Does Manufacturing Matter? Foreign Investment and Local Linkages in the Malaysian Solar Industry

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Abstract

The rise of green industrial policy has catapulted renewable energy manufacturing into the spotlight as a catalyst for energy transition. In light of the US China trade war, Chinese solar manufacturers relocated operations to Malaysia, Vietnam, Thailand, and Cambodia. Will this investment spark renewable energy growth? I draw upon bilateral solar panel trade data, interviews with Malaysian firms, and spatial patterns in local solar installation to show that Chinese production relocation had minimal effect on both backwards linkages with local suppliers and local solar installation. Rather, Chinese panels assembled in Malaysia use imported components and are destined for export to Western countries. Upstream, Chinese manufacturers are vertically integrated and source products from China, and downstream, profit more from exporting to the United States than selling to locals. Instead, Malaysian solar project owners actually import panels from mainland China. The only local linkage lies in the direct employment of locals in the manufacturing facilities themselves. This calls into question existing green industrial policy scholarship that emphasizes the localization of production for downstream market growth.

Keywords: industrial policy, renewable energy, international trade, foreign direct investment, global value chains

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1 Introduction

Tariffs on Chinese exports to the United States and European Union have reshaped global supply chains across critical industries from washing machines and steel to semiconductors and solar panels (Fajgelbaum & Khandelwal 2021). The latter, solar panels, are an essential component of the global energy transition. Low cost Chinese solar panel manufacturers caused a steep drop in the cost of solar panels on the global market, and the tariffs were poised to increase prices again for Western consumers (Ball, Reicher, Sun, & Pollock 2017). Yet rather than sell to Western markets under the steep anti-dumping (AD) and countervailing (CVD) duties, Chinese firms rearranged supply chains for solar panel exports to these critical markets (Bradsher 2014; Ball et al. 2017).

Leading firms firms including including JinkoSolar, JA Solar, BYD, and LONGi off-shored and scaled up existing solar panel manufacturing in Malaysia, Thailand, Cambodia and Vietnam (Ball et al. 2017). This paper examines the extent to which solar manufacturing investment in these countries creates opportunities for local firms along the value chain. The recent popularization of green industrial policy, like the United States' Inflation Reduction Act, has catapulted renewable energy manufacturing into the spotlight as a potential catalyst for energy transition (Rodrik 2014; Harrison, Martin, & Nataraj 2017; B. Allan, Lewis, & Oatley 2021; B. B. Allan & Nahm 2024). Yet there is little evidence about the benefits of foreign solar manufacturing investment in the developing world. Can tariff-jumping Chinese solar manufacturers in Malaysia, Vietnam, Thailand, and Cambodia actually empower local solar development?

On the one hand, manufacturing has long been the cornerstone of industrial policy (Amsden 1992; Wade 1992; Gereffi & Wyman 1990). A broad literature on global value chains contends that foreign manufacturing investment can create spillovers across the supply chain, including (1) upstream materials procurement (Rodríguez-Clare 1996; Javorcik & Spatareanu 2004; P. Lin & Saggi 2007), (2) higher wages and skills for employees (Feenstra & Hanson 1995; Lipsey & Sjöholm 2004; Driffield & Love 2006), and (3) downstream segments of the supply chain as the material costs of inputs and transaction costs of procurement decline for domestic firms (Javorcik & Spatareanu 2005; Blalock & Gertler 2008). In solar, FDI has led to spillover in the past. Chinese firms learned from the Western wind and solar companies which moved operations to China in the early 2000s in pursuit of low cost labor (Lewis & Wiser 2007; Lewis 2014; Ball et al. 2017). These Chinese firms moved up the value in chain in solar manufacturing, which triggered a wave of local solar project investment as the price of solar panels fell (Zhang, Deng, Margolis, & Su 2015).

On the other hand, despite the great potential for spillover, there is mixed evidence as to whether foreign direct investment actually benefits local firms across the supply chain (Javorcik & Spatareanu 2004; Javorcik 2004; Gorodnichenko, Svejnar, & Terrell 2014). While investment from foreign manufacturers boosts manufacturing sector output in the short-term, it may fail to catalyze industrial upgrading at higher value added segments of the supply chain (Wade 2010; J. Y. Lin 2017). This "middle income trap" (Kharas & Kohli 2011; Eichengreen, Park, & Shin 2013) plagues emerging markets that are pursuing development, but have found themselves stuck in relatively low-wage manufacturing operations alone. As income rises, they fail to compete even for low wage FDI, and their industrial sector stagnates. Despite the successes of Japan, South Korea, and others in the 1990s, export-oriented manufacturing does not guarantee spillover between manufacturing and downstream higher value-added segments of the global supply chain. In particular, this phenomenon occurs in the absence of political coalitions in support of upgrading (R. F. Doner & Schneider 2016; Holland & Schneider 2017).

This paper explores whether and why Chinese solar manufacturing investment affords Southeast Asian host countries a leg up in the global solar industry. I first introduce literature which emphasizes the potential benefits of foreign manufacturing investment for local economic growth, with a focus on employment and forward linkages to local firms.[1] I contrast the local linkage perspective with an alternative account emphasizing the limitations of manufacturing for meaningful technology transfer. I propose that private sector preferences determine whether upgrading occurs, due to liberal market reforms that constrain governments in bargaining over domestic benefits.[2] In the case of solar energy, private sector barriers to local linkages are twofold: the new domestic solar industry in host countries held little leverage to bargain, and the context of the trade war diminished Chinese firms' incentives to supply the local market.

I assess these hypotheses through a combination of regression analysis and interviews with Malaysian government officials and solar firms. I first draw upon interviews from 20 solar industry professionals to assess whether Chinese manufacturing led to local linkages with the solar industry in Malaysia. Interviews confirm that Chinese manufacturers used Malaysia as platform to export panels to the US and EU, with few connections to the local market beyond direct employment.

