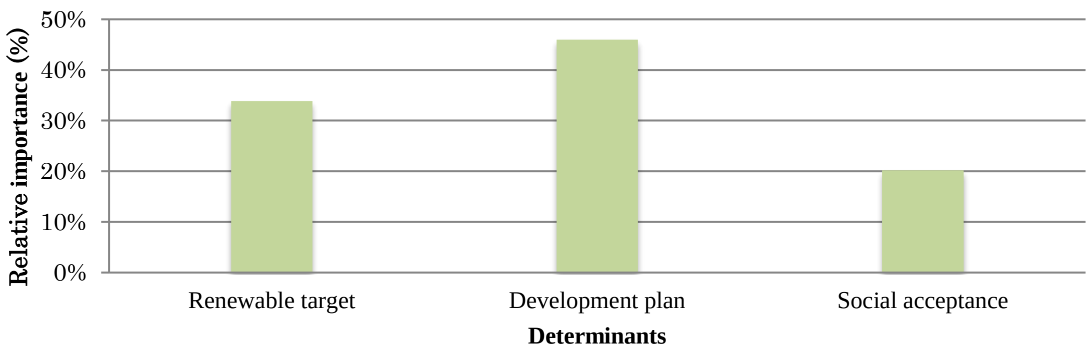


Figure 9 Relative significance of the political support policies

4.7 Relative significance among all of the determinants

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

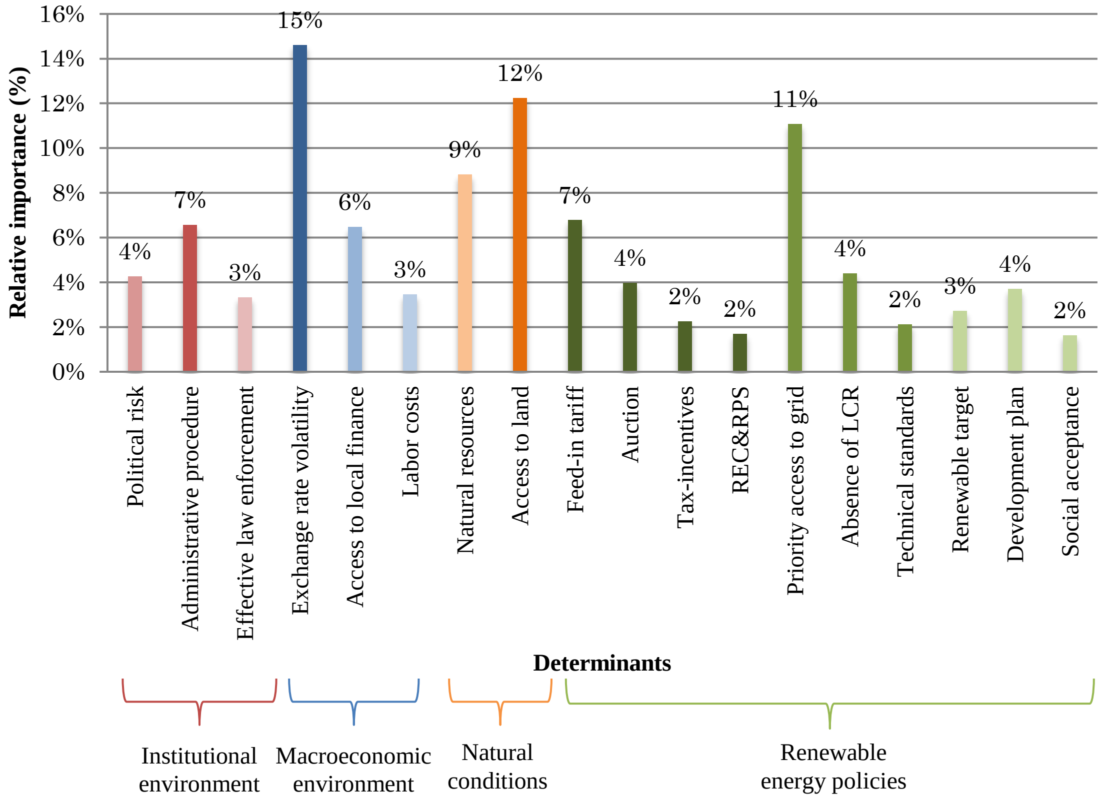


Figure 10 Relative significance of the determinants

Figure 10 shows the final results for all of the determinants. Exchange rate volatility holds the highest weight among the determinants with the weight of 15%, followed by access to land (12%), priority access to grid (11%), natural resources (9%), feed-in tariff (7%), and administrative procedure (7%). This final result highlights what factors are important for enhancing attractiveness for FDI in renewable energy, and the priorities (relative significance) between the determinants.

