Chasing the Sun: The Political Economy of Solar Investment in the Global South

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Abstract

How can developing countries sustain their energy transitions? Foreign direct investment is often cited as critical for renewable energy growth in low and middle income countries. Using an original dataset of solar projects, I show that while large foreign investors lead to quick initial growth, countries dependent on foreign investment experience a boom-and-bust cycle. In contrast, those with more domestic investment grow at a slower but steady pace. I argue that these differences stem from firm embeddedness in the local political context and outside options for future investments. When faced with regulatory roadblocks, local firms use their political connections to lobby bureaucrats for policy reforms, whereas foreign firms invest elsewhere. I find support for this argument through large-N observational analysis of policy adoption, as well as interviews with over 100 firms and government officials in Malaysia, Colombia, and Panama.

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1 Introduction

The Colombian energy transition stands on the edge of a precipice. Although the government awarded permits for over 10 gigawatts (GW) of wind and solar projects as of 2022 - nearly enough to satisfy Colombia's entire energy demand - only one GW of solar power is online (Ini 2024). The stakes are high for renewable energy: from April to June of 2024, hydroelectricity shortages prompted drinking water rationing in the capital and forced the government to turn on expensive backup fossil fuel power plants (Jaramillo 2024). New solar projects are crucial to prevent blackouts and sustain the energy transition (Interview 71). With eager investors and looming power cuts, why is Colombia unable to bring solar projects online?

Colombia's energy crisis is driven by solar investors' response to renewable energy regulatory hurdles. In 2017, foreign solar developers arrived in Colombia after renewables subsidies expired in their home countries (Gürtler, Postpischil, & Quitzow 2019). Lack of coordination across government agencies, and in some cases, deliberate obstruction from utility providers reluctant to pay the costs of energy transition, led to delays in solar project permitting (Interview 57, 60, 69).[1] These unexpected delays have driven foreign firms to abandon their projects (Interview 57, 58, 61). When impending drought threatened energy security in April 2024, the government turned to water rationing to compensate for the lack of solar power (Interview 61). Despite the promise of foreign investment, which is capable of quickly scaling up solar, Colombia faces energy crisis.

Colombia is a typical case, where renewable energy demands regulatory reform (S. E. Kim, Urpelainen, & Yang 2016; Stokes 2020; Meckling 2015) but foreign firms exit the market instead of lobbying the government to improve policy. Renewable energy requires significant technical changes to existing regulation and physical infrastructure, even in a hydropower dependent country like Colombia that generates the majority of its power from renewable energy.[2] Regulatory hurdles are often revealed in the aftermath of early state support for renewable energy, like subsidies and tax incentives, as unanticipated technical and political costs accrue. Evidence from the United States (Stokes 2020; Breetz, Mildenberger, & Stokes 2018) even finds deliberate resistance from utility providers, which paid actors to speak out against solar energy subsidies at public hearings. Cases across the developing world echo these patterns of regulatory resistance to renewable energy (Baker & Sovacool 2017; Hochstetler 2020). Irrespective of energy market structure, across a diverse set of cases (Seawright & Gerring 2008)[3] renewable energy regulation demands reform, but existing

[1] Several domestic agencies manage renewable energy policy, but bureaucrats "do not always talk to each other" (Interview 57, 60, 61).

[2] Renewable energy requires regulatory reform, which places costs on energy sector institutions and incumbent firms. For example: (1) Renewable energy is variable, and generates power when it is sunny or windy. The grid is set up to dispatch power than can be turned on and off at will, so this variability requires investment in advanced technologies. (2) Renewables are quick to construct, so transmission and distribution lines must be planned and built before renewables since they take longer to build. This requires additional planning, since in conventional energy grid infrastructure is built only after the projects are selected. (3) Renewables cut into shares of fossil fuel generation.

[3] Energy market incumbents are foreign companies (Panama), private domestic firms (Colombia) or government-

actors and institutions resist.

Renewable energy firms' political participation is critical to overcome regulatory hurdles (Meckling, Kelsey, Biber, & Zysman 2015), because renewable energy is a sector characterized by low salience and high-complexity (Culpepper 2010). The government relies on firms to provide private information (Austen-Smith 1993; Schnakenberg 2017; Wen 2024) about policy solutions. However, it is less clear if and how renewable energy firms effectively lobby the government to update existing regulation. When faced with regulatory hurdles, I propose that firms can exercise voice - provide the government with information about necessary regulatory reforms - or exit the market. In issue areas with centralized decision-making, large and foreign firms are typically the most active and effective in lobbying (I. S. Kim 2017; Osgood et al. 2017; Lee 2023; Brutger 2023). However, renewable energy governance is characterized by decentralized decision making (Naoi & Krauss 2009), where several government entities control different parts of the investment process. I argue that lobbying costs are driven by a firm's embeddedness — social and economic integration — rather than firm size, given the challenge of identifying whom to lobby and what reforms to request. This means foreign firms find lobbying expensive but can easily exit, while domestic firms find it cheaper to lobby but costlier to leave. This cost calculation determines firms' political participation when facing regulatory barriers to the energy transition.

This paper makes two important contributions to political economy scholarship. First, political economy work finds that large and foreign investors are most important in lobbying for regulation across issue areas like trade and international standards (I. S. Kim 2017; Osgood et al. 2017; Perlman 2023; Lee 2023; Brutger 2023). I extend this scholarship, arguing that the structure of issue area governance shapes the extent to which firm size shapes lobbying costs. In renewable energy, a new sector where governance is scattered across multiple domestic institutions, I expect that firm experience with local political institutions is a key determinant of effective political participation. This means that firms with extensive local experience but which are small in size can exert important political influence over renewable energy regulation.

Second, while comparative political economy scholarship finds that domestic firms often purse rent seeking policies (J. S. Hellman 1998; Haggard 1990; Kaufmann & Pape 1999; Morck, Wolfenzon, & Yeung 2005), I show that the existential political threat posed by incumbents to renewable energy leads to collective action among locals. In the face of resistance to renewables, domestic firms pursue collective action to improve market competition rather than lobbying for individual kickbacks. In sum, the decentralized structure of renewable energy governance leads to a pattern of firm-level political participation that departs from common political economy explanations for regulatory reform. This is both important to shape our understanding of other emerging industries, and to guide policy-making for the energy transition.

linked companies (Malaysia)

The paper proceeds as follows. First, I introduce the motivating puzzle: why has solar installation slowed in countries with experienced foreign investors but continues to steadily grow in countries with less experienced domestic firms?[4] This situates the core contribution of this paper: when faced with regulatory roadblocks, foreign firms choose to exit the market, while domestic firms lobby, secure reforms, and continue investing in long-term energy transition. While previous work suggests that large and foreign firms wield the greatest influence over regulatory outcomes, I contend that domestic firms will secure the reforms necessary for energy transition due to the complexity of renewable energy governance. I draw upon an original dataset of solar projects and investor characteristics, in addition to over 100 interviews in Colombia, Malaysia, and Panama, to show how embeddedness shapes firms' political participation. A cross-national regression shows that countries with a higher share of domestic investment pass more renewable energy policies, which is suggestive of successful domestic firms' lobbying efforts. I conclude on a cautionary note: while foreign investment can boost short-term solar deployment, it may not build domestic political coalitions for a long-term energy transition.

2 Motivating Puzzle: The Rise and Fall of FDI

Why are countries with large foreign solar investors experiencing slowdown after a fast expansion of solar energy? Although large foreign investors have the most experience to quickly build solar projects, countries reliant on foreign solar investment have stalled in their growth while domestic investment steadily grows. Initially, foreign firms opened new markets for renewable energy in the developing world, building large scale solar projects that leverage experience from their home countries (Steffen, Matsuo, Steinemann, & Schmidt 2018). Many companies from developed economies which pioneered renewable energy policy, like Germany and Denmark, have already built solar projects and are enmeshed in networks with other lead firms from the Global North (Lipp 2007; Steffen et al. 2018; Gürtler et al. 2019). Multinationals (MNCs) from Italy (Enel Green Power), Spain (Iberdrola), France (Engie), the United States (AES Corporation), and China (Canadian Solar) all developed solar in their home countries, and led large scale solar investment in the developing world (Steffen et al. 2018).

Only solar industry players with experience can build large scale solar projects, so foreign investors should build solar faster than domestic firms (Steffen, Beuse, Tautorat, & Schmidt 2020).[5] Local firms have little solar industry specific knowledge, and can only draw upon their core competencies in other sectors like engineering and construction (Kelsey 2018). As a result, MNCs build large projects while locals must start small and learn to scale up. Based on the capabilities of foreign companies relative to their domestic counterparts, foreign firms should be well-positioned

[4] I exclude India and China from my analysis, since these countries have a very large domestic market and have employed policy tools not available to the majority of developing countries as a function of their market size (Lewis 2014; Ball, Reicher, Sun, & Pollock 2017; Nahm 2021).

[5] Appendix Section A.1 uses cross-national survival analysis to confirm this proposition. I find that countries with a higher share of foreign investment scale up solar quickly in the short term.

to drive quick energy transition in the developing world. Indeed, foreign firms do appear to drive short-term scale up. The figure below shows the percentage of countries with over two percent solar in the energy mix for countries with over 50 percent foreign investment (blue) versus domestic investment (red) from 2000-2023.[6] Countries with high foreign investment achieved two percent solar generation much earlier than those with a large share of domestic investment.

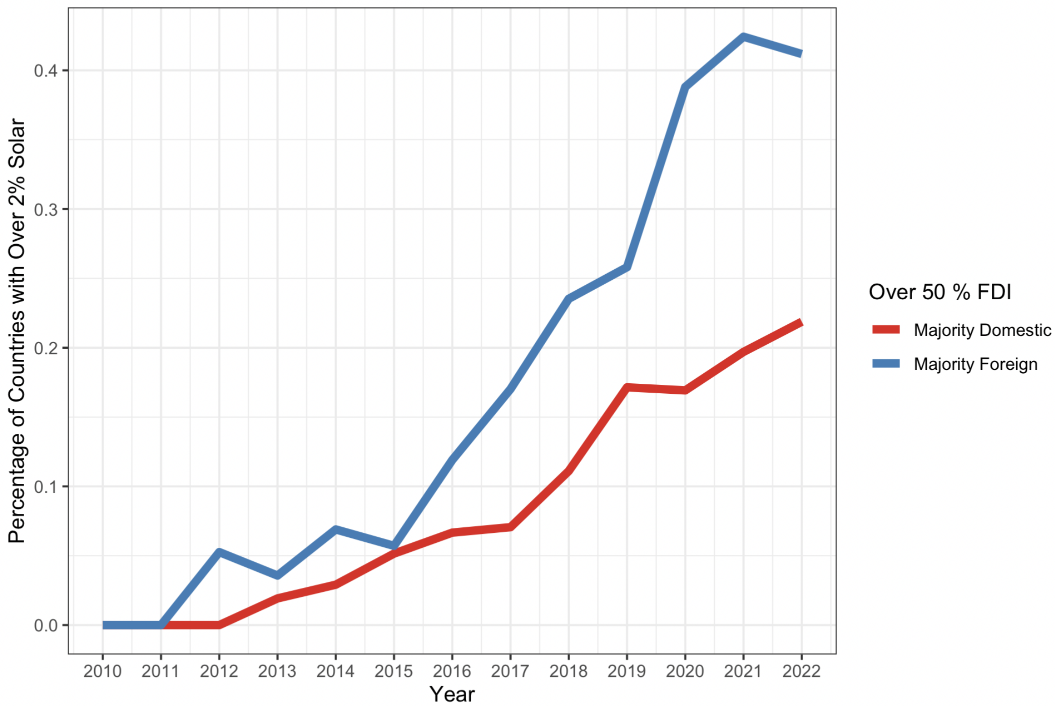

Figure 1: **FDI Share and Time to two percent.** The figure shows the percentage of countries with two percent solar generation based on investor ownership. The x-axis indicates the year, and y-axis the proportion of countries for FDI-majority (red) and domestic-majority (blue) low and middle income countries. I include all projects with foreign participation as foreign invested in this figure. Countries with majority foreign investment reach this threshold faster.

However, the benefits of FDI appear to be short-lived. While foreign firms scale solar quickly, the rate of solar energy build-out has slowed in FDI reliant countries. On the other hand, domestic-majority countries take longer to reach investment milestones, but have a smoother trajectory of growth. The figure below compares the percentage of generation from solar by countries with majority foreign solar investment against those with majority domestic solar investment. While majority-FDI countries indeed reach higher thresholds of generation faster, their growth is flattening. On the other hand, countries with majority domestic investment are growing slowly, but

[6] I choose two percent as a threshold as a nod to Panama's cap on solar at two percent of energy generation, but replicate the analysis with thresholds of one and three percent as a robustness check (Appendix Tables A.1.2-A.1.4). Results hold with these alternative specifications. Selecting a higher threshold leads to convergence problems because few countries have over 3 percent solar energy in the generation mix.

steadily, in their share of solar energy generation. Recent news from Bloomberg New Energy Finance confirms this trend, projecting that global renewable energy growth will slow down as countries encounter regulatory hurdles with the energy grid (Catsaros 2024).