Both the trade war context and weak domestic solar industry coalition diminished the potential for negotiation over local linkages. However, interviews provide strong evidence of growth in the Malaysian solar industry - just not as a result of manufacturing relocation. Malaysia is indeed entering higher value added stages of the value chain, with local firms scaling up project-level investment in the in the last ten years alongside a thriving market of local service providers. This is, in part, because mainland Chinese factories increased exports to Malaysia and others in the developing world as the US and EU reduced imports from these production facilities. While Chinese firms in Malaysia sold panels to Western buyers willing to pay a high markup, Malaysians used the same firms' panels *from mainland China*. As one interviewee put it, Malaysians can wait six weeks for any expensive leftover domestic panels that did not make it to the US, or import panels in two weeks from China. This qualitative evidence suggests that the trade war did not create local linkages via manufacturing, but increased the availability of cheap technology for countries without tariffs on panels from mainland China.

Quantitative evidence lends support for this explanation. I first draw upon unique project-level data in Malaysia to demonstrate that manufacturing production relocation, in and of itself, had little impact on local solar installation, though descriptive statistics indicate some local job creation in manufacturing facilities. I then leverage global data on solar panel trade to show that Southeast Asian states served as an export platform to tariff-imposing states, which further confirms a lack of local linkages. This data also indicates that while countries with an anti-dumping duty decreased solar module imports from mainland China, the rest of the world imported more Chinese products. Tariffs afforded countries like Malaysia found a new, low-cost source of solar panel supply. Figure 1 illustrates this trend, plotting the total value Chinese solar imports to the EU, US and rest of world over time. While the EU and US taper off in their shares of Chinese imports after tariffs (2012 and 2013, respectively, per the color-corresponding lines), imports elsewhere soared.

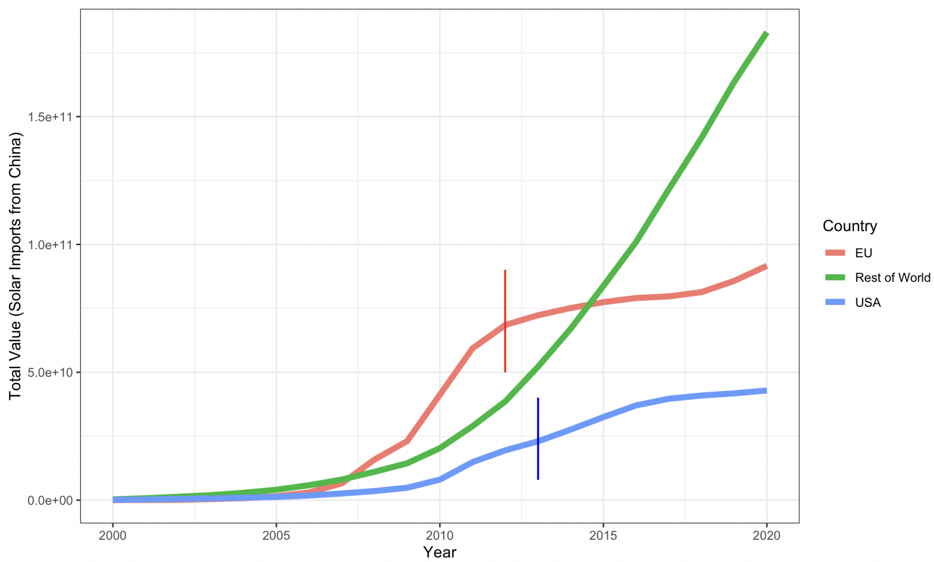

Figure 1: **Solar Imports from China (2000-2020)**. Each line represents the total value of solar imports from China, and the red and blue vertical lines indicate the dates of the first anti-dumping imposition for the US and EU respectively.

Overall, I find counter-intuitive evidence regarding the effects of tariffs on solar industry development for Southeast Asian countries. On one hand, the potential benefits of manufacturing like localized demonstration effects or material cost reductions in the areas surrounding Chinese production facilities in Malaysia did not pan out. But surprisingly, the trade war created an unexpected positive externality for the pro-renewable energy political coalition in Malaysia. Manufacturing factories in mainland China faced lower profits from the US and EU after the imposition of tariffs. Rather than let production lines sit idle, these factories increased exports to countries like Malaysia. This increase in global production and decrease in the cost of solar technology allowed Malaysian firms to to import low-cost modules from mainland China, leave costly German suppliers behind, and grow the local solar industry. Overall, the vast majority of local firms building solar projects benefited significantly from Chinese solar panels - just not due to forward linkages from local manufacturers.

2 Background: Solar Industry Supply Chain Fragmentation

Chinese industrial policy promoting solar panel manufacturing led to a subsequent boom in the global supply of solar panels, and upended global value chains for modules (Ball et al. 2017). This successful industrial policy led to a massive increase in the quantity of solar panels available on the global market, deeply undercutting higher cost production in the US and Europe (Zhang & Gallagher 2016). Industrial policy took off between 2005-2008, with Chinese manufacturing expansion fueled by local production incentives and early demand-side measures (Zhi, Sun, Li, Xu, & Su 2014). Local governments offered land incentives, tax breaks and accelerated permitting processes, particularly in areas with rapidly growing energy demand and established glass and metal manufacturers well positioned to enter the solar industry (Nahm 2017; Corwin & Johnson 2019).

Amidst the implementation of both national and local industrial policies, new Chinese manufacturing leaders made their initial public offerings in the global marketplace: Suntech (2005), Trina (2006) and Yingli, JA Solar and China Sunergy (2007) (Fu & Zhang 2011; Zhang & Gallagher 2016). In addition to industrial policy, the 2008 global financial crisis solidified the lead of the largest Chinese solar manufacturers. Lead firms received finance from the China Development Bank (CDB), a Chinese development finance institution, which supported solar manufacturing export growth throughout the global slowdown (Andrews-Speed, Zhang, Zhao, & He 2013; Nahm 2023). While the Chinese government cut subsidies to smaller firms with low production capacity, the largest national champions received concessional CDB finance during the crisis (Zhi et al. 2014). On the other hand, German and American competitors struggled in the face of both falling global demand for their products and weathering the global recession without significant government support.