5 CONCLUSIONS AND POLICY IMPLICATIONS

This paper employed expert opinions and the AHP method to identify the relative significance of the determinants of FDI in renewable 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 renewable energy sector, besides the traditionally argued determinants of FDI including natural conditions, institutional environment, and macroeconomic environment, renewable energy support policies have been shown to have equivalent or stronger influence on decision-makings of FDI, supporting the results of the quantitative studies that have been performed on this topic. This study breaks down the renewable energy support policies in more detail, and provides the experts' opinions on the relative importance of each policy (feed-in tariff, REC&RPS, auction, priority access to electricity grid, etc.). The paper further sheds light on another important point that some of the traditionally argued determinants such as exchange rate volatility, access to land, and administrative procedure also hold very strong influence as determinants of FDI in renewable 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 traditionally argued determinants such as exchange rate volatility risk can also be hedged through properly designed renewable energy support policies. The following section focus on the key determinants for attracting FDI in the renewable energy sector, and provide policy implications that could be applied to various developing countries aiming to enhance the enabling environment for FDI.

5.2 Policy Implications

Through the AHP analysis, this paper has shown that traditional FDI determinants such as exchange rate volatility, access to land, and administrative procedure, and renewable energy sector-specific determinants including priority access to grid, feed-in tariff, and auction both hold strong importance as determinants behind location decisions of FDI in renewable energy in developing countries. Focusing on the determinants that were identified as highly important determinants, which are exchange rate volatility, access to land, administrative procedure, priority access to grid, feed-in tariff, and auction, this section provides policy implications that could contribute to enhancing the enabling environment for FDI in the renewable sector.

5.2.1 Exchange rate volatility risk and renewable economic support policies

Strong volatility of exchange rate indicates currency instability of a host country, which was evaluated as the most important determinant influencing decision-makings for FDI in renewable energy in developing countries (see Figure 10). Considering the long-term payback period of renewable energy projects, and the role of investment in renewable energy as low-volatility investment in a lot of companies' investment portfolios, a country with high exchange rate risk discourages foreign investors. Exchange rate risk not only affects future return from a project but also raises the cost of finance. From 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, there are several measures that could be taken by policy makers to reduce exchange rate risk with appropriate design of renewable economic support policies.

Two of the major renewable economic support policies that are employed in a lot of developing countries and deemed as very important support policies by foreign investors are feed-in tariff and auction/competitive bidding. Feed-in tariff and auction system provide payments for electricity from renewable energy at a guaranteed price for a fixed long-time period contract. Some of the ways to reduce the impact of exchange rate risk on FDI projects is to index a portion of the payments made under 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, but through enhanced competition and lowered levelized cost of energy of renewable energy projects, they could potentially reduce the cost required for renewable energy policies. In fact in a lot of 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 the investors to themselves, the simplest but also more expensive option is to pay the tariff in US dollar. Countries such as Uganda pay the tariff in US dollars (ERA, 2016).

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

5.2.2 Feed-in tariff vs. auction/competitive bidding

Feed-in tariff and auction are both employed by a lot of 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 Figure 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 could be challenging because of the fast-changing cost of renewable energy projects, and the information-gap between policy makers and practitioners in young markets. Therefore, for a country that lacks capacity to design feed-in tariff systems, implementing competitive bidding prior to adopting feed-in tariff system could help finding out appropriate tariffs for renewable energy projects. Competitive bidding systems are preferred by a lot of developing countries partly owing to their controllability by the government. However, competitive bidding also needs to be designed carefully to make the system beneficial. First, the process needs to be clear and transparent, and second, the quality of the bid needs to be considered carefully in addition to price. In order to implement successful competitive bidding, ensuring the realization of the target and maintaining efficiency, Kreiss et at. (2017) recommend high financial and adjusted physical pre-qualifications. It is considered 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 (OECD, 2015)". South Africa is a good example among developing counties, which sets previous experience of developers as one of the bidding criteria. Although competitive bidding is an effective support policy, from the eyes of foreign investors, recent aggressive competitions among developers of the projects and often time-consuming bidding processes make it questionable if competitive bidding is a long-term support policy that a country can maintain successfully. Including the design of a system, what measures to adopt depends on the conditions of a country, including the macroeconomic situation, overall currency and balance of payment exposure, and the state of the cost of renewable energy projects in the country.