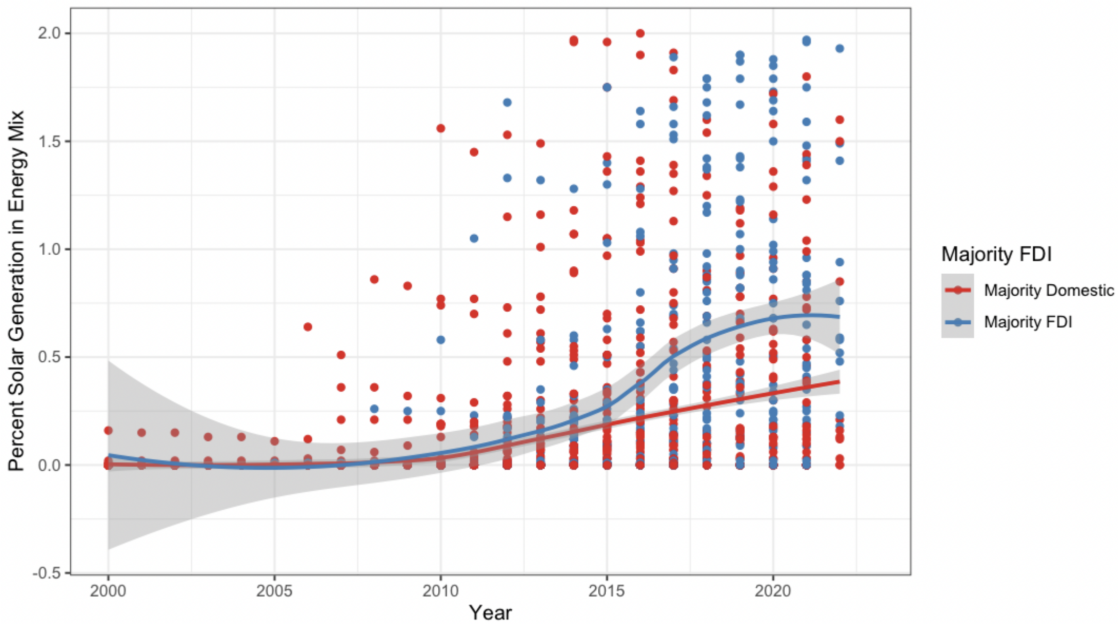

Figure 2: **Investor Composition and Solar Generation Share** The x-axis shows year, and y-axis plots the share of generation from solar energy for each country-year observation. Colors correspond to countries with majority foreign investment (blue) versus majority domestic investment (red). Each group of countries is fitted by a loess curve.

This is important because many countries skew heavily towards domestic or foreign solar investment, rather than an even mix of the two. The histogram below shows the distribution of foreign investment in 2023 among countries with solar investment. This plot reveals that several countries are almost entirely reliant on FDI. As a result, the rise and fall of FDI may be particularly acute, since in majority-foreign markets there are few local firms left behind to lobby for energy transition.

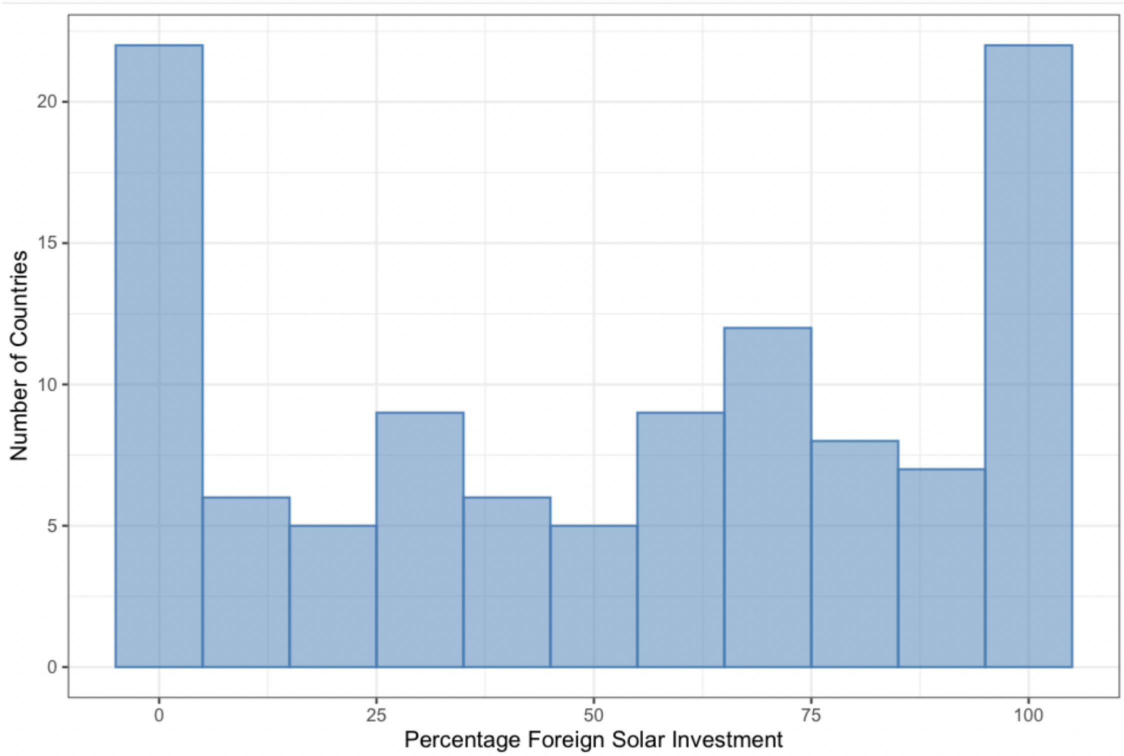

Figure 3: **Percent Foreign Investment** The histogram shows the percentage of solar investment from foreign firms on the x-axis for all low and middle income countries (except India and China) in 2022. This reveals that many countries skew heavily towards domestic or foreign investment, so the symptoms of boom-and-bust will be especially acute.

3 Exit or Voice?

Fast-paced build-out is insufficient for energy transition because renewable energy faces significant regulatory roadblocks from incumbent actors as it grows. Renewable energy often complicates existing regulatory procedures, and in doing so, provokes opposition from energy sector firms across generation, transmission and distribution(Stokes 2020).[7] Even in climate leaders, renewables generated early backlash from incumbent utilities that very nearly undermined the green transition. In Germany, early policy success in the 2000s led to a rise in renewable energy, which cut into incumbent generation share. German utilities responded by blocking new solar grid connections on technical grounds and lobbied to limit renewable energy by revising the original subsidy. The head of the utility Preussenelektra even stated that "we will do everything possible to stop [the subsidy]" (Stenzel & Frenzel 2008). Evidence suggests that strong support from solar manufacturers,

[7] The majority of opposition arises from transmission and distribution firms, because firms in generation can diversify their business into solar, while transmission and distribution companies are both less equipped to invest in solar themselves and face high costs from solar. Solar requires new policies to manage grid connection, base-load power (since renewables are variable in their energy production), and process for permitting power projects. This means that renewables require policy changes and impose costs on incumbent utilities, notwithstanding their effect on fossil fuels.

other utilities with renewables holdings, and especially smaller solar firms was key to maintaining subsidies (Jacobsson & Lauber 2006; Stenzel & Frenzel 2008).

The German case illustrates how renewable energy firms are essential to influence climate policy. Firms are the predominant interest groups advocating for policy change because the energy sector is a complex and low salience issue area (Stokes 2020). Since regulators cannot rely on the media or public to provide information on the topic at hand, businesses provide essential information about their preferred policies (Culpepper 2010; Junk 2019; Stokes 2020; Wen 2024). As a result, renewable energy firms are crucial to lobbying for renewable policy reform (Meckling et al. 2015; Meckling & Trachtman 2023). Cases across both the developing world and other developed countries echo this pattern, where incumbent interests pushed back against renewable energy investment after initial growth. Renewable energy coalitions - or the absence thereof - were the crucial determinant of long-term policy reform (Baker & Phillips 2019; Hochstetler 2020; Stokes 2020; Bayulgen 2023).

This departs from evidence indicating that the early beneficiaries of reform - in this case renewable energy firms that benefit from subsidies - often lobby against the deepening of reforms (J. S. Hellman 1998; J. Hellman & Schankerman 2000; J. S. Hellman, Jones, & Kaufmann 2003).[8] While this literature foregrounds the role of domestic firms in lobbying for protection (Haggard 1990; Kaufmann & Pape 1999; Corrales 2010), I find the opposite: domestic firms support policy which benefits the industry as a whole. I argue that this difference arises due to regulatory roadblocks, sometimes outright opposition, which threatens the industry. [9] The threat of renewable industry collapse motivates locals to lobby reforms that promote competition and sustain solar industry growth.

Although regulatory hurdles threaten all solar industry firms, I argue that not all investors fight for policy reform; some will lobby, and others will leave. In the face of regulatory hurdles, firms can choose to exit the market or exercise voice (Hirschman 1970), and I contend that investor ownership determines the costs of exit relative to voice. First, outside options for future investment, or other countries where firms can build a solar project, determine firms' cost of exit. This poses both a hard constraint on exit and reduces firms' incentive to develop voice. Second, firm embeddedness (Granovetter 1985), or social and economic linkages to the domestic economy, determines the cost of voice. Renewable energy policy is fragmented across government agencies, so I argue that embeddedness in social networks reduces the costs of exercising voice (Dowding & John

[8] Nearly all developing countries adopted a renewable energy subsidy. Of the 132 low-and-middle countries that have installed some quantity of solar energy, 42 percent have adopted a feed-in-tariff, or long-term subsidy for solar ranging between 10 to 20 years, while 39 percent held at least one auction round, which entails competition over large-scale solar project contracts (Climate Policy Database, 2023).

[9] The vulnerability of a sector can push firms and business associations to switch from rent seeking to efficiency oriented lobbying. Work focuses in large part on export dependence as a source of vulnerability (R. H. Bates 1988; R. Bates 1997; Urrutia Montoya 1983; Doner & Schneider 2000), but I propose that regulatory vulnerability in renewable energy also motivates firms to mobilize for regulations that promote competition.

2008; Naoi & Krauss 2009). This departs from political economy scholarship which emphasizes the influence of large and foreign firms over lobbying, but focuses on issue areas with centralized decision-making (Osgood et al. 2017; Lee 2023; Brutger 2023). The following section lays out how outside options and embeddedness shape exit and voice, and proposes hypotheses linking variation in project ownership to observable implications for political participation and policy adoption.[10]

3.0.1 Outside Options and Future Investments

In the face of political opposition to renewable energy, firms can choose to exit a market, or push back. In this case, "exit" refers to firm's choice to locate future investments in a different country than current investments, sometimes combined with divestment. While in extreme cases, investors have literally dismantled existing renewable energy projects in the face of opposition to renewable energy, it is rare to shut down their existing facilities (Bocanegra 2023). Instead, firms face a choice over the location of future solar investments. For example, Norwegian Scatec Solar filed a case against Honduras at the International Centre for Settlement of Investment Disputes (ICSID) over regulatory changes that reduced payments for solar energy (Pousset 2023), but continues to own and operate two large scale solar farms in the country. However, Scatec has not continued to invest, and instead has built solar in other emerging markets such as Tunisia, South Africa, and even Iraq after the ICSID case. I argue that outside options, or other locations where a firm could invest in the future, both lower the cost of exit and reduce firms' incentive to learn how to exercise voice in the domestic context.

First, the greater a firms' international network, the greater its outside options. This draws a stark cleavage between the outside options of domestic versus foreign firms. Firms that have never invested abroad face prohibitively high exit costs, and effectively have no outside option.[11] On the other hand, investors with assets abroad can leverage their expertise to invest in other countries. For example, when a two percent limit on solar energy generation in Panama threatened industry survival, a United Kingdom based multinational firm first considered alternative markets like Guatemala rather than engaging officials (Interview 35). Among firms with international assets, large companies like Italian utility Enel Green power or American AES Corporation enjoy more outside options than smaller, regional multinationals. To a lesser extent, large domestic firms with overseas presence also have outside options in neighboring countries. For example, large Thai business conglomerate B Grimm Group built solar projects across Southeast Asia after years of learning in its domestic market. While B Grimm is local to Thailand, it has more outside options than a domestic firm which has never invested abroad.