The rapid expansion of Chinese manufacturing capacity, supported both by state finance and bottom-up industrial policy, eroded profits for American and European solar manufacturers unable to match low-cost Chinese exports (Ball et al. 2017). Tariffs from the US were first enacted in 2012 and were followed by the EU in 2013 (Goldenberg 2012; Halper & Stein 2022). This first round of trade barriers was followed by subsequent 2014 tariffs initiated by Solar World Americas, a German manufacturing firm with operations in the United States, which doubled the import price of solar panels from China to the US.

In response to these first tariffs, Chinese solar manufacturers invested and scaled up manufacturing facilities first in Taiwan, and then Malaysia, Thailand, Cambodia and Vietnam (Houde & Wang 2022). JA Solar, JinkoSolar and LONGi all shifted production facilities to Malaysia in 2015 after the drastic hike in US and EU tariffs, with JA and JinkoSolar located in Penang, and LONGi in Sarawak. These three facilities accounted for over one-third of total Malaysian solar exports in facility capacity (i.e., number of production lines) at the time of construction, representing a significant boost to the local solar industry. These same companies opened additional branches in Thailand, Vietnam, and Cambodia, and in total accounted for up to 80 percent of solar panel imports into the United States after production scaled up (Howe 2024). But despite the rapid scale up in production, there is yet evidence as to whether solar manufacturing benefited local solar companies. The following section lays out two contrasting perspectives regarding the potential impacts of these facilities for the local solar industry in Southeast Asia, before assessing both qualitative and quantitative evidence.

3 Foreign Investment and Local Linkages

The relocation of Chinese manufacturing facilities to Southeast Asian countries provided an opportunity for host country firms to enter the solar value chain. A robust economics literature foregrounds success cases of foreign manufacturing investment and local linkages[3]. Benefits include both higher local wages (Feenstra & Hanson 1995; Lipsey & Sjöholm 2004) and local firm productivity up and down the value chain (Blomström & Persson 1983; Javorcik 2004; Helpman 2006; Havranek & Irsova 2011). Multinational corporations (MNCs) are the most productive firms from their countries of origin, and can bring skills, technology, and higher production standards to developing countries which do not have prior experience with new technologies like solar (Greenhill, Mosley, & Prakash 2009; Malesky & Mosley 2018).

Much attention has been devoted to identifying the occurrence of backwards linkages, when a multinational manufacturer sources inputs from local suppliers (Rodríguez-Clare 1996; Belderbos, Capannelli, & Fukao 2001; Javorcik & Spatareanu 2004; P. Lin & Saggi 2007). However, in order to establish backwards linkages, local suppliers must be able to produce with economies of scale (?). Solar panel manufacturers require polysilicon, which is derived from quartz glass (Mulvaney 2014). Chinese firms already have established large economies of scale in silicon manufacturing, with a large industrial glass complex located in Western China (Marigo 2007; S. Wang & Lloyd 2023). It would be difficult for inexperienced local firms to match these economies of scale starting from scratch. Given the poor case for forward linkages due to the structure of the upstream solar supply chain, I focus my theory building on the employment of local workers and forward linkages to domestic firms that could purchase solar panels for installation. However, I do confirm the absence of backward linkages with interview evidence below.

Beyond backwards linkages, manufacturing can provide employment for local workers, especially skilled labor (Scheve & Slaughter 2004; Pandya 2010; 2016; Walter 2010). FDI can transfer skills and offer higher wages than local competitors (Feenstra & Hanson 1995; Lipsey & Sjöholm 2004; Driffield 1999). Of course, these employment benefits are conditional upon whether foreign firms can actually find qualified local workers. The absorptive capacity, or the ability of a local market to uptake a foreign technology, in terms of labor, domestic capital, and financial market development, determines whether foreign firms can find qualified employees (Perez 1997; J.-Y. Wang & Blomström 1992; Kinoshita & Mody 2001; Blomström, Lipsey, & Zejan 1996; Blomström & Kokko 1998; Blomström, Kokko, & Globerman 2001; Alfaro, Chanda, Kalemli-Ozcan, & Sayek 2004). Southeast Asian countries, especially Malaysia, Thailand, and Vietnam, have a long history of manufacturing products including electronics, semiconductors, and medical devices for export (Felker 2003; Intarakumnerd, Chairatana, & Chaiyanajit 2016; Raj-Reichert 2020). While wages may be higher, especially in Malaysia and Thailand, than China, Southeast Asia offers a skilled workforce often geographically clustered in special economic zones, which lends itself to economies of scale in production (Felker 2003; Athukorala & Kohpaiboon 2014). As a result, I expect manufacturers to directly employ locals in production facilities.

Hypothesis 1: *In Malaysia, solar manufacturing facilities create employment opportunities for local workers.*

In addition to local employment, foreign firms can introduce a technology to the local market via forward linkages, in this case supplying local firms with solar panels. This linkage could reduce costs of procuring panels for locals, and potential learning from foreign firms' expertise (Blalock & Gertler 2008; Havranek & Irsova 2011; Javorcik 2004). Beyond the direct cost of inputs and transaction costs of procurement, foreign firms can convey substantive knowledge about best practices and quality materials to local firms and workers (Borensztein, Gregorio, & Lee 1998; Hanushek & Kimko 2000). One pathway by which these linkages form is through the spatial proximity of manufacturing firms to local solar installers. The transaction costs of procurement may be lowest for domestic firms closest to manufacturing facilities, which can more easily learn about and secure contracts with upstream suppliers (Saggi 2002).

These demonstration effects could allow local firms located near Chinese manufacturers to acquire products at a lower cost than far-away competitors, given firms' relatively high exposure to foreign partners. In Vietnam, Malaysia, and Thailand, renewable energy projects were already subsidized at the national level prior to Chinese manufacturing relocation (Joshi 2018; Tongsopit & Greacen 2013; Tongsopit 2015). Given existing government support for solar installation, there is a strong case to expect forward linkages from multinational manufacturing to domestic solar installation. Again, these states have sufficient human and technological capital to integrate the foreign technology downstream (Xu 2000; Blanton & Blanton 2007), so there is potential for foreign manufacturing investment to create linkages and growth in solar panel installation.

Hypothesis 2: *In Malaysia, areas near foreign solar manufacturing facilities will install more solar than areas far away from foreign solar manufacturing.*

Challenges for Local Linkages?