5.2.3 One-stop agency for efficient administrative procedure

Renewable energy projects require various permits and licenses, involving various ministries and stakeholders. Obtaining permits and licenses can be a slow and unclear process for 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 the complex and inefficient administrative procedures would promote project implementation and enhance the enabling environment.

In the case of Indonesia, there are generally around 14 permits and licenses required to carry out renewable energy projects, of which nine need to be obtained at the local level[4]. Different notions among local authorities, and sometimes-unclear decision-making power distribution between different levels of authorities had been slowing down renewable energy development. In order to resolve the complex procedures, the Indonesian government established a one-stop agency in 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 an investment process, including planning, application for approval, approval procedure and project implementation. They contact the relevant authorities, submit the required documents and function as a 'bridge' between investors and the administrative system as presented in Figure 11. One-stop agencies can simplify the tiring process needed for obtaining the required permits and licenses from different levels of authorities through creating the common understanding between different authorities and making the procedure more transparent.

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[4] Information obtained through 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 through Oct. 16th to Oct. 18th in Jakarta, Indonesia.

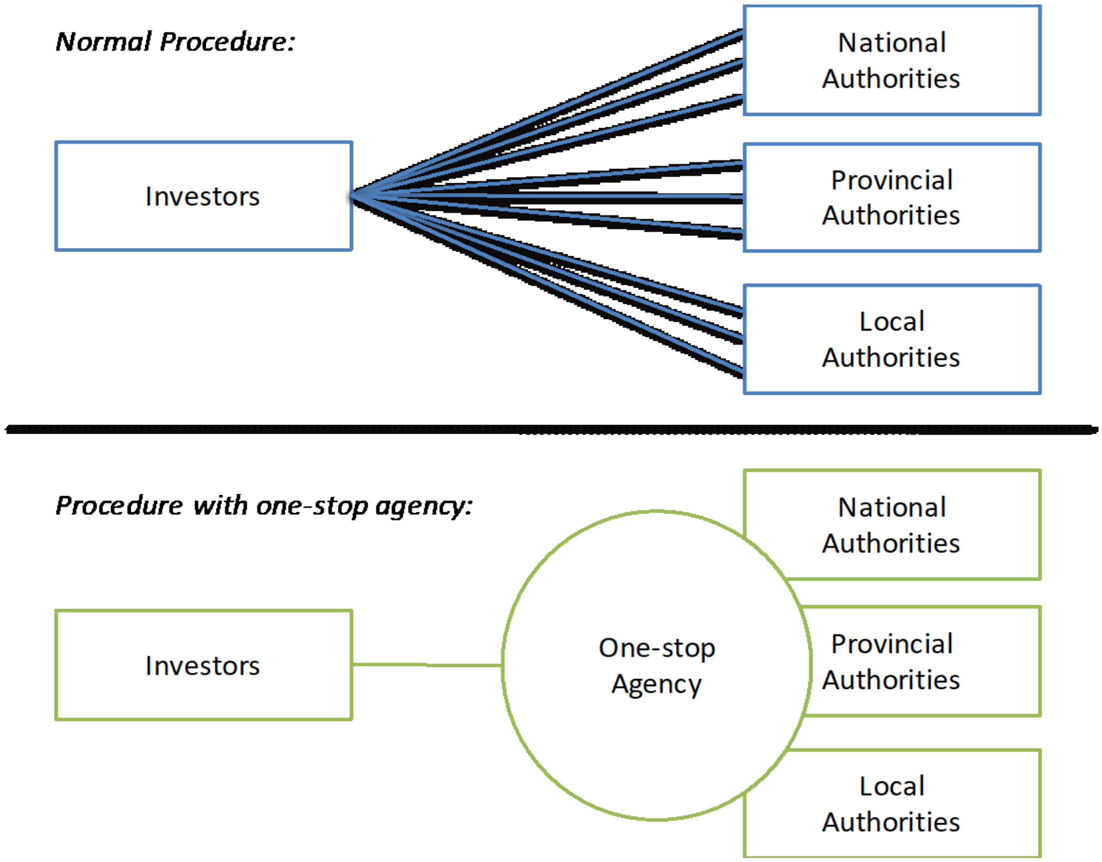

Figure 11 The structure of a one-stop agency. The top panel shows the normal procedure to obtain permits and licenses, while the bottom panel shows the procedure with one-stop agency.

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

5.2.4 Renewable energy resource mapping and improving access to land

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

Another notable point is easiness 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 could be improved, and also it could help identifying lands that need land-use adjustment to enable renewable energy project developments.

Detailed mapping of renewable energy potential and improving land access issues require comprehensive local and provincial coordination, and collaboration between different responsible units at 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.

5.2.5 Access to grid, and other regulations

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

Especially for foreign investors, there are also other regulations that could impose restrictions on implementing renewable energy projects, which include LCRs and import tariffs. If 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 could negatively affect the government of the host country through increasing the support required for the development of renewable energy projects. LCRs can also increase technology risk that affects both the developer and the electricity system with the limited capacity of local supply chain. Furthermore, considering that a large part "of the value created (in USD/MW installed) in renewable energy is generated after the manufacturing phase (EEW & NRDC, 2012)", LCRs could negatively impact host country from the value-added point of view.