[10]Note that while embeddedness and outside options are not mutually exclusive by definition - embedded firms can also have outside options - firms often have one or the other. Very few domestic firms in the Global South have expanded operations beyond their home country, and most foreign solar investors in the developing world do not have longstanding holdings in a given host country.

[11]While domestic firms could technically exit into other sectors in the local market, the costs of doing are high since solar assets are technology-specific. This exit option is more costly than moving to a different market for the same technology.

Second, outside options can "atrophy the development of the art of voice" (Hirschman, 1970, p. 43). When voice is already established, outside options increase a firm's bargaining leverage and thereby the effectiveness of voice (Gehlbach 2006). However, if a firm has not yet established voice, outside options dissuade learning about the most effective channels to exercise voice (Hirschman 1970; Dowding & John 2008). This is exemplified by foreign firms' reliance on rigid and legalistic mechanisms for dispute settlement in the developing world, which undermine negotiations with the offending government (Vernon 1971; Woodhouse 2005; Henisz & Zelner 2010). Formal international arbitration can sour business-government relations and preclude future investment, but foreign firms prefer a guaranteed post hoc settlement because they know they can invest elsewhere in the future (Wells & Ahmed 2007; Post 2014).

3.0.2 Embeddedness and Voice

Alternatively, firms can provide information to regulators about their policy preferences (Austen-Smith 1993; Schnakenberg 2017; Ellis & Groll 2020; Perlman 2023; Brutger 2023; Schnakenberg & Turner 2024). Corporations can share information with decision-makers through industry associations, comments on draft regulations, or through personal relationships with bureaucrats (Schneider 2008; 2009; S. E. Kim et al. 2016; Lee & Stuckatz 2024). I refer to this diverse collection of activities as informational lobbying. Informational lobbying is effective when firms possess private information about the state of the world that is otherwise unavailable to the government (Austen-Smith & Wright 1992; Schnakenberg & Turner 2024; Wen 2024). In renewable energy policy-making, firms have knowledge about problems with policy implementation which the government can not easily verify. For example, firms can attest to utility incumbents intentionally delaying the issuance of solar project permits (Interview 67, 69), while the government can only observe overall delays.

International political economy scholarship often finds that the largest firms, namely foreign investors and exporters, exert the most influence over standards, trade policy, and other regulatory outcomes through both informational lobbying and campaign contributions (I. S. Kim 2017; Osgood et al. 2017; I. S. Kim & Osgood 2019; Lee 2023; Brutger 2023; Lee & Stuckatz 2024; Wen 2024). However, these findings may not generalize to renewable energy because they focus on issue areas governed by centralized decision-making authorities like the United States Congress or World Trade Organization (Madeira 2016; I. S. Kim 2017; I. S. Kim & Osgood 2019; Lee 2023; Brutger 2023; Perlman 2023; Ban, Park, & You 2023). In contrast, in issue areas governed by decentralized political structures (e.g. decision making authority is not concentrated in one branch of government), interest groups must lobby a diverse set of actors because legislators alone cannot enforce contracts (Naoi & Krauss 2009; Lee & Stuckatz 2024). I argue that because renewable energy is characterized by decentralized governance (Culpepper 2010; Stokes 2020), firms must employ a broader range of lobbying strategies across a wider set of actors.

To provide context, while legislators can pass sweeping energy laws to increase renewables, bureaucrats design regulations that govern solar investment. In Colombia, the Ministry of Energy and Mines sets the direction of policy and national plans, but multiple independent agencies implement technical standards. New laws and objectives are passed to the planning agency, Unidad de Planeación Minero Energética (UPME). UPME develops and implements energy planning, including where transmission lines will be built and selecting applications for renewable energy projects (Interview 61). Then, the Comisión de Regulación de Energía y Gas (CREG) develops specific regulations to govern plan implementation, like taxes or subsidies for power producers, which are enforced by several sub-national agencies (Interview 21, 58). In short, there are several bureaucratic actors responsible for implementing the broad objectives laid out by the executive branch, and firms' relationships with these bureaucracies shapes regulatory decisions.

I borrow from an economic sociology tradition which emphasizes firms' embeddedness in the market (Granovetter 1985) to argue that embedded firms are best able to select and implement effective lobbying strategies in renewable energy. Firms' "attempts at purposive action are...embedded in concrete, ongoing systems of social relations." (Granovetter 1985, p. 487), and I argue that embeddedness reduces a firm's cost of exercising voice.[12] Embeddedness encompasses both cultural and structural ties to a market. Cultural embeddedness refers to shared beliefs and values, while structural embeddedness to repeated patterns of economic exchange between market actors (Granovetter 1985; Zukin & Dimaggio 1990; Moran 2005; Drahokoupil & Bandelj 2009).

Cultural embeddedness includes both implicit beliefs and explicit agreements over the structure of interpersonal coordination (DiMaggio & Powell 1983; Patterson 2014; Goldberg, Srivastava, Manian, Monroe, & Potts 2016). Firms that are culturally embedded draw upon lobbying strategies – both formal and informal – that are tailored to the domestic context (Schneider 2009; Post 2014). For example, in July 2024, Colombia released a draft regulation on distributed solar generation (CREG 2024). The CEO of a medium-sized domestic solar company saw problems with the regulation that would complicate implementation, and immediately called up a friend at the Ministry of Energy and Mines to discuss revisions (Interview 67). Structural embeddedness, on the other hand, constitutes 'the connectedness of not only two parties, but the extent of interconnection among third parties or mutual contacts of dyadic partners' (Nohria & Eccles 1992). This encompasses both bilateral relationships between actors and structural hierarchies of social interaction in the market (Moran 2005). Firms can draw upon relationships from their previous market transactions, including sympathetic lawmakers and bureaucrats, to lobby for their preferred policy

[12] Embeddedness differs from Hirschman's conceptualization of "loyalty" (Hirschman 1970). While both embeddedness and loyalty stem from economic and social ties (Dowding & John 2008), loyalty is often attributed to an actor's "special attachment to an organization" (Hirschman 1970, p. 77). This shapes voice through a psychological channel (Rusbult, Zembrodt, & Gunn 1982; Dowding, John, Mergoupis, & Van Vugt 2000) whereby firms are concerned with the well being of an organization, independent of profit maximization (Barry 1974; Graham 2003; Luchak 2003; Saunders, Sheppard, Knight, & Roth 1992). I focus, instead, on a firms' calculation between the costs of exit and voice, rather than a firms' intrinsic preference for the latter.

outcomes. In sum, firms which possess structural and cultural embeddedness can exercise voice - or lobby - at a lower cost than firms without. They should also be more effective in their lobbying efforts, since they are better informed about which strategies will be effective.

The following two-by-two summarizes my theoretical framework. There are two typical cases. Foreign firms, on average, have outside options but are not embedded. This means their cost of exercising voice is high, but their cost of exit is low. On the other hand, outside options are very costly for domestic firms, but these firms are embedded. Their cost of voice is lower than exit.

	High Cost of Voice	**Low Cost of Voice**
Low Exit Costs	**Typical case:** Most foreign firms	Large domestic firms (uncommon)
High Exit Costs	NA	**Typical case:** Most domestic firms

I propose two hypotheses based on these twypical cases. The first is an observable implication of the argument that domestic firms are more likely to effectively exercise voice, while the second examines how domestic firms exercise voice.

Hypothesis 1: *Countries with a higher share of domestic investment are more likely to adopt a higher number of renewable energy policies.*

Hypothesis 2: *Domestic firms are more likely to participate in renewable energy policy-making.*

4 Methods

Here, I provide an assessment of firms' political participation in the face of regulatory roadblocks to renewable energy. I leverage a mixed methods design, using a quantitative analysis to show how domestic firms contribute to renewable energy policy adoption, and interviews to trace how firms choose between exit and voice. First, I describe my data collection project about solar project ownership. Drawing upon this data, I use ordinary least squares regression (OLS) to estimate whether a higher share of domestic investment - a proxy for embeddedness - corresponds with more renewable energy policy adoption. Then, I draw upon interview evidence from fieldwork conducted throughout 2022-2024 to show how embeddedness shapes firms' participation in renewable energy policy-making.

4.1 Original Dataset: Solar Projects and Firm Characteristics

I compile an original project-year-dataset of solar investment to identify trends in early stages of investment and longer term market growth. I use the Platt's World Electric Power Plant Database (WEPP) to identify all solar projects in low-and-middle-income countries. This is a common database used to identify firm names in the energy sector (Li, Gallagher, & Mauzerall 2020). The dependent variable in both analyses draws upon this dataset, which includes the amount of solar installed in megawatts (MW), rather than dollar amounts of investment. WEPP provides data at the firm-project-year level, but for roughly one quarter of the 4,299 projects WEPP does not identify the year of project operation. I am currently collecting missing years through online internet searches, but for projects where I am unable to identify public data via internet searches, I estimate the year of project operation through established methodology (Pfeiffer, Hepburn, Vogt-Schilb, & Caldecott 2018). I calculate missing values using the median operating year of solar projects grouped by country, size category, and ownership (domestic versus foreign), where possible, and country/size category alone when there is not sufficient heterogeneity in ownership.

While WEPP provides project size over time, it neither identifies relevant information about the investor itself nor provides public sources to verify information. Given these limitations, I match parent firms in WEPP to the Bureau Van Djik ORBIS database, which identifies firm size, country of origin, location, and revenues, among other metadata.[13] To identify matches, I first use a fuzzy matching algorithm, which matched approximately 50 percent of the 4,074 solar projects by firm name. For un-matched projects, I - and a team of undergraduate research assistants - search for firm names manually in ORBIS and validate matches with publicly available information (i.e. firm websites, industry publications, policy reports). We archive a minimum of two public sources for each investor-project. Appendix Section A.4 includes the data verification and sourcing methodology in greater detail. An important contribution of this project is a public database of firm-level solar investment. In the analyses below, I leverage these firm and project-level variables to analyze patterns of solar energy investment and regulatory reform.

4.2 Quantitative analysis: Domestic firms and renewable energy policy

I assess how the share of investment from domestic firms correlates with renewable energy policy adoption among low and middle income countries from 2000 to 2023. I conceptualize embeddedness as a firm's cultural and social ties to a market. Domestic firms are, on average, more culturally and structurally embedded in their local market. There is some variation among foreign investors in both structural[14] and cultural embeddedness.[15] Among foreign firms, those with more assets in the developing world may have structural embeddedness (Wells & Ahmed 2007; Post 2014), and those from countries in the developing world (Beazer & Blake 2018; Dreher et al. 2015;

[13] I describe my process for coding projects with multiple owners in Appendix Table A.4.

[14] Firms with more assets in the developing world are better equipped to overcome regulatory hurdles instead of resorting to legalistic mechanisms like international arbitration (Wells and Ahmed 2007; Chan and Levitt 2011). For example, in the Indonesian energy sector after the Asian Financial Crisis, firms with investments in the developing world and Indonesia itself renegotiated contracts (Wells and Ahmed 2007, p. 204), while those without cashed political risk insurance payouts, sought dispute settlement at the ICSID, and divested (Wells and Ahmed, p. 211).

[15] Firms also vary in their cultural similarity to host countries. The diversity of foreign investors has grown since the early 2000s, as more emerging economies like the BRICS invest in other developing countries (Dreher, Sturm, & Vreeland 2015; Beazer & Blake 2018; Gallagher & Qi 2021). Firms from the developing world are accustomed to navigating complex institutional contexts that may be fraught with corruption and other bureaucratic hurdles. They face lower transaction costs (Williamson 1989) of lobbying than firms from developed countries without similar political institutions (Beazer and Blake 2018).

Gallagher & Qi 2021) have cultural context. Yet, foreign firms' frame of reference will always be their country of origin (Morgan & Kristensen 2006). This places MNCs at a relative disadvantage to domestic investors in selecting and implementing lobbying tactics.

As a result, my primary specification focuses on the typical cases of "domestic" and "foreign" firms. In the specification below, my independent variable is a country's share of total solar investment from domestic firms. I include additional specifications using the number of domestic firms and the number of solar projects owned by domestic firms as alternative measures of domestic firm coalition size. However, I include robustness checks that incorporate variation in the degree of foreign firm embeddedness. I add foreign firms that hold conventional energy assets in a given country to the share of embedded investment out of total investment in Appendix Table A.3.5-A.3.7 and results are inconsistently significant.