However, a growing body of work focused on the political determinants of industrial upgrading offers a counterweight to optimism about the potential of foreign investment to support local industry growth. While late industrializers like Japan, South Korea, and Taiwan leveraged export industries in manufactured products to propel themselves up the global value chain (Gereffi & Wyman 1990; Haggard 1990; Amsden 1992), this success has not carried over to all emerging markets. Recent cases of the "middle income trap" suggest that foreign manufacturing investment does not guarantee industrial upgrading (Wade 2010; Kharas & Kohli 2011). While many developing nations moved beyond low-wage labor, including Southeast Asian states, they now struggle to upgrade from export-oriented manufacturing to indigenous innovation (**?**Ito 2017). This creates a dilemma - these countries are no longer competitive investment destinations based on low labor cost, but also do not have the capability to innovate on their own.

This problem, however, may be "more politics than economics" (R. F. Doner & Schneider 2016). Specifically, in order to make the move from manufacturing to innovation, upgrading coalitions, or interest groups that support industrial upgrading, are necessary(R. F. Doner & Schneider 2016; R. Doner & Schneider 2020; Kang & Paus 2020). Early East Asian success is attributed to "strong" state institutions which mediate business-government relations, craft long-term industrial policy, and condition policy support on firm performance (e.g. reciprocal control mechanisms)

(Evans 1995; Gereffi & Wyman 1990; Chang 2003; Amsden 2003; Haggard 2018) These bureaucratic institutions are critical to shape the trajectory of industrial development, in their ability to "nudge subsidiaries of foreign firms to link up with domestic suppliers" to create local linkages and positive spillovers (Wade 2010).

Despite following in the footsteps of the TIGER's successes, emerging economies including Vietnam, Thailand, and Mexico have struggled to make the step from export-oriented manufacturing under the leadership of foreign firms to indigenous innovation (Ohno 2009; Kharas & Kohli 2011; Eichengreen et al. 2013; Paus 2012; 2020). Most notably, governments are more focused on attracting foreign manufacturing investment than directing the market, which leaves discretion over local linkages up to the private sector. Scholars attribute the absence of upgrading coalitions to liberal reforms that disempower state intervention in the market and reliance on politically inactive foreign companies (R. F. Doner & Schneider 2016; Raj-Reichert 2020; Kang & Paus 2020; R. Doner & Schneider 2020). For example, evidence from science and technology in Vietnam (Klingler-Vidra & Wade 2020) suggests that ministry budget, lack of industry coordination, and a market-based approach to policy led to sectoral stagnation. Similarly, in the Malaysian electronic sector, reliance on foreign investment left little room for government negotiation, and led to the persistence of low skilled, low wage jobs (Raj-Reichert 2020). In short, the erosion of government influence over industry places upgrading in the hands of private sector actors, and their preferences about establishing local linkages.

In this view, the solar industry is a challenging case for upgrading coalitions due to both the early stage of solar installation and context of the trade war. In this case, either the domestic industry or foreign manufacturers themselves would have to push the government for local linkages. At the time of manufacturing relocation, the local solar industry was just beginning to grow; Malaysia and Thailand had built some small scale projects, and solar was nonexistent in Vietnam and Cambodia (Tongsopit & Greacen 2013; Tongsopit 2015; Joshi 2018; Do, Burke, Baldwin, & Nguyen 2020). Given the early stage of industry growth, there was unlikely to be much domestic pressure on the government for establishing local linkages to foreign manufacturers.

As a result, foreign manufacturers were a pivotal actor in determining the extent of local linkages. Manufacturers often have little incentive to establish deep local roots because they already have an established value chain, and instead conduct the majority of R&D in home countries rather than host countries, avoid domestic politics, and safeguard technology (R. F. Doner & Schneider 2016; Raj-Reichert 2020; Naseemullah 2022). Solar industry is no different; Chinese solar manufacturers have established strong upstream production networks in glass and aluminum, and are often vertically integrated across early stages of production (Zhang & Gallagher 2016; Ball et al. 2017). In light of the trade war, disincentive to establish linkages with domestic solar companies was even more acute. Chinese firms earn a higher markup from selling to the United States and European Union than Southeast Asian states, due to buyers' higher willingness to pay. Furthermore, production costs in Thailand and Malaysia, in particular, are even higher than in mainland China (Ito 2017). As a result, Chinese firms needed to sell Southeast-Asian-made panels at a higher markup than those produced in mainland China to turn a profit, further increasing the incentive sell at the highest possible price. On balance, manufacturers had little incentive to engage with the local industry given both the higher price of production in Southeast Asia, and higher profits available broad.

Due to the lack of a solar upgrading coalition across both local and foreign firms, this framework suggests that Southeast Asia would simply serve as an export platform for Chinese panels. This leads me to develop the following hypothesis, which cuts against the logic of local linkages.

Hypothesis 3: *After the imposition of tariffs, Chinese solar manufacturers used Southeast Asia as an export platform to access countries with tariffs.*

4 Case Study: Solar Manufacturing and Local Linkage in Malaysia

This section explores the effects of supply chain fragmentation for local linkages through an in-depth case study of Malaysia. I draw upon upon 24 interviews conducted throughout 2023-2024 and select secondary sources to evaluate hypotheses regarding employment, local linkages, and evidence of tariff circumvention. I focus on the Malaysian case due to its importance as an upper middle-income country caught in the crossfire of the US-China trade dispute. Malaysia is also an ideal case to examine whether manufacturing production positively impacted local solar installation because solar manufacturing relocation occurred in the middle of solar subsidy implementation. When Chinese production relocated to Malaysia between 2014-2015, Malaysia was in the process of implementing a Feed in Tariff (FiT) (2011-2015) and Net Energy Metering (NEM) (2015-2018), which allowed firms to sell solar back to the grid (Joshi 2018). Malaysia is also a data-rich case, with detailed information about domestic household and firm-level solar installation under specific green industrial policies,[4]. Below, I first provide background on Chinese manufacturing relocation to Malaysia and its direct benefits, before detailing the procurement choices of Malaysian solar project owners and the barriers to local linkages.