There are also other trade-related measures such as limiting equity in renewable energy projects for foreign investors to benefit from 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 should be carefully treated in order not to miss the chance to embrace the capital and innovative potential FDI can bring to the host countries.

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REFERENCES

- Abdmouleh, Z., Alammari, R.A., Gastli, A., 2015. Review of policies encouraging renewable energy integration & best practices. Renewable and Sustainable Energy Reviews. 45, 249-262.
- Bhushan, N., Rai, K., 2007. Strategic decision making: applying the analytic hierarchy process. Springer Science & Business Media, Berlin.
- Brunelli, M., Critch, A., Fedrizzi, M., 2013. A note on the proportionality between some consistency indices in the AHP. Applied Mathematics and Computation. 219 (14), 7901-7906.
- Cheng, E.W., Li, H., 2002. Construction partnering process and associated critical success factors: quantitative investigation. Journal of Management in Engineering. 18 (4), 194-202.
- Edwards, S., 1990. Capital flows, foreign direct investment, and debt-equity swaps in developing countries. NBER Working Paper. 3497. Cambridge.

- EEW., NRDC., 2012. Laying the Foundation for a Bright Future: Assessing Progress Under Phase 1 of India's National Solar Mission. Council on Energy, Environment and Water Natural Resources Defence Council, New York.
- ERA., 2016. Uganda Renewable Energy Feed-in Tariff Guidelines. ERA, Kampala.
- Eyraud, L., Clements, B., Wane, A., 2013. Green investment: Trends and determinants. Energy Policy. 60, 852-865.
- FDiintelligence., 2017. The FDireporT 2017 Global Greenfield Investment Trends. Financial Times, London.
- Foxon, T., Pearson, P., 2008. Overcoming barriers to innovation and diffusion of cleaner technologies: some features of a sustainable innovation policy regime. Journal of Cleaner Production. 16, 148-161.
- Gatzert, N., Vogl, N., 2016. Evaluating investments in renewable energy under policy risks. Energy Policy. 95, 238-252.
- GlobalData, Energy, plant database. https://energy.globaldata.com/ (accessed 25 September, 2017)
- Goepel, K.D., 2013. Implementing the analytic hierarchy process as a standard method for multi-criteria decision making in corporate enterprises–a new AHP excel template with multiple inputs. Proceedings of the international symposium on the analytic hierarchy process. 1-10.
- International Monetary Fund., 2017. World Economic Outlook: Seeking Sustainable Growth. IMF, Washington.
- IRENA., 2013. Renewable Energy Auctions in Developing Countries. IRENA, Abu Dhabi.
- Kambezidis, H. D., Kasselouri, B., Konidari, P., 2011. Evaluating policy options for increasing the RES-E penetration in Greece. Energy Policy. 39(9), 5388-5398.
- Kaufmann, D., Kraay, A., Mastruzzi, M., 2011. The worldwide governance indicators: methodology and analytical issues. Hague Journal on the Rule of Law. 3, 220-246.
- Kaya, T., Kahraman, C., 2010. Multicriteria renewable energy planning using an integrated fuzzy VIKOR & AHP methodology: The case of Istanbul. Energy. 35 (6), 2517-2527.