I measure my dependent variable, renewable energy policy adoption, as the number of new renewable energy policies adopted in the following year drawing on the International Energy Agency Policy Database (2024) (IEA), Climate PoliciesC. P. Database (2023) (CPD), and Climate Laws of the World Dataset (2024) (CLW).[16] Each database has a process for classifying renewable energy policies. The IEA Policy Database includes a tag for renewable energy policies and a tag for national-level (rather than sub-national) policies. I include all policies both categorized as renewable energy and national. The Climate Policy Database includes categories for renewable energy polices and policy sector. I limit the policies included to policies about the electricity sector and renewable energy . The Climate Laws of the World dataset includes a tag for renewable energy policy, which I use to subset the data. I group this dataset by unique 'Family' ID, since they provide multiple documents for each law, and group documents into unique families for each unique law.

All three databases aim for comprehensive coverage of renewable energy policy, yet there is variation in the number of policies. As a result, I assess my hypotheses with all three databases.[17] The analysis relies on the assumption that renewable energy policy benefits the solar industry. While policies may vary in the extent to which they provide strong versus weak support, it is generally the case that policies specifically targeting renewable energy are to solar firms' benefit. These databases are widely used in other analyses of renewable energy policy adoption (Alizada 2018; Carley, Baldwin, MacLean, & Brass 2017; Carley, Davies, Spence, & Zirogiannis 2018; Baldwin, Carley, & Nicholson-Crotty 2019; Schmidt & Fleig 2018; Kersey, Blechinger, & Shirley 2021).[18]

I use ordinary-least-squares (OLS) regression model with country and year fixed effects and

[16]This means that if a country has a policy for ten years, I only count the first year of policy adoption.

[17]I provide a snapshot of discrepancies in the count of renewable energy policies in each year in Appendix Table A.3.1. However, results are robust to all three specifications of the dependent variable.

[18]Furthermore, these policies are adopted at the national level, and should therefore benefit the industry as a whole rather than specific firms. My analysis does assume that policies are non-discriminatory due to lack of data about policy design (e.g. limits on foreign ownership, local content requirements).

standard errors clustered at the country level. This allows me to capture the correlation between an increase in the share of domestic investment and an increase in renewable energy policy adoption within a country over time. I include a variety of controls for other factors that might influence renewable energy policy adoption, including Overseas Development Aid, trade, FDI, fossil fuel generation, and democracy (Jenner, Chan, Frankenberger, & Gabel 2012; Bayer & Urpelainen 2016; Baldwin, Carley, Brass, & MacLean 2017). This descriptive analysis is liable to endogeneity, particularly reverse causality. I discuss this further in Appendix Section A.3.4. Variables and sources are located in Appendix Table A.1.1.

$$\text{RE POLICIES}_{t+1} = \beta_0 + \beta_1 \cdot \text{DOMESTIC INVESTMENT SHARE}_{it} + \text{COUNTRY} + \text{YEAR FE} + \epsilon_{it}$$

Results below utilize the International Energy Agency's count of renewable energy policies. Across models, a higher share of domestic investment, a larger number of domestic firms, and a higher count of domestic-owned projects are all associated with more renewable energy policy adoption. Additional tables are available at Appendix Table A.3.2 and A.3.3 with the number of policies in the Climate Laws of the World and Climate Policy Database, and results hold consistently across different measurements of both policy adoption and domestic solar industry.

Table 1: Domestic Firms and Renewable Energy Policy Adoption

	Model 1 (Domestic Share)	Model 2 (Count of Firms)	Model 3 (Count of Projects)
(Intercept)	2.758	5.739	5.592
	(11.034)	(10.974)	(10.975)
Percent Domestic Solar	0.092*		
	(0.045)		
Number of Domestic Solar Firms		0.089**	
		(0.033)	
Number of Domestic Solar Projects			0.071*
			(0.028)
Energy Imports	0.000	0.000	0.000
	(0.007)	(0.007)	(0.007)
Democracy	0.111	0.138	0.141
	(0.151)	(0.152)	(0.152)
Development Aid	0.006	0.004	0.003
	(0.024)	(0.024)	(0.024)
Fossil Fuel Gen.	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)
FDI	−0.009	−0.010	−0.010
	(0.013)	(0.013)	(0.013)
GDP (per capita)	0.018	0.026	0.025
	(0.052)	(0.052)	(0.052)
Population	−0.249	−0.217	−0.217
	(0.165)	(0.165)	(0.165)
Land Area	0.097	−0.166	−0.154
	(0.803)	(0.798)	(0.798)
Num.Obs.	2334	2334	2334
R2	0.263	0.264	0.264
R2 Adj.	0.214	0.215	0.215
Log.Lik.	−1770.618	−1769.111	−1769.579
F	5.359	5.385	5.377
RMSE	0.52	0.52	0.52

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: The dependent variable is the count of renewable energy policies adopted in a country-year. I employ OLS with country and year fixed effects to estimate the relationship between a higher share of domestic solar investment and the number of new renewable energy policies in the next year.

4.3 Qualitative evidence: Variation in political participation

Interviews with over 100 firms and government actors illustrate how firms weigh the costs of exit and voice in the face of opposition to renewable energy.[19] I draw upon interviews because there is minimal quantitative data on lobbying activities outside of the United States and Canada (Lee & Stuckatz 2024). My interviews include firms from a cross national sample of countries, but the majority of my interviews focus on three cases: Panama, Colombia, and Malaysia. These middle income countries are a diverse set of cases (Seawright & Gerring 2008) that span the range of high foreign to high domestic investment. As of 2023, Panama is a case of high FDI (90 percent FDI),

[19]I interviewed 69 firms, 24 government officials, and 11 non-state actors.

Malaysia of high domestic investment (83 percent domestic), and Colombia lies between the two (58 percent FDI) (Author's original data). This allows me to compare the strategies of domestic and foreign firms across different types of markets. A comprehensive table of all interviews can be found in Appendix table A.2.1 and discussion of my sampling strategy in Table A.2.2.

While cases differ in their share of embedded firms, I find evidence of opposition to renewable energy from similar actors, and consistent support for my hypotheses that foreign firms with lower exit costs strategize to leave while embedded firms with lower lobbying costs mobilize more effectively. The few firms that both have outside options *and* are embedded appear to hedge their bets and pursue both strategies. In this section, I first briefly summarize the types of renewable energy obstacles that my interviewees face, before turning to the role of outside options and embeddedness in shaping firms' political participation. All interviewee names and firm names are confidential. Appendix Table A.2.1 includes a description of each firm with its size, nationality, and number of interviewees.

4.3.1 Obstacles to Renewables

Across each of my three main cases, firms cite regulatory roadblocks as a key impediment to renewables build-out. Outdated regulation on the books, designed by incumbent interests, must be revised to make space for renewable energy. The most common thread is opposition from utility providers that operate the grid, more frequently than the fossil fuel sector. Renewable energy imposes several costs on transmission and distribution companies that are only revealed when renewables begin to grow. Solar varies throughout the day and cannot simply be turned on or off, so utility providers must invest in load balancing technologies to keep supply constant with demand (Interview 17, 32, 21, 59). It also reduces consumers' reliance on transmission networks, since they can generate power on their own rooftops (Interview 35, 40, 43, 45 Panama; 50). Finally, because renewable energy depends on resource availability, utility providers must build transmission lines to new regions, and there is not a clear framework to finance these investments (Interview 15, 24, 49, 50, 59).[20] These utility incumbents are often linked to the government and wield significant influence over the design of renewable energy policies. In short, renewables demand new and costly technical changes from utility incumbents, and as a result, these actors have an incentive to delay energy transition via regulatory hurdles.

In Malaysia, government-linked utility incumbent Tenaga Nasional has slowed the pace of energy transition because it controls electricity transmission and distribution, and owns fossil fuel generation (Interview 10, 16, 50). Tenaga only allows firms to install renewable energy in fixed quotas, so firms can not install as many solar projects as they would like (Interview 9-12, 14, 16, 17, 22). As a grid operator, Tenaga also sets regulations for different parts of the permitting process, and is able to charge high fees for necessary steps such as the Power System Study, which

[20]Local government and community opposition can also play a role in impeding renewables (Interview 35, 37-38, 40, 43, 45).I explore these additional sources of opposition in my book project.

assesses the impact of small-scale solar on the distribution network (Interview 9). Tenaga has warmed to renewable energy in recent years, even foraying into some solar project holdings itself (Tenaga 2024). Yet even this crowds out other renewable energy firms, because Tenaga can use its access to information about electricity consumption and purview over the permitting process to pull clients away from competitors (Interview 16). In short, the utility incumbent and its historical influence over energy sector policies poses the strongest roadblock to Malaysian solar expansion.

One might expect that Panama and Colombia could avoid utility incumbent push-back because their grid is managed by private, and in some cases foreign, companies. However, this is not the case. In both countries, regulatory reform is essential for renewables expansion. In Panama, several interviewees indicated that the incumbent distribution company ENSA - a subsidiary of Colombian multinational Empresas Publicas Medellín - has thrown up renewable energy roadblocks similar to Tenaga. ENSA supported the two percent cap on solar generation, controls permitting processes required for grid connection, and can strengthen laws to impede renewables. For example, they delay new applications for solar projects to connect to the grid, which can take up to four months (Interview 35). ENSA also supports a tax on renewable energy firms' sales to the grid, which it justifies because renewable energy will require grid upgrades (Interview 35). Most strikingly, ENSA is also diversifying into renewables, potentially in an effort to undercut its competition via privileged information. ENSA created a subsidiary, ENSA Servicios ENSA (2024), that is technically independent but is known to use data on industrial electricity consumption to target firms which are best suited for solar (Interview 33, 35, 40, 48). This echoes Tenaga's behavior in Malaysia, and threatens renewable energy firms that are actually competing in the market.

In Colombia, transmission companies and bureaucratic processes have created hurdles for renewable energy firms. First, transmission and generation companies are pushing back against renewable energy policy. When the regulator tried to mandate that grid operators purchase a fixed amount of solar energy, these companies voiced their opposition (Interview 27). Some distributors like Enel are aggressive and do not want to lose market power, so they delay and block renewable energy permits in the hopes that small solar companies can not weather the financial stress (Interview 69).The bureaucracy is also struggling to adapt. When the planning agency opened up applications for grid permits and 800 firms applied - a big jump from the case-by-case awards of the past - bureaucrats were overwhelmed (Interview 24, 27). Many firms received contracts, but are trying to resell after facing delays (Interview 26, 27). As a result, the government *does not know* how many solar projects will be built until projects fail to reach operational milestones, and the application for new projects is closed until Spring of 2025 (Interview 24, 27). Without pressure from the renewable energy industry, it is unlikely that renewable energy permits will be granted for another year. Across all cases, renewable energy regulation is a critical barrier to investment.

4.3.2 Outside Options and Exit

Interviews in Panama and Colombia illustrate how outside options reduce investors' cost of exit.[21] Firms range in their levels of embeddedness. Most foreign firms are newcomers in the market, while a few foreign investors have longstanding historical ties to the host country. Though more uncommon, some large domestic firms also have outside options because they have already expanded their business to neighboring countries. Interviews indicate that newcomers plan for and exercise their outside options when renewable energy faces regulatory roadblocks.

First, foreign companies diversify investment destinations as a risk management strategy. A company from the United Kingdom operating in Panama maintains a database of different potential investment destinations ranked by political risk indicators from Bloomberg ClimateScope, as well as a no-go list of countries that don't meet their criteria for political stability (Interview 44). Another Venezuelan-based multinational in Panama similarly searched abroad for market opportunities before the two percent regulatory revision, and even considered a return to its home country (Interview 38). A Norwegian multinational in Colombia stressed that it is necessary to maintain these exit options, because project delays from regulatory barriers and incumbent opposition undermine their CEO's bottom line back home (Interview 57). In short, foreign companies with few existing ties to a host country prior to solar investment intentionally strategize their exit, so they can more easily move on to more profitable opportunities if obstacles in one market arise.

Most often, firms exercise their outside options by investing abroad in future periods, but under particularly harsh conditions will also divest. A large Chinese firm in Brazil reports that they plan to sell acquired assets to domestic buyers willing to remain in the market if conditions change dramatically (Interview 29). In Colombia, a Norwegian multinational is pursuing an even more drastic exit strategy. After spending seven years unsuccessfully attempting to secure transmission connection and environmental licenses, the C-suite executives in Europe decided to divest all energy holdings in Colombia, sell licenses for projects currently under development, and focus on other countries in the Latin American market (Interview 57). Their base of assets elsewhere in the region allows them to keep staff and personnel in the Bogota office, but focus on project opportunities in Panama and Guatemala. Another Italian multinational that arrived in Colombia during the 2017-2019 renewable energy auctions is also throwing up its hands and suspending projects in Colombia after hefty project delays (Interview 57, 70, 77).