Solar manufacturing in Malaysia

The location of Chinese investments in Malaysia provides an opportunity for local employment, but evidence suggests less so for forward linkages with local firms. While manufacturing firms drew upon local talent for employment, there was little interaction with the market outside production enclaves. This dynamic occurred due to both lack of pro-linkage political coalitions within Malaysia, and little minimal incentives to establish linkages on the part of MNCs. Below, I draw upon select interviews with business-people in the solar sector and descriptive evidence from the fdiMarkets database to illustrate the extent to which manufacturing positively formed local linkages.

In Malaysia, all Chinese solar manufacturing facilities are located in Special Economic Zones (SEZs), which are well-documented to be production enclaves where foreign-manufactured goods are destined for export rather than domestic consumption (Alkon 2018).[5] Interviews with solar industry businessmen indicate that facility siting was strategic to make the most of Malaysian expertise (Interviews 3, 13, 19). These industrial areas are home to several technology parks and where workers enjoy a high-level of engineering expertise that translates well to solar manufacturing. In addition, both JinkoSolar and JA Solar are located in the predominately Chinese state of Penang. This only further reduces the transaction costs of local employment (Interview 19). As a result, locals account for a majority of employees, with only the uppermost managerial staff brought in from abroad (Interview 13). The CEO of JinkoSolar's personal testimony supports this view:

"Malaysia offers us talent pool of highly educated workers and engineers, relatively advanced industry infrastructure, a receptive business investment climate, cost competitive environment. In return, we bring our latest technology and manufacturing excellence know-how and expertise, our experienced management team helping to cultivate local talents, and our capital as well." - CEO Kanping Chen (JinkoSolar 2015)

Other solar panel manufacturers operating in Malaysia offer a useful benchmark for solar manufacturing job creation. While these other manufacturers are unlikely to foster linkages due to the comparatively high cost and technical complexity of their products relative to China, they have been operating in the Malaysian market much longer, so should easily source local labor. American firms First Solar and Sun Power constructed manufacturing facilities in Malaysia prior to 2011, while South Korea and Japan each have one manufacturing facility.[6] While South Korean and Japanese solar manufacturing is relatively new to Malaysia, arriving only a few years before China, both Hanwha and Panasonic have operated in Malaysia for decades.

In keeping with the benefits of industrial areas, Panasonic from Japan invested in Kulim Hi-Tech Industrial Park in the district of Kedah, while South Korean Hanwha Q-Cells located their manufacturing facility in Selangor, near the capital of Kuala Lumpur (Achu & Yvonne 2016; Colville 2017). These firms also appear to utilize local labor. For example, in a 2016 interview, the Panasonic Malaysian Managing Director Cheng Chee Chung stated that the "internal mission here in Panasonic Malaysia is to enrich the lives of Malaysian families by promoting eco, healthy and comfortable lifestyles" (Achu & Yvonne 2016). Drawing upon job creation data from fdi-Markets, I provide a simple visualization of the jobs created-to-capital ratio for each production facility, color coded by investor country of origin (fDi Markets 2022). The figure below, with logged capital investment on the x-axis and jobs created on the y-axis provides suggestive evidence that Chinese manufacturers create a similar number of jobs per dollar invested in comparison to their counterparts.

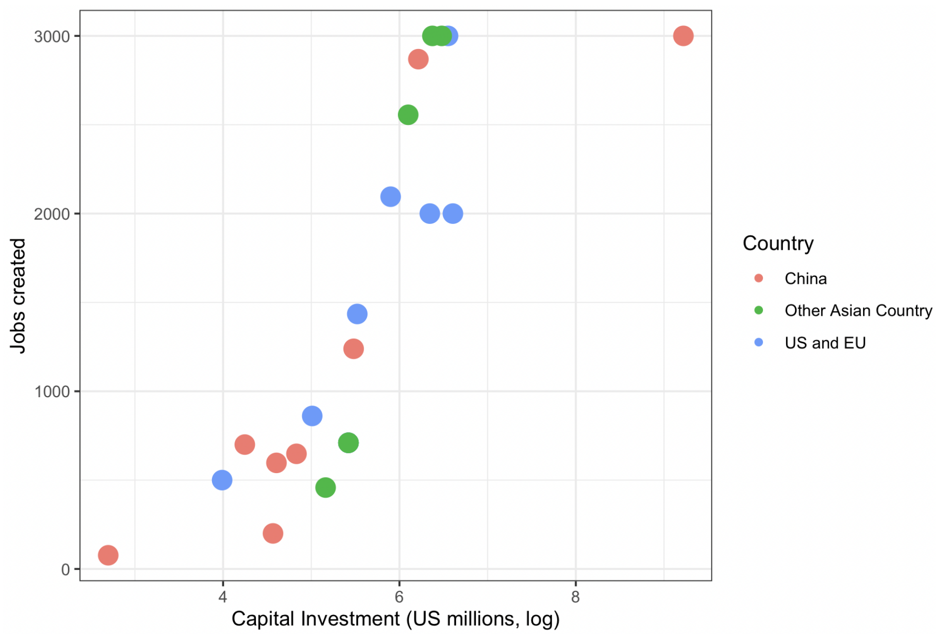

Figure 2: **Investment and Jobs Creation in Malaysia**. The x-axis indicates the amount of capital investment in US Dollars (logged) for each solar manufacturing facility in Malaysia, sourced from fdiMarkets, and y-axis shows jobs created. Colors indicate country of firm ownership.

However, there is scarce evidence for benefits beyond direct employment in local facilities. When asked why the Malaysian government did not ask for greater concessions from China, an interviewee put it simply - the benefits for locals via employment were enough for constituents, and the government prioritized a swift investment deal over the negotiation of benefits like a local content requirement, or local sales, for example (Interviews 13, 22-24). Local content requirements, while often popular in the developing world, had little potential. The Malaysian solar industry produces components at a higher cost than Chinese firms; when the government tried to include local content requirements later on for local solar projects, the cost was too high for many firms to comply with the regulation (Interview 22). Furthermore, the local solar industry was small at the time of Chinese relocation, so there was no coalition of firms to push policymakers to negotiate with manufacturers (Interviews 11, 13). This echoes work focused on upgrading coalitions as a key determinant of industrial upgrading.