- Keeley, A.R., 2017. Renewable energy in pacific small island developing states: The role of international aid and the enabling environment from donor's perspectives. Journal of Cleaner Production. 146, 29-36.
- Keeley, A.R., Ikeda, Y., 2017. Determinants of Foreign Direct Investment in Wind Energy in Developing Countries. Journal of Cleaner Production. 161, 1451-1458.
- Keeley, A. R., Matsumoto, K. I., 2018. Investors' perspective on determinants of foreign direct investment in solar and wind energy in developing economies–Review and expert opinions. Journal of Cleaner Production. 179, 132-142.
- Kreiss, J., Ehrhart, K. M., Haufe, M. C., 2017. Appropriate design of auctions for renewable energy support–Prequalifications and penalties. Energy Policy. 101, 512-520.
- Lam, K., Zhao, X., 1998. An application of quality function deployment to improve the quality of teaching. International Journal of Quality & Reliability Management. 15 (4), 389-413.
- Lee, G.K., Chan, E.H., 2008. The analytic hierarchy process (AHP) approach for assessment of urban renewal proposals. Social Indicators Research. 89 (1), 155-168.
- Matsumoto, K., Morita, K., Mavrakis, D., Konidari, P., 2017. Evaluating Japanese Policy Instruments for the Promotion of Renewable Energy Sources. International Journal of Green Energy. 14(8), 724-736.
- Maulud, A. L., and Saidi, H., 2012. The Malaysian fifth fuel policy: re-strategising the Malaysian renewable energy initiatives. Energy policy. 48, 88-92.
- McInerney, C., Johannsdottir, L., 2016. Lima Paris Action Agenda: Focus on Private Finance–note from COP21. Journal of Cleaner Production. 126, 707-710.
- Murovec, N., Erker, R.S. and Prodan, I., 2012. Determinants of environmental investments: testing the structural model. Journal of Cleaner Production. 37, 265-277.
- Nigim, K., Munier, N. & Green, J. 2004. Pre-feasibility MCDM tools to aid communities in prioritizing local viable renewable energy sources. Renewable Energy. 29 (11), 1775-1791.
- Nikolaev, A., Konidari, P., 2017. Development and assessment of renewable energy policy scenarios by 2030 for Bulgaria. Renewable Energy. 111, 792-802.
- OECD., 2015. OECD policy guidance for investment in clean energy infrastructure. OECD, Paris.

- Painuly, J.P., 2001. Barriers to renewable energy penetration; a framework for analysis. Renewable Energy. 24, 73-89.
- Peláez, J. I., Lamata, M. T., 2003. A new measure of consistency for positive reciprocal matrices. Computers & Mathematics with Applications. 46(12), 1839-1845.
- Regmi, M.B., Hanaoka, S., 2012. Application of analytic hierarchy process for location analysis of logistics centers in Laos. Paper presented at 91th Annual Transportation Research Board Meeting, Washington, DC.
- REN21., 2016. Renewables 2016 Global Status Report. REN21, Paris.
- REN21., 2017. Renewables 2017 Global Status Report. REN21, Paris.
- Saaty, T.L., 1980. The analytic hierarchy process: planning, priority setting, resource allocation. McGraw-Hill, New York.
- SEDA, 2012. Frequently Asked Questions on Feed-in Tariff (FiT). Available: http://www.seda.gov.my/ (accessed 23 October 2017).
- Thao, P.T.M., Kurisu, K.H., Hanaki, K., 2014. Evaluation of Rice Husk Use Scenarios Incorporating Stakeholders' Preferences Revealed through the Analytic Hierarchy Process in An Giang Province, Vietnam. Low Carbon Economy, 5 (3), 95-106.