Among firms with outside options, investors with some embeddedness appear more patient. A large American utility with holdings across Panamanian gas and hydropower, with some hold-

[21] In Malaysia, there are a handful of recent MNCs entrants that are by and large replicating projects from their European home countries. Foreign companies have only entered the market in recent years with the 2018 large scale solar auction rounds (Interview 16, 50). These large investors, as reported by a leading member of the Malaysian Photovoltaic Industry Association, do not participate much in policy-making, but political opposition has not yet forced their hand to exit.

ings in renewable energy, is adopting a wait-and-see approach rather than strategizing their exit. While Panama lacks the transmission capacity for more renewable energy at this moment, the American company is investing in storage and biding their time until the right laws are on the books (Interview 51). Two large domestic companies in Colombia with outside options also appear more patient in the face of administrative delays, despite concern about their challenges with transmission capacity and environmental licensing procedures (Interview 19-20, 70, 72). Yet while these companies did not signal their intent to exit the Colombian market during interviews, both have invested elsewhere in 2023 to avoid regulatory delays (BNAmericas 2023). One company has diverted renewable energy component shipments from Colombia to a new project in Peru, and the other has established paperwork for subsidiaries in renewable energy across Panama, Guatemala, and Colombia (BNAmericas 2023).[22] In short, foreign firms face lower exit costs, though firms with both low exit costs and low costs of exercising voice may be more patient.

4.3.3 Embeddedness and Voice

Interviews highlight how domestic firms have lower participation costs, so they are more likely to participate in policy-making rather leaving the market. They also provide suggestive evidence that when foreign firms do make attempts to lobby, they select ineffective strategies due to their lack of embeddedness. Across Malaysia, Panama, and Colombia, domestic firms, and even foreign firms with a history of operation in a country, are active participants in renewable energy policy-making. These firms employ a broad range of appropriate strategies to communicate their preferences to governments, including submitting comments on draft regulations (Interview 36, 56, 75, 78, 83), meeting with relevant decision-makers (Interview 36, 72, 78) and drawing on informal networks to communicate policy preferences (Interview 37, 67, 69). On the other hand, newcomer foreign firms are naive about norms in the local market, and ask decision-makers for policy exceptions that the state is either unable or unwilling to provide (Interview 43, 58, 61, 65).

In Malaysia, most solar energy firms are small domestic project owners that diversified into solar from other industrial sectors like electrical engineering, construction, and logistics (Interviews 8, 10, 14, 16). However, there are a few large domestic companies that have scaled up and even made Initial Public Offerings (IPO) (Interview 22). While these large domestic firms typically set the agenda in the Malaysian Photovoltaic Industry Association, firms of all sizes play an important role in advocating for supportive policies (Interview 16). A leading member of the MPIA stated expressly that domestic firms drive policy reform, advocating for new incentives like a virtual power purchase agreement, which allows firms to sell energy to one another (Interview 50). A government official confirmed that the local solar industry has pushed them to create market space for small firms instead of giving contracts to the utility provider (Interview 92). Foreign companies from Europe and the China are relative newcomers, and typically sit on the sidelines of policy debates (Interview 52). This is not an issue for energy policy, however, since most firms in Malaysia are

[22] Exact article citation not included to preserve interviewee confidentiality.

proactive locals.

The Colombian case provides a sharp contrast in lobbying strategy between domestic and foreign firms. Locals draw on these personal connections to improve the quality of national regulation, within the bounds of regulator's capabilities (Interview 54, 58, 59, 67, 69). For example, a prominent energy startup incubator led to several fruitful partnerships between firms and academia to study regulatory barriers for the Colombian solar market, and share findings with the government (Interview 67, 69). These local firms built credibility with policymakers through long-term engagement, and as a result, are well positioned to inform policy.

Foreign investors, on the other hand, are not able to effectively lobby. Prior to exit, foreign firms do attempt to contact the government, but are ineffective in their efforts. Three domestic energy experts stressed that newcomer foreign companies from countries like Portugal, France, and China do not understand Colombian law and expect similar regulatory frameworks to their home countries (Interview 56, 58, 59). After entering hastily-designed project agreements promising naively low project costs based on projects abroad, investors pressure the government for individual policy exceptions (Interview 58, 61). Foreign companies ask the planning agency for tax incentives, connection points, and other exceptions outside of the agencies' purview (Interview 61). These individual requests are all denied, and companies lose legitimacy in the government's eyes (Interview 57).[23] A quote from a former regulator summarizes an important case of this pattern.

> "Trina Solar [a prominent Chinese company] decided to sign a long-term contract with the intent of developing and selling projects. When [the market conditions changed], they told the government that they couldn't fulfill the contract anymore. This is ripping off the market. When these companies came to ask the government to improve conditions, but they'd violated market protocol, what did they expect to happen? Of course the government does not have confidence in these companies."

Notably, out of 20 interviewees across 15 foreign companies interviewed in Panama and Colombia, none mention hiring a lobbyist to communicate preferences to government. Instead, companies directly ask for exceptions, are denied, and decide it is less costly to leave than invest in voice (Interview 57, 58,70). This is consistent with the adage that options 'atrophy the development of the art of voice (Hirschman, 1970, p. 43).' In sum, evidence from a diverse set of markets suggests that domestic firms will effectively secure renewables policy reform, while foreign firms without local context face high barriers to political participation.

[23] Instead, companies are told to send an email to the designated complaints line because bureaucrats do not have time to meet with each complainant (Interview 61).

5 Conclusion

This paper finds that foreign investment, despite driving quick short-term growth, is insufficient to motivate long-term energy transition in middle income countries due to the political incentives of foreign investors. Countries with a higher share of FDI generate a larger percentage of energy from solar in the short run, in part because foreign firms build relatively large projects in comparison to inexperienced domestic firms. Yet these foreign firms sit on the sidelines when incumbent actors resist updating renewable energy regulation, while domestic firms lobby for policy amendments. This gap between short-term renewable energy build out and long term political coalitions is critical for developing countries seeking to simultaneously decarbonize and pursue development.

This paper makes several contributions to both existing scholarship and to inform policymaking for the energy transition. First, this paper furthers our understanding of firm-level political participation in sectors with decentralized governance. While existing work focused on firm level lobbying of centralized decision-making authorities finds that large, dominant firms are most influential, their political power may not carry over into sectors where lobbying requires deep knowledge of complex domestic political institutions. My paper provides an alternative mechanism, firm embeddedness, to explain lobbying outcomes when decision making is decentralized. The case of renewable energy reveals opportunities for small, domestic firms to shape policy outcomes through their intimate knowledge of energy sector bureaucrats and institutions.

This project also contributes an open source dataset of solar project ownership for all low and middle income countries with the exception of China and India. Existing repositories of solar projects offer a snapshot of investment location, date and size, but fall short of revealing information about ownership. Firm level data offers a better understand of why some countries are more likely to quickly scale up solar energy generation via large foreign projects, while in other otherwise similar countries, generation is clustered in urban areas and takes longer grow. This data will be published in Spring 2025 in collaboration with Global Energy Monitor's Global Solar Power Tracker.

Finally, this paper can inform policy solutions to mitigate the trade-off between fast-paced and long-term energy transition. Policies to promote collaboration and dialogue between domestic and foreign firms could reduce barriers to information sharing and increase the rate of local learning. Moreover, the need for collaborative policy is increasingly urgent, as transmission bottlenecks slow down global renewable energy growth (Catsaros 2024). This type of policy would both increase the pace of solar energy investment and build stronger pro-renewable energy political coalitions for a sustainable energy transition.

A Appendix

Contents

A.1 Analysis 1: FDI and Scale Up

I assess whether foreign ownership leads to fast-paced solar build-out in the short term. I use my dataset of solar projects to estimate how the share of domestic versus foreign investment in a country shapes the pace of solar build-out. My main independent variable is the proportion of foreign solar investment, lagged by a year. I use a cross sectional survival model, or a logistic regression where countries drop out of the dataset after the first year that foreign energy comprises comprise least two percent of total energy generation, the average amount of solar generation for 2022. All specifications include year fixed effects with standard errors clustered at the country level. [24]

$$\text{TIME TO SOLAR GENERATION } \%_{it} = \beta_0 + \beta_1 \cdot \text{SOLAR FDI } \%_{it} + \text{YEAR} + \epsilon_{it}$$

[24] I control for energy imports (EMBER 2023), energy sector competition (World Electric Power Plant Database 2023), Industrial Complexity (Hausmann & Hidalgo 2010), and democracy (VDEM 2022), foreign direct investment inflows, trade, corruption, gross domestic product, population, land area (**?**), renewable energy subsidization (C. P. Database 2023), and political constraints (PolCon 2021).

The table below provides summary statistics for the key variables used through this and the remaining analyses in the paper, before discussing regression results.

A.1.1 Summary Statistics

Solar Energy Share (% Generation) (Ember Climate)	2699	0.56	0	26
Count Renewable Energy Policies (IEA)	2928	0.2	0	8
Count Renewable Energy Policies (CPD)	2928	0.11	0	6
Count Renewable Energy Policies (CLW)	2928	0.24	0	5
Percentage Foreign Investment	2928	0.21	0	1
Percentage Domestic Investment	2928	0.21	0	1
Number of Domestic Projects	2928	0.61	0	73
Number of Domestic Firms	2928	0.41	0	45
Number of Embedded Projects	2928	0.77	0	101
Number of Embedded Firms	2928	0.49	0	53
Democracy (VDEM)	2673	0.44	0.067	0.92
Energy Imports (Ember Climate)	2707	-0.027	-48	43
Domestic Energy Competition (WEPP)	2720	0.4	0.00000076	1
Domestic Core Competency (OEC)	1909	-0.44	-2.8	1.4
Property Rights (VDEM)	2673	0.67	0.006	0.95
Foreign Direct Investment (net, log) (WDI)	2661	20	10	25
Trade (net) (WDI)	2562	76	2.2	348
Corruption (WDI)	2674	-0.63	-1.9	1.6
GDP per capita (log) (WDI)	2868	7.6	4.7	9.9
Population (WDI)	2928	16	12	19
Land Area (sq. km) (WDI)	2660	12	5.7	17
Overseas Development Assistance (WDI)	2684	3.6	-2.5	6.6
Political Constraints (PolCon)	2351	0.2	0	0.72

A.1.2 Regression Table: FDI Share and Solar Scale Up

The regression table below shows effect sizes for the time to two percent of solar. The relationship between the share of foreign investment and time to two percent energy generation from solar is both positive and significant.

Table A.1.2: FDI Share and Solar Scale Up (Two percent)

	Model 1 (VDem)	Model 2 (VDem)	Model 3 (PolCon)	Model 4 (PolCon)
(Intercept)	−21.568	−22.422	−18.808	−22.027
	(2965.095)	(2808.090)	(3045.938)	(2816.967)
Percent Foreign Solar	0.953*	1.273**	1.180*	1.429**
	(0.476)	(0.457)	(0.539)	(0.534)
Energy Imports	0.014	0.015	0.011	0.016
	(0.038)	(0.038)	(0.043)	(0.044)
Democracy	0.992	0.038		
	(1.107)	(1.068)		
Fossil Fuel Gen.	0.003	0.003	0.003	0.004
	(0.003)	(0.003)	(0.003)	(0.003)
Trade	0.003	0.004	0.002	0.006
	(0.006)	(0.005)	(0.006)	(0.006)
GDP (per capita)	−0.486	−0.293	−0.541	−0.476+
	(0.307)	(0.231)	(0.340)	(0.261)
FDI	0.343		0.329	
	(0.225)		(0.257)	
Total_policies	0.018		0.055	
	(0.049)		(0.051)	
Land Area	−0.296+	−0.227	−0.206	−0.156
	(0.174)	(0.172)	(0.197)	(0.200)
Population	−0.035	0.335	−0.207	0.330
	(0.296)	(0.207)	(0.341)	(0.236)
Corruption		0.958*		1.377**
		(0.401)		(0.431)
Political Constraints			0.194	0.098
			(0.999)	(0.964)
Num.Obs.	2093	2143	1914	1946
AIC	319.1	321.4	269.7	260.0
BIC	499.8	491.5	447.5	427.2
Log.Lik.	−127.573	−130.707	−102.847	−99.979
F	0.789	0.972	0.663	0.922
RMSE	0.12	0.12	0.11	0.11

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: The dependent variable is a binary indicator taking the value of 1 when a country has over two percent solar in the energy mix. I employ longitudinal survival analysis to assess the predictors of a faster time-to-two percent solar generation.