Forward Linkages for Solar Panels?

While solar panel manufacturing created jobs for locals workers, interviews paint a less positive portrait for local supplier and buyer relationships. Here, I develop a profile of the modal solar project owner in Malaysia, and trace their process of selecting component suppliers from the range of possible manufacturers. The average Malaysian investor in solar generation is a domestic firm with operations in construction, electrical engineering, warehousing, telecommunications or manufacturing (Interview 3, 4, 8, 12, 21). These companies range from small firms operating in one industrial park to engineering, procurement, and construction (EPC) firms that work both in Malaysia and neighboring Asian countries like the Philippines and Thailand (Interview 5, 16). Of course, industry composition has changed over time; while all locals started small, a few key leaders have emerged in recent years as innovative firms built large scale projects (Interviews 13, 21, 22).

Interviewing firms of all sizes, including two of the largest investors alongside many small- and medium-sized firms, allowed me to rule out the possibility that procurement strategy varies by firm size. Despite variation in the size of solar investors, interviewees provide a unanimous account of how Chinese solar panels affect the Malaysian market. Both large and small firms indicate that solar panels produced in Malaysia are destined for export to the US or Europe, while in Malaysia, solar project owners import panels directly from mainland China (Interviews 1 - 4, 6-7, 10-12, 21). Firms of all sizes indicated the vast majority — 99 percent by one interviewee's estimate — of solar panels installed on Malaysian rooftops are imported from mainland China (Interviews 1, 3-4, 6-7).

The trade war creates different incentives for Chinese manufacturers in Malaysia versus the mainland. On the one hand, Chinese firms producing in Malaysia reap a higher profit from exporting solar to the US instead of selling to locals (Interviews 1, 3, 8, 19, 21-22, 24). On the other hand, mainland Chinese factories profit more from selling to Malaysia, and the rest of the world, relative to the US and EU after the imposition of tariffs. Even smaller firms like warehouse owners and boutique construction companies, without established connections to global solar component suppliers, import solar panels from mainland China (Interviews 2, 6). A large firm reports being contacted by Chinese suppliers in search of customers (Interview 1), while smaller companies work with EPCs with connections to China and can easily source panels from abroad (Interview 2).

Other Malaysian-made solar panel alternatives cannot compete with imports from Chinese manufacturers - particularly when solar panel costs comprise roughly 40 percent of total project costs. A representative from a medium-sized firm noted that American, Japanese and South Korean panels manufactured in Malaysia are now relatively costly to Chinese imports, although in the early days of the market, South Korean cells were used for some local installations since Western or other

Asian imports were the only available options (Interview 2). Interviewees also noted that other companies like First Solar have a specialized production process with more efficient-but-expensive modules, and as a result, are unlikely to ever gain popularity in the Malaysian market (Interviews 3-4).

While solar firms in Malaysia certainly benefited from China's manufacturing scale up, barriers to widespread solar implementation remain. Costs are still an important limitation; two interviewees report capital costs as a constraint to expanding their business to larger projects (Interviews 3-4, 18-19, 22). A medium-size firm noted that engineering, procurement, and construction (EPC) has become a more profitable alternative to project ownership, as capital costs and upfront investment rises exponentially as project size increases (Interview 3). Others noted the availability of finance as a key area for improvement in order to boost market growth (Interview 5, 21). While Chinese manufacturing overcapacity has allowed Malaysian firms to swap out costly German panels for low-cost alternatives (Interviews 2, 10), there is still room for domestic policy making to support the local solar installation and services market in project development, EPC, and operations and maintenance.

However, the industry's influence has also increased with time. In the early stages of industry growth, the Malaysia Photovoltaic Industry Association (MPIA) and its members were seen as tree-huggers, but now the group wields substantial policy influence (Interview 13, 19). In short, there is a stronger upgrading coalition to push for renewable energy. A position on the MPIA board is viewed with prestige, and the association is well networked with the policy community, whereas in the past they were dismissed as an annoyance (Interview 13). This suggests optimism for future negotiations over the distributive benefits of investment in renewable energy. While the trade war conditions and small pro-solar political coalition led to few returns from Chinese manufacturing, the industry continues to steadily grow and push for supportive policy, in part thanks to low-cost imports from mainland China.

5 Quantitative Analysis: Manufacturing and Local Linkages

The first component of the quantitative analysis evaluates whether areas near Chinese and other foreign manufacturing facilities benefit from lower costs of procurement, and in turn install a greater amount of solar than areas further afield. The second analysis provides descriptive evidence about tariff circumvention as an alternative explanation for solar industry outcomes. Here, I evaluate whether the EU and US decrease their imports of Chinese solar modules after the imposition of AD tariffs, while increasing imports from Southeast Asian countries to which China relocated production facilities. All data and replication code is available for download from Mendeley except two proprietary datasets from fdiMarkets and the PRS Group.

The following sections provide an overview of the respective analyses, detailing variable selection, model choice, and results. I first introduce a regression to estimate the relationship between the location of Chinese, American and other manufacturing facilities and Malaysian solar installation. I find no evidence that areas near manufacturers of any nationality experienced a significant increase in solar investment — though solar installation did increase overall. However, I do find evidence of tariff circumvention. After the imposition of antidumping duties, countries import less from China, while increasing imports from the Southeast Asian countries (Malaysia, Thailand, Vietnam and Cambodia) subject to the 2022 US Department of Commerce investigation(Wong, Singh, & Casey 2022)The qualitative and quantitative evidence, taken together, suggest that cost savings to local Malaysian companies stem from importing low-cost Chinese panels, rather than local manufacturing relocation.

Analysis 1: Manufacturing and Local Linkages

This first analysis estimates the relationship between manufacturing location and solar installation in the nearby vicinity. I operationalize the independent variable of proximity to solar manufacturing using dummy variables taking the value of 1 if a solar manufacturer from a given country operates in a given district-year in Peninsular Malaysia and 0 otherwise. There are separate dummy variables for each manufacturer (Chinese, United States, Japan, South Korea, etc.), since each entered the market at a different date. I include a robustness check in Appendix Table A.4 where the independent variable is a vector containing the names of *all* manufacturers located in a district in a given year, in case there is some multiplicative effect for the one district with multiple manufacturers.

I draw upon the fdiMarkets database (fDi Markets 2022) to identify all solar manufacturing investment in Malaysia, which allows me to compare the relative impacts of Chinese manufacturing against areas with no manufacturing and manufacturers of a different country of origin. I first select all projects listed in the Environmental Technology cluster and manufacturing industry segment. While there is no designation for solar manufacturing, I take the following steps to identify solar facilities. I first subset out entries where the sub-sector is “Biomass power”, “Engines & Turbines”, “General purpose machinery”, “Basic chemicals” and “Glass & glass products.” This leaves me with 25 investments, 19 of which have solar, sun, silicon, or cell explicitly in the company name or project description. For the remaining 6 entries, I manually verify that these investments correspond to solar manufacturing. Indeed, the remaining companies are all solar panel manufacturers.[7]

I leverage spatial (raster) data based on remote sensing and other advanced estimation techniques from J. Chen et al. (2022); University (2018) superimposed over the administrative level 2 boundaries of Malaysia to calculate sub-national control variables: population, gross domestic product, infant mortality, and land area. Income and other demographics data is not readily available at the district level from government data sources, so I use Python to calculate summary statistics for the aggregated overlay of $1 * 1$ kilometer raster shapefiles for the respective controls in 2011-2018 in lieu of available government data at this level of aggregation.

I operationalize my dependent variable, local solar installation, with the total solar installed (megawatts) in each of the 89 districts comprising Peninsula Malaysia. I derive MW from the Sustainable Energy Development Authority’s dataset of project-level solar applications (**?**), which encompasses over 10,000 projects, with 611 firm-level installations and over 9,000 households. For this analysis, I subset to firms, which comprise 91.1 percent of solar capacity (1068 MW) given the very small size of household installations. I use ordinary least squares regression (OLS) with district and year fixed effects and standard errors clustered at the district level to estimate the relationship between manufacturer location by country of origin and solar installation.

$$\text{SOLAR INSTALLATION}_{it} = \beta_0 + \beta_1 \cdot \text{CHINA MANUFACTURER}_{it} + \text{DISTRICT FE} + \text{YEAR FE} + \epsilon_{it}$$

Figure 3a (left)) shows the average marginal effect of the presence of a given manufacturer in a Malaysian district on installed solar capacity. Each country variable takes the value of 1 in years a manufacturer from a given country operates in a district and 0 otherwise.[8] Overall, manufacturing facility operation in a given district is not associated with higher levels of solar installation across different manufacturers. Figure 3b (right) shows the marginal effect of Chinese manufacturing on solar installation in a district, illustrating there is not a positive relationship between the two.

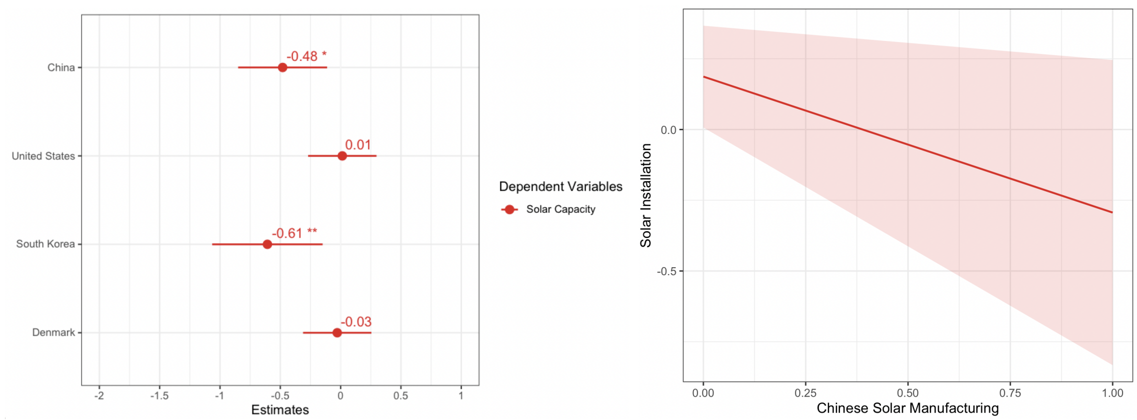

Figure 3: **(a) Effects Plot (b) Marginal Effects.** The lefthand figure shows regression results for imports from China and Southeast Asia respectively after the imposition of tariffs. The right figure plots the total value of solar imports from China for countries with and without tariffs respectively (2000-2021).

Analysis 2: Solar Supply Chains: Imports from China and SE Asia

In the second two analyses, I assess whether Southeast Asia became an export platform for Chinese solar panels to countries imposing trade barriers on panels from mainland China. To do so, I employ two complementary regression analyses. First, I establish that countries with antidumping duties decrease their solar panel imports from mainland China, and second, I show that these countries go on to import a larger quantity of solar from Southeast Asia after the imposition of trade barriers.

My primary independent variable in both regressions is a binary indicator taking the value of 1 if a country has imposed an antidumping duty on Chinese imports in a given year, and 0 otherwise. I source data on antidumping duty imposition from Global Trade alert, which notes the year of imposition and also removal - essential because the European Union removed tariffs against Chinese solar imports in 2018 (Evenett 2009). I account for a battery of controls: democracy, gross domestic product, land area, fossil fuel consumption, electricity consumption, trade, foreign direct investment, (Bank 2023) political constraints (Henisz 2023), and corruption (Group 2023), each lagged by one year.