Longitudinal survival analysis is vulnerable to certain threats to inference which can bias estimates, namely right and left censoring of the data.[25] First, right censoring occurs when the event of interest has not yet been observed. Though the model is designed to account for this information, since right-censored observation take the longest amount of time possible to reach the event, there is uncertainty about when the event will occur in the future. While this is an issue

[25] I need not worry about the typical assumption of proportional hazards because I am using longitudinal survival analysis with a design accounting for time varying covariates. Other threats to inference typically stem from selection bias - common in medical studies where survival analysis is most common - and lack of observation of an event (e.g. a heart attack). However, this analysis does not suffer from these common issues since it includes the entire population of low-and-middle income countries, and the event in question is measured with reliable data.

here, with only 46 of 132 countries reaching two percent solar generation, it is a frequent issue in survival analyses more broadly. A common resolution is sensitivity analysis to observe if results change with more or less right censoring. I replicate the analysis with two different thresholds, one (62 countries at threshold) and three percent (39 countries at threshold), to assess sensitivity to right censoring in Appendix Tables A.1.2 and A.1.3, and achieve similar results. Left censoring arises when the event of interest, in this case renewable energy policy adoption, occurs before the beginning of the observational period, which is the year 2000 in this study. However, very few countries adopt renewable energy policies prior to 2000 across each dataset. The Climate Policies database reports 11 out of 341 policies, the Climate Laws of the World Database indicates 27 of 772 policies, and the IEA policies database includes 52 of 578 policies adopted prior to 2000. As a result, left censoring of the data is minimal.

A.1.3 Foreign Investment Share and Pace of Solar Deployment, One Percent

Table A.1.3: FDI Share and Solar Scale Up (One Percent)

	Model 1 (VDem)	Model 2 (VDem)	Model 3 (PolCon)	Model 4 (PolCon)
(Intercept)	−21.321	−21.244	−18.589	−20.416
	(2989.437)	(2800.826)	(3063.749)	(2853.523)
Percent Foreign Solar	0.822*	1.141**	1.043*	1.246**
	(0.382)	(0.366)	(0.411)	(0.399)
Energy Imports	0.024	0.025	0.029	0.027
	(0.027)	(0.028)	(0.028)	(0.029)
Democracy	1.107	−0.154		
	(0.874)	(0.839)		
Fossil Fuel Gen.	−0.001	0.001	−0.002	0.000
	(0.002)	(0.002)	(0.003)	(0.003)
Trade	0.003	0.002	0.002	0.002
	(0.004)	(0.004)	(0.005)	(0.004)
GDP (per capita)	−0.198	−0.212	−0.182	−0.244
	(0.245)	(0.189)	(0.263)	(0.203)
FDI	0.132		0.102	
	(0.161)		(0.167)	
Total Policies	0.008		0.040	
	(0.042)		(0.045)	
Land Area	−0.219	−0.141	−0.196	−0.137
	(0.144)	(0.142)	(0.159)	(0.156)
Population	0.036	0.193	−0.080	0.151
	(0.234)	(0.165)	(0.258)	(0.181)
Corruption		1.100***		1.037***
		(0.302)		(0.310)
Political Constraints			0.023	−0.233
			(0.763)	(0.747)
Num.Obs.	2023	2070	1859	1889
AIC	423.2	429.3	370.9	370.3
BIC	602.8	598.4	547.8	536.7
Log.Lik.	−179.618	−184.655	−153.468	−155.169
F	1.138	1.600	1.010	1.445
RMSE	0.15	0.15	0.14	0.15

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: The dependent variable is the percent of foreign solar in the energy mix. The models use longitudinal data to analyze the factors influencing the share of foreign solar energy in a country's total solar generation.

A.1.4 Foreign Investment Share and Pace of Solar Deployment, Three percent

Table A.1.4: FDI Share and Solar Scale Up (Three Percent)

	Model 1 (VDem)	Model 2 (VDem)	Model 3 (PolCon)	Model 4 (PolCon)
(Intercept)	−26.919	−24.802	−27.925	−24.230
	(2954.177)	(2815.562)	(4983.799)	(4679.705)
Percent Foreign Solar	0.995*	1.189*	1.251*	1.360*
	(0.502)	(0.481)	(0.583)	(0.572)
Energy Imports	−0.027	−0.035	−0.028	−0.050
	(0.033)	(0.033)	(0.034)	(0.035)
Democracy	1.908	1.021		
	(1.202)	(1.180)		
Fossil Fuel Gen.	−0.001	−0.001	−0.001	−0.001
	(0.003)	(0.003)	(0.004)	(0.004)
Trade	0.013*	0.010*	0.009	0.007
	(0.005)	(0.005)	(0.007)	(0.007)
GDP (per capita)	0.013	−0.138	0.296	−0.150
	(0.319)	(0.232)	(0.376)	(0.269)
FDI	−0.104		−0.169	
	(0.196)		(0.207)	
Total Policies	−0.030		−0.112	
	(0.062)		(0.108)	
Land Area	−0.186	−0.167	−0.149	−0.167
	(0.186)	(0.183)	(0.224)	(0.229)
Population	0.477	0.323	0.468	0.283
	(0.314)	(0.218)	(0.377)	(0.279)
Corruption		0.439		0.980*
		(0.404)		(0.426)
Political Constraints			1.200	1.148
			(1.052)	(1.060)
Num.Obs.	2133	2186	1944	1978
AIC	294.5	305.0	238.0	236.7
BIC	475.8	475.7	416.3	404.4
Log.Lik.	−115.234	−122.487	−86.999	−88.344
F	0.546	0.673	0.433	0.656
RMSE	0.11	0.12	0.10	0.10

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: The dependent variable is a binary indicator taking the value of 1 when a country has over three percent solar in the energy mix. I employ longitudinal survival analysis to assess the predictors of a faster time-to-three percent solar generation.

A.2 Analysis 2: Interviews and Political Participation

A.2.1 List of Interviews

The following table summarizes my interviews with actors in the energy sector. I provide interview number, date, country of origin, country of operation, and a brief description of the interviewee(s). The names of individuals are all confidential. I preserve the anonymity of firms, but mention government agencies by name as they appear in my study.

Table A.2: Interview Metadata

No.	Date	Company HQ	Country	Organization Type
1	10-Aug-22	Pakistan	Pakistan	Industry
2	30-Sep-22	Turkey	Turkey	Industry
3	14-Oct-22	Panama	Panama	Industry
4	13-Oct-22	China	Bangladesh	Industry
5	8-Oct-22	USA, Europe	Colombia	Industry
6	12-Nov-22	USA	Malaysia	Industry
7	20-Nov-22	Colombia	Colombia	Industry
8	15-May-23	Malaysia	Malaysia	Industry
9	16-May-23	Malaysia	Malaysia	Industry
10	30-May-23	Singapore	Malaysia	Industry
11	31-May-23	Malaysia	Malaysia	Industry
12	31-May-23	Malaysia	Malaysia	Industry
13	6-Jun-23	Malaysia	Malaysia	Industry
14	7-Jun-23	Malaysia	Malaysia	Industry
15	21-Jun-23	Malaysia	Malaysia	Industry
16	26-Jun-23	Malaysia	Malaysia	Industry
17	26-Jun-23	Malaysia	Malaysia	Industry
18	3-Jul-23	Malaysia	Malaysia	Industry
19	4-Jul-23	Colombia	Colombia	Industry
20	4-Jul-23	Colombia	Colombia	Industry
21	6-Jul-23	Colombia	Colombia	Government
22	7-Jul-23	Malaysia	Malaysia	Industry
23	10-Jul-23	Colombia	Colombia	Industry
24	11-Jul-23	Colombia	Colombia	Association
25	12-Jul-23	Colombia	Colombia	Government
26	12-Jul-23	Spain	Colombia	Industry
27	12-Jul-23	USA, Europe	Colombia	Industry
28	17-Jul-23	Colombia	Colombia	Government
29	18-Jul-23	Colombia	Colombia	Association
30	1-Aug-23	Brazil	Brazil	Association
31	1-Aug-23	Brazil	Brazil	Industry
32	1-Aug-23	Brazil	Brazil	Government
33	10-Oct-23	Norway	Brazil	Industry
34	5-Jan-24	Panama	Panama	Government
35	5-Jan-24	USA, Europe	Panama	Industry

36	8-Jan-24	Panama	Panama	Association
37	8-Jan-24	Panama	Panama	Association
38	8-Jan-24	Venezuela	Panama	Industry
39	9-Jan-24	Panama	Panama	Industry
40	10-Jan-24	Panama	Panama	Industry
41	11-Jan-24	Panama	Panama	Industry
42	12-Jan-24	Panama	Panama	Industry
43	15-Jan-24	USA, Europe	Panama	Industry
44	16-Jan-24	Spain	Panama	Industry
45	17-Jan-24	Panama	Panama	Industry
46	17-Jan-24	United Kingdom	Panama	Industry
47	18-Jan-24	Panama	Panama	Industry
48	18-Jan-24	Spain	Panama	Industry
49	19-Jan-24	Panama	Panama	Government
50	19-Jan-24	Panama	Panama	Industry
51	19-Jan-24	Panama	Panama	Industry
52	1-Feb-24	Malaysia	Malaysia	Association
53	21-May-24	USA	Panama	Industry
54	22-May-24	Colombia	Colombia	Industry
55	29-May-24	Italy	Colombia	Industry
56	4-Jun-24	Colombia	Colombia	Industry
57	6-Jun-24	Norway	Colombia	Industry
58	12-Jun-24	Colombia	Colombia	Industry
59	14-Jun-24	Colombia	Colombia	Industry
60	14-Jun-24	Spain	Colombia	Industry
61	14-Jun-24	Colombia	Colombia	Government
62	19-Jun-24	Colombia	Colombia	Community Member
63	19-Jun-24	Colombia	Colombia	Community Member
64	20-Jun-24	United States	Colombia	Industry
65	21-Jun-24	Colombia	Colombia	Association
66	21-Jun-24	Colombia	Colombia	Government
67	23-Jun-24	Colombia	Colombia	Industry
68	24-Jun-24	Colombia	Colombia	Community Member
69	24-Jun-24	Colombia	Colombia	Industry
70	25-Jun-24	Colombia	Colombia	Industry
71	25-Jun-24	Colombia	Colombia	Government

72	26-Jun-24	Colombia	Colombia	Industry
73	27-Jun-24	Colombia	Colombia	Industry
74	27-Jun-24	Colombia	Colombia	Industry
75	28-Jun-24	Spain	Colombia	Industry
76	28-Jun-24	Colombia	Colombia	Industry
77	28-Jun-24	Colombia	Colombia	Government
78	3-Jul-24	Colombia	Colombia	Association
79	3-Jul-24	United States	Colombia	Industry
80	3-Jul-24	Colombia	Colombia	Industry
81	4-Jul-24	Colombia	Colombia	Government
82	5-Jul-24	Colombia	Colombia	Government
83	5-Jul-24	Colombia	Colombia	Government
84	8-Jul-24	Colombia	Colombia	Government
85	8-Jul-24	Spain	Colombia	Industry
86	19-Jul-24	Malaysia	Vietnam	Industry
87	22-Jul-24	Malaysia	Malaysia	Government
88	23-Jul-24	Malaysia	Malaysia	Industry
89	24-Jul-24	Malaysia	Malaysia	Government
90	29-Jul-24	Malaysia	Malaysia	Government
91	29-Jul-24	China	Malaysia	Government
92	29-Jul-24	Malaysia	Malaysia	Government
93	30-Jul-24	Malaysia	Malaysia	Industry
94	30-Jul-24	Malaysia	Malaysia	Industry
95	31-Jul-24	Malaysia	Malaysia	Industry
96	31-Jul-24	Malaysia	Malaysia	Government
97	1-Aug-24	Malaysia	Malaysia	Government
98	1-Aug-24	Malaysia	Malaysia	Government
99	2-Aug-24	Malaysia	Malaysia	Government
100	2-Aug-24	Malaysia	Malaysia	Government
101	12-Aug-24	Colombia	Colombia	Industry
102	16-Aug-24	Colombia	Colombia	Industry
103	27-Aug-24	Netherlands	Colombia	Industry

A.2.2 Interview Methodology

This study has been approved by the UC Berkeley Institutional Review Board, protocol 2022-08-15553. The population of this study is employees of renewable energy firms in solar panel installation, engineering and procurement, and operations and management, as well as government officials in the energy ministry, infrastructure ministry, ministry of the interior, ministry of the economy, or other specific ministries related to renewable energy and environmental licensing, as well as non-governmental organizations working on energy and the environment. Renewable energy firms are contacted via publicly available information on solar firm investors online and in the World Resource Institute's Global Power Plant Database, and government employees and non-state actors are identified through information available online.