The dependent variable for these analyses leverages imports data from UN ComTrade to calculate the annual value of solar imports from China, and Malaysia, Thailand, Cambodia, and Vietnam (HS Code 854140). The DV in the first analysis measures the percent of solar imports from China as a fraction of total imports based on primary value (Appendix Table A.5-A.6).[9]

The second replicates this measure, but instead with the fraction of solar imports from the four Southeast Asian states to which Chinese manufacturing was rerouted after the imposition of tariffs.

$$\text{SOLAR IMPORTS (CHINA)}_{it} = \beta_0 + \beta_1 \cdot \text{ANTIDUMPING DUTY}_{it} + \text{COUNTRY FE} + \text{YEAR FE} + \epsilon_{it}$$

I employ linear regression with country and year fixed effects with standard errors clustered at the country level for both analyses. In Model 2, the primary independent variable is an indicator of antidumping duty imposition taking the value of 1 in all years an AD duty is active, and dependent variable is the percentage of a country's solar imports sourced from China in a given year. I then evaluate whether Southeast Asian countries subject to Department of Commerce tariff circumvention investigations export a larger quantity of solar panels after countries' imposition of antidumping duties. The regression model and independent variable here is consistent with Model 2, but the dependent variable is share of solar imports from Malaysia, Thailand, Vietnam, and Cambodia after AD duty imposition.

Figure 4a provides a plot comparing coefficients on the variable $ANTIDUMPING_{i,t}$ for Model 2 and Model 3 respectively, and 5b provides a complimentary visualization of the value total solar imports from China over time among countries imposing AD duties and those that do not. Per the expected effects of tariffs on imports, AD countries reduce imports from China after tariffs are imposed, but increase solar imports from alternative Southeast Asian suppliers. This compliments interview evidence above, indicating that Malaysian firms source directly from the Chinese mainland, while panels manufactured at Chinese facilities in Malaysia are destined for export to tariff-affected countries.

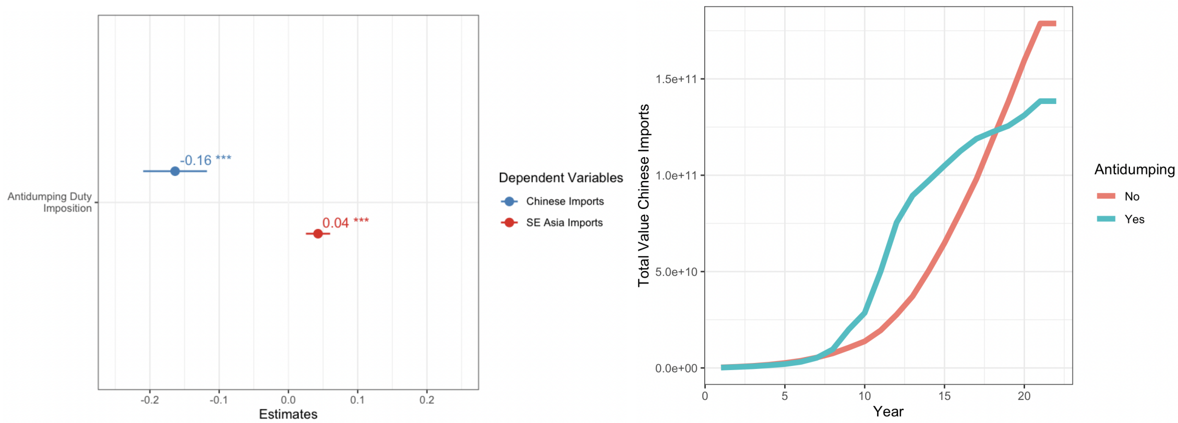

Figure 4: **(a) Effects Plot (b) Tariffs and Imports Over Time.** The lefthand figure shows regression results for imports from China and Southeast Asia respectively after the imposition of tariffs. The right figure plots the total value of solar imports from China for countries with and without tariffs respectively (2000-2021).

6 Conclusion

While Chinese industrial policy has shaped the local solar industry in emerging markets, it is not through the relocation of production facilities and local linkages to other emerging markets. There is some evidence indicative of local employment at manufacturing facilities, but less evidence of downstream segments of the supply chain. Both spatial patterns of solar investment growth and interviews with solar firms themselves indicate that while cost reductions did indeed occur due to Chinese solar panels, it was not through production localization. Rather, there was an across-the-board reduction in costs for all firms in the Malaysian market as firms swapped high cost German panels for low cost panels imported from mainland China. Interviewees emphasize that American and European solar components were relatively costly, and that the cost reductions in switching from German to Chinese modules was a significant factor in scaling up Malaysian solar. In sum, the cost of components' steady decline, fueled by China and its industrial policies, allowed for industry growth abroad.

Second, I provide evidence about the challenges of industrial upgrading via foreign manufacturing investment. Beyond employing a few thousand workers, there is limited evidence that solar manufacturing production facilities provide additional value added to the local solar industry. Interviews highlight how economic factors disincentivized local linkages, and the absence of upgrading coalitions to pressure government on behalf of the local solar industry. Upstream linkages were foreclosed due to high levels of vertical integration among Chinese manufacturers, and downstream linkages were unattractive because of the high markups available in Western markets. The Malaysian solar industry at the time of relocation was quite small, and absent a coalition of domestic firms advocating for local benefits, the government had little incentive to negotiate with manufacturers.

However, in the years after manufacturing, interviewees stress that there is now a strong domestic solar industry coalition that is pushing for renewable energy policy. Many of the original local FiT recipients like Cypark and Gading Kencana have built large scale projects the size of several football fields, and are powerful voices in policy making. These firms have lobbied successfully for policies including third party access, or power purchase agreements between firms and companies, as well as grid interconnection within the region (Interview 24). While Malaysia was not able to capture value added in manufacturing, it was, however, able to grow a local solar industry in part due to affordable panels imported from China. For emerging markets like Malaysia, affordable components are essential for small firms to enter the market, and for local industries to grow from the bottom up. Many countries have far less solar in the energy mix than Malaysia, and Malaysia's experience in scaling up solar investment via both supply chain linkages and demand-side subsidies may be informative for those that have yet to grow. The case of Malaysia and solar manufacturing presents a cautionary tale about reliance on manufacturing as a catalyst of green upgrading, but indicates opportunities for local self-determination as the cost of green technology declines.

Notes

[1]Below I discuss further why backwards linkages are unlikely as the primary input for solar panels is poly-silicon, derived from quartz glass. This is very constrained by resource endowments, which are abundant in China itself (