My recruitment strategy includes both these cold emails and snowball sampling. I asked interviewees if they have any recommendations for helpful contacts, and their contact information. I asked my interviewees to let their contacts know I will reach out over email or WhatsApp, or if they wish, contact me first. This was necessary because potential interviewees were busy, especially firms and government, and did not have time to reach out to me first. I interviewed people in each country until interviewees were putting me in touch with the same people I had already met.

The table below shows the breakdown of interviewees by country and interviewee type. Interview balance, to a large extent, reflects governance across cases. In Malaysia my sample skews heavily towards government, in line with the state's larger role in energy sector management, while in Panama, my sample is almost entirely industry, reflective of the state's comparatively hands-off role. The Panamanian regulatory agency ASEP is also extremely reclusive and does not typically meet with even the solar industry association, hence the few interviews with government.

Table A.2.1 Agency Type by Country

Country	Association	Government	Industry	Total
Panama	2	2	16	20
Malaysia	1	10	17	28
Colombia	4	11	30	45
Other	1	1	6	8

I used semi-structured interviews, which allow for flexibility in questions based on firms' experiences. Rigid interview protocol would have prevented me from probing unanticipated breakdowns in the regulatory framework of my cases. Furthermore, interviewees varied in the extent to which they are familiar with different aspects of regulatory reform, since project size determines the relevant set of government agencies for certain issues like environmental licensing. All interviews were not recorded, and I took handwritten notes. This aided with building trust and rapport with interviewees. I provide a template for my interviews with firms below:

> **Research Description:** This project explores the determinants of success for solar in emerging economies. One component focuses on domestic/foreign firms, like [COMPANY NAME], that started with smaller projects and eventually scaled up opera-

tions/invest in new markets abroad. The goal is to understand what factors incentivized companies to enter the solar market and helped sustain growth over time.

Data usage: This interview will be used as background information to inform my quantitative analysis. The interview will not be recorded; the researcher will only take written notes. With your consent, the researcher may use anonymized short direct quotes or paraphrased information in written project deliverables (i.e. policy reports, academic publications). If so, quotes will be presented in an anonymized manner that omits company name, interviewee name/title, and geographic location of any solar projects in question. Only the company's business activities will be listed (i.e. "QUOTE" – Employee, Solar installation company)

1. What motivated your company to develop its first solar project?

2. After the first project, what empowered your company to grow its solar energy business, either economically or politically? Relatedly, what were some early indicators of success?

3. What factors led to your company to expand to the international market? [If applicable/firm is multinational]

4. If, and how, were your other business initiatives complementary to solar? [If applicable, i.e. solar firm is part of a business conglomerate]

5. Overall, did domestic political conditions shape the company's development, either positively or negatively?

6. Were international partners helpful in developing expertise, acquiring materials, or other elements of expanding your renewable energy business?

7. Overall, please identify the three largest challenges your company has faced in solar installation.

8. Where does your company see itself expanding (vis a vis renewable energy) in the future?

I analyze my interviews through process tracing (Collier 2011), which allows me to identify common themes across my diverse set of cases. I am able to trace both the origins of renewable energy roadblocks and firm responses. This is crucial, because if renewable energy regulatory roadblocks were very different across my three cases, it would be challenging to compare outcomes of firm lobbying and exit. However, process tracing confirms that the causes of roadblocks often lie in utility incumbents, and provides consistent evidence that coalitions of domestic firms are key to overcoming these regulatory obstacles.

A.3 Analysis 3: Embeddedness and Policy Adoption

A.3.1 Renewable Energy Policy Measurement Discrepancies

The figure below shows the count of renewable energy policies recorded in each year by the three different databases in my analysis: the Climate Policy Database (CPD), the Climate Laws of the World Database (CLW), and International Energy Policy Database (IEA). While IEA and CPD record similar counts of policy adoption, CLW often records a larger count of policies, most prominently after 2012 and onwards. However, the trends in policy adoption increase and decline follow largely the same pattern.

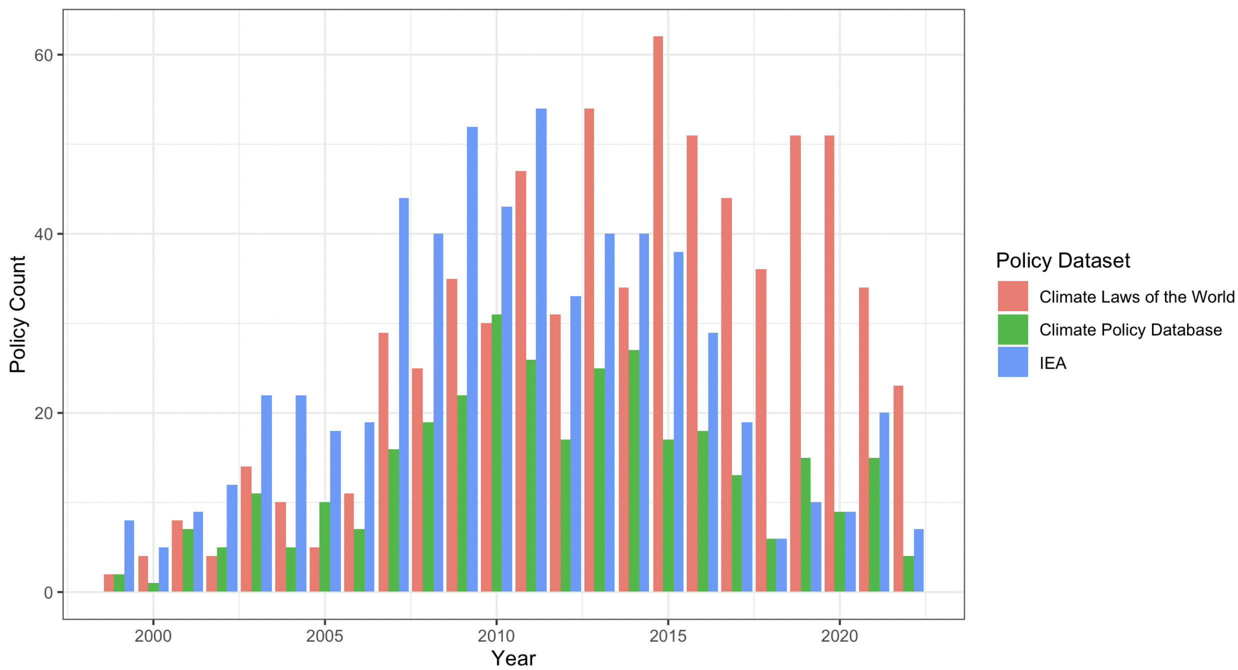

Figure A.3: Policy Adoption Measurement Discrepancies. The x-axis includes year of policy adoption. The y-axis shows the total annual count of policies as recorded by the Climate Policies Database, Climate Laws of the World, and International Energy Agency Policy Database.

A.3.2 Domestic Firms and Policy Adoption, Climate Laws of the World

The regression table below replicated the analysis in Table 1, using the Climate Laws of the World Database as an alternative specification of policy count.

Table A.3.2: Domestic Firms and Policy Adoption, Climate Laws of the World

	Model 1 (Domestic Share)	Model 2 (Count of Firms)	Model 3 (Count of Projects)
(Intercept)	−2.239	1.786	1.648
	(11.109)	(11.005)	(10.997)
Percent Domestic Solar	0.109*		
	(0.045)		
Number of Domestic Solar Firms		0.169***	
		(0.033)	
Number of Domestic Solar Projects			0.153***
			(0.028)
Energy Imports	0.000	−0.001	−0.002
	(0.007)	(0.007)	(0.007)
Democracy	−0.218	−0.154	−0.136
	(0.152)	(0.152)	(0.152)
Development Aid	−0.004	−0.006	−0.007
	(0.024)	(0.024)	(0.024)
Fossil Fuel Gen.	−0.001	−0.001	−0.001
	(0.001)	(0.001)	(0.001)
FDI	0.003	0.002	0.003
	(0.014)	(0.013)	(0.013)
GDP (per capita)	−0.017	−0.005	−0.006
	(0.052)	(0.052)	(0.052)
Population	−0.460**	−0.403*	−0.397*
	(0.166)	(0.166)	(0.166)
Land Area	0.764	0.391	0.394
	(0.808)	(0.801)	(0.800)
Num.Obs.	2334	2334	2334
R2	0.192	0.199	0.200
R2 Adj.	0.138	0.146	0.147
Log.Lik.	−1786.967	−1776.037	−1774.568
F	3.555	3.730	3.753
RMSE	0.52	0.52	0.52

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: The dependent variable is the count of renewable energy policies adopted in a country-year. I employ OLS with country and year fixed effects to estimate the relationship between a higher share of domestic solar investment and the number of new renewable energy policies in the next year.

A.3.3 Domestic Firms and Policy Adoption, Climate Policy Database

The regression table below replicated the analysis in Table 1, using the Climate Policy Database as an alternative specification of policy count.

Table A.3.3: Domestic Firms and Policy Adoption, Climate Policy Database

	Model 1 (Domestic Share)	Model 2 (Count of Firms)	Model 3 (Count of Projects)
(Intercept)	−3.603	−1.317	−1.327
	(7.362)	(7.335)	(7.333)
Percent Domestic Solar	0.081**		
	(0.030)		
Number of Domestic Solar Firms		0.036+	
		(0.022)	
Number of Domestic Solar Projects			0.036+
			(0.019)
Energy Imports	0.008+	0.008+	0.008+
	(0.004)	(0.004)	(0.004)
Democracy	0.014	0.018	0.024
	(0.101)	(0.101)	(0.101)
Development Aid	0.002	−0.001	−0.001
	(0.016)	(0.016)	(0.016)
Fossil Fuel Gen.	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
FDI	0.000	−0.002	−0.002
	(0.009)	(0.009)	(0.009)
GDP (per capita)	0.006	0.011	0.011
	(0.034)	(0.034)	(0.034)
Population	−0.137	−0.120	−0.118
	(0.110)	(0.110)	(0.110)
Land Area	0.433	0.243	0.241
	(0.536)	(0.534)	(0.533)
Num.Obs.	2334	2334	2334
R2	0.290	0.289	0.289
R2 Adj.	0.243	0.241	0.242
Log.Lik.	−826.214	−828.713	−828.280
F	6.129	6.084	6.091
RMSE	0.34	0.35	0.35

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: The dependent variable is the count of renewable energy policies adopted in a country-year from the Climate Policy Database. I employ OLS with country and year fixed effects to estimate the relationship between a higher share of domestic solar investment (number of firms, number of projects) and the number of new renewable energy policies in the next year.

A.3.4 Reverse Causality: Policy and Domestic Investment Share

In order to address endogeneity, I attempt to include theoretically relevant covariates and use the three leading climate policy databases to reduce omitted variable bias and measurement error in the dependent variable. However, it is important to establish whether prior climate policy adoption corresponds with a higher share of domestic investment. The tables below provide results from a regression of climate policy adoption across the three specifications across each measure of domestic solar investment.

The results do not consistently point towards a reverse causality issue. By one measure, the Climate Laws of the World Database, renewable energy policy adoption is a significant predictor of higher domestic investment share. However, this measure over counts climate policies relative to other databases. By the other two measures of renewable energy policy, reverse causality is not an issue. In fact, per two specifications of domestic investment, using IEA policy data, policy adoption appears negatively correlated with domestic firms.

Table A.3.4: Reverse Causality Test (IEA)

	Model 1 (Percent Domestic)	Model 2 (No. Domestic Firms)	Model 3 (No. Domestic Projects)
(Intercept)	29.174***	−10.563	−11.536
	(5.131)	(6.822)	(8.044)
IEA Policy	0.009	−0.041**	−0.044**
	(0.010)	(0.013)	(0.015)
Energy Imports	0.003	0.004	0.009+
	(0.003)	(0.004)	(0.005)
Democracy	−0.204**		
	(0.070)		
FDI	−0.020**	−0.008	−0.010
	(0.006)	(0.008)	(0.010)
Fossil Fuel Gen.	0.000	−0.001+	−0.001+
	(0.000)	(0.000)	(0.000)
Development Aid	−0.047***	−0.024+	−0.030+
	(0.011)	(0.014)	(0.017)
GDP (per capita)	0.034	−0.073*	−0.080*
	(0.024)	(0.031)	(0.037)
Population	−0.017	−0.246*	−0.304**
	(0.077)	(0.098)	(0.116)
Land Area	−2.105***	1.147*	1.297*
	(0.373)	(0.497)	(0.586)
Num.Obs.	2334	2473	2473
R2	0.532	0.384	0.382
R2 Adj.	0.500	0.344	0.342
AIC	286.2		
BIC	1138.0		
Log.Lik.	4.889	−710.762	−1118.350
F	17.009	9.511	9.440
RMSE	0.24	0.32	0.38

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Note: The dependent variable is the percentage of solar investment from domestic firms in megawatts, the number of domestic solar firms, and the number of projects owned by domestic solar firms. I employ OLS with country and year fixed effects to estimate the relationship between the number of new renewable energy policies in the next year and a higher share of domestic solar investments.

A.3.5 Reverse Causality, CPD Data

This analysis uses the Climate Policy Database as the independent variable, with domestic firm market share, firm count, and project count as the dependent variables.

Table A.3.5: Reverse Causality Test (CPD)

	Model 1 (Percent Domestic)	Model 2 (No. Domestic Firms)	Model 3 (No. Domestic Projects)
Climate Policy Database	0.0245+	0.0138	0.0125
	(0.0143)	(0.019)	(0.023)
Energy Imports	0.003	0.005	0.009+
	(0.003)	(0.004)	(0.005)
Democracy	−0.203**		
	(0.070)		
FDI	−0.019**	−0.009	−0.010
	(0.006)	(0.008)	(0.010)
Fossil Fuel Gen.	0.000	−0.001+	−0.001+
	(0.000)	(0.000)	(0.000)
Development Aid	−0.046***	−0.025+	−0.031+
	(0.011)	(0.014)	(0.017)
GDP (per capita)	0.033	−0.074*	−0.081*
	(0.024)	(0.031)	(0.037)
Population	−0.017	−0.242*	−0.299*
	(0.077)	(0.099)	(0.116)
Land Area	−2.108***	1.164*	1.315*
	(0.373)	(0.498)	(0.587)
(Intercept)	29.191***	−10.846	−11.842
	(5.128)	(6.836)	(8.058)
Num.Obs.	2334	2473	2473
R2	0.532	0.381	0.380
R2 Adj.	0.501	0.341	0.339
AIC	284.1		
BIC	1135.9		
Log.Lik.	5.959	−715.983	−1122.706
F	17.038	9.406	9.353
RMSE	0.24	0.32	0.38

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Note: The dependent variable is the percentage of solar investment from domestic firms in megawatts, the number of domestic solar firms, and the number of projects owned by domestic solar firms. I employ OLS with country and year fixed effects to estimate the relationship between the number of new renewable energy policies in the next year and a higher share of domestic solar investments.

A.3.6 Reverse Causality, CLW Data

This analysis uses the Climate Laws of the World Database as the independent variable, with domestic firm market share, firm count, and project count as the dependent variables.

Table A.3.6: Reverse Causality Test (CLW)

	Model 1 (Percent Domestic)	Model 2 (No. Domestic Firms)	Model 3 (No. Domestic Projects)
(Intercept)	28.933***	−11.435+	−12.511
	(5.118)	(6.794)	(8.011)
CLW Policy	0.034***	0.069***	0.079***
	(0.010)	(0.013)	(0.015)
Energy Imports	0.004	0.005	0.009+
	(0.003)	(0.004)	(0.005)
Democracy	−0.199**		
	(0.070)		
FDI	−0.019**	−0.008	−0.009
	(0.006)	(0.008)	(0.010)
Fossil Fuel Gen.	0.000	−0.001+	−0.001+
	(0.000)	(0.000)	(0.000)
Development Aid	−0.047***	−0.025+	−0.030+
	(0.011)	(0.014)	(0.017)
GDP (per capita)	0.033	−0.075*	−0.083*
	(0.024)	(0.031)	(0.037)
Population	−0.004	−0.218*	−0.271*
	(0.077)	(0.098)	(0.116)
Land Area	−2.105***	1.176*	1.328*
	(0.372)	(0.495)	(0.583)
Num.Obs.	2334	2473	2473
R2	0.534	0.389	0.387
R2 Adj.	0.503	0.349	0.347
AIC	274.0		
BIC	1125.8		
Log.Lik.	11.001	−700.802	−1108.219
F	17.177	9.711	9.643
RMSE	0.24	0.32	0.38

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Note: The dependent variable is the percentage of solar investment from domestic firms in megawatts, the number of domestic solar firms, and the number of projects owned by domestic solar firms. I employ OLS with country and year fixed effects to estimate the relationship between the number of new renewable energy policies in the next year and a higher share of domestic solar investments.

A.3.7 Embeddedness and Policy Adoption, IEA Data

Here, I replicate the analysis in Table 1 and Appendix Tables A.3.2-A.3.3 but operationalize embeddedness as any firm that is domestic or has built an energy project in the country prior to renewables investment. These results are much weaker, suggesting that foreign firms are on average at a disadvantage relative to domestic firms.

Table A.3.7: Embedded Investment and Policy Adoption, IEA

	Model 1 (Domestic Share)	Model 2 (Count of Firms)	Model 3 (Count of Projects)
(Intercept)	3.895	5.614	5.486
	(11.029)	(10.980)	(10.981)
Percent Embedded Firms	0.049		
	(0.042)		
Energy Imports	0.001	0.000	0.000
	(0.007)	(0.007)	(0.007)
Democracy	0.103	0.135	0.134
	(0.151)	(0.152)	(0.152)
Development Aid	0.005	0.003	0.003
	(0.024)	(0.024)	(0.024)
Fossil Fuel Gen.	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)
FDI	−0.010	−0.010	−0.010
	(0.013)	(0.013)	(0.013)
GDP (per capita)	0.021	0.026	0.025
	(0.052)	(0.052)	(0.052)
Population	−0.238	−0.219	−0.220
	(0.165)	(0.165)	(0.165)
Land Area	0.000	−0.154	−0.142
	(0.802)	(0.799)	(0.799)
Number of Embedded Solar Firms		0.069*	
		(0.031)	
Number of Embedded Solar Projects			0.051*
			(0.026)
Num.Obs.	2334	2334	2334
R2	0.262	0.264	0.263
R2 Adj.	0.213	0.215	0.214
AIC	3840.4	3836.6	3837.7
BIC	4692.2	4688.4	4689.5
Log.Lik.	−1772.213	−1770.317	−1770.838
F	5.331	5.364	5.355
RMSE	0.52	0.52	0.52

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: The dependent variable is the count of renewable energy policies adopted in a country-year from the International Energy Agency Policy Database. I employ OLS with country and year fixed effects to estimate the relationship between a higher share of domestic solar investment (number of firms, number of projects) and the number of new renewable energy policies in the next year.

A.3.8 Embeddedness and Policy Adoption, CLW Data

This analysis uses the Climate Laws of the World Database as the dependent variable of policy count.

Table A.3.8: Embedded Investment and Policy Adoption, CLW

	Model 1 (Domestic Share)	Model 2 (Count of Firms)	Model 3 (Count of Projects)
(Intercept)	−0.967	1.854	1.688
	(11.106)	(10.998)	(10.996)
Percent Embedded Firms	0.060		
	(0.042)		
Energy Imports	0.000	−0.001	−0.002
	(0.007)	(0.007)	(0.007)
Democracy	−0.226	−0.140	−0.128
	(0.152)	(0.152)	(0.152)
Development Aid	−0.005	−0.006	−0.007
	(0.024)	(0.024)	(0.024)
Fossil Fuel Gen.	−0.001	−0.001	−0.001
	(0.001)	(0.001)	(0.001)
FDI	0.002	0.002	0.003
	(0.014)	(0.013)	(0.013)
GDP (per capita)	−0.013	−0.004	−0.004
	(0.052)	(0.052)	(0.052)
Population	−0.446**	−0.395*	−0.391*
	(0.166)	(0.166)	(0.166)
Land Area	0.654	0.375	0.382
	(0.807)	(0.800)	(0.800)
Number of Embedded Solar Firms		0.167***	
		(0.031)	
Number of Embedded Solar Projects			0.141***
			(0.026)
Num.Obs.	2334	2334	2334
R2	0.191	0.201	0.201
R2 Adj.	0.137	0.147	0.147
AIC	3872.9	3844.5	3843.8
BIC	4724.7	4696.3	4695.6
Log.Lik.	−1788.461	−1774.257	−1773.903
F	3.532	3.758	3.764
RMSE	0.52	0.52	0.52

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: The dependent variable is the count of renewable energy policies adopted in a country-year from the Climate Laws of the World Database. I employ OLS with country and year fixed effects to estimate the relationship between a higher share of domestic solar investment (number of firms, number of projects) and the number of new renewable energy policies in the next year.

A.3.9 Embeddedness and Policy Adoption, CPD Data

This analysis uses the Climate Policy Database as the dependent variable of policy count.

Table A.3.9: Embedded Investment and Policy Adoption, CPD

	Model 1 (Domestic Share)	Model 2 (Count of Firms)	Model 3 (Count of Projects)
(Intercept)	−2.923	−1.337	−1.373
	(7.360)	(7.335)	(7.335)
Percent Embedded Firms	0.056*		
	(0.028)		
Energy Imports	0.008+	0.008+	0.008+
	(0.004)	(0.004)	(0.004)
Democracy	0.010	0.019	0.021
	(0.101)	(0.101)	(0.102)
Development Aid	0.001	−0.001	−0.001
	(0.016)	(0.016)	(0.016)
Fossil Fuel Gen.	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
FDI	−0.001	−0.002	−0.002
	(0.009)	(0.009)	(0.009)
GDP (per capita)	0.008	0.011	0.011
	(0.034)	(0.034)	(0.034)
Population	−0.127	−0.120	−0.119
	(0.110)	(0.110)	(0.110)
Land Area	0.370	0.244	0.246
	(0.535)	(0.534)	(0.534)
Number of Embedded Solar Firms		0.032	
		(0.021)	
Number of Embedded Solar Projects			0.027
			(0.017)
Num.Obs.	2334	2334	2334
R2	0.289	0.289	0.289
R2 Adj.	0.242	0.241	0.241
AIC	1952.1	1953.8	1953.9
BIC	2803.9	2805.6	2805.7
Log.Lik.	−828.044	−828.918	−828.940
F	6.096	6.080	6.079
RMSE	0.35	0.35	0.35

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: The dependent variable is the count of renewable energy policies adopted in a country-year from the Climate Policy Database. I employ OLS with country and year fixed effects to estimate the relationship between a higher share of domestic solar investment (number of firms, number of projects) and the number of new renewable energy policies in the next year.

A.4 Solar Project Firm Ownership Data Collection Methodology

I worked with a large team of undergraduate research assistants between 2023-2024 to compile a dataset of solar projects and owners from publicly available sources.[26] This section briefly explains the manual data sourcing and verification methodology, after the generation of the company matches list based on the ORBIS algorithm and names of solar project owners from the S&P

[26]Thank you to Kyle Park, Isabelle Winstead, Krisha Nair, Khushi Jain, Bria Roettger, Muiz Mustamir, Christina Pellico, Denise Thompson, Erika Tam, Ilana Villa, Natalie Avida, Namya Ramalingam, Elissa Mei, and Eric Xie for your research assistance.

World Electric Power Plant Database. The data will be published in collaboration with Global Energy Monitor in Spring 2025.

We verify the firm-project match with two public sources. At least one source confirms firm ownership of the specific project. We additionally collect information about the company's website in order to identify its country of origin. There are several complicated cases of ownership, first and foremost, joint ventures. There are 334 cases where multiple firms own a project. In the quantitative analyses, I split the project megawatts equally between owners (e.g. a 60 MW solar project with one foreign and domestic owner would be recorded as 30 MW foreign and 30 MW domestic as it contributes to total solar generation. I code a project as foreign owned if at least one of the owners is foreign, which includes 261 of the projects, 118 of which are foreign-domestic co-owned. We do not record ownership shares because this is reported very inconsistently and infrequently.

If the company is a subsidiary of a larger business group, we change the owner to the Parent company, and record sources about the ownership structure, since news articles and other sources often only report local company names. We also check to see if projects have changed hands over the years, and record the original investor, since the intent is to capture firms' ability to initially build a solar project. Finally, we also manually populate the year column for the year projects become operational, since Platts' has a relatively high level of missingness.

I provide an example of verifying a project below, a large scale solar project in Mexico.

Project Name	**Capacity**	**S&P Name**	**ORBIS Name**	**Country**
Tuto Energy PV I	131.00	ACCIONA	ACCIONA SA	MEX

Sources reveal that this project is actually a joint venture between Acciona SA, a large Spanish firm and Tuto Energy, a subsidiary of Mexican conglomerate Biofields group. The following sources, from Acciona themselves and NS Energy, a reputable news outlet reporting on industry trends, verify the firms' co ownership of the project. The Acciona website and Biofields LinkedIn page confirm company ownership.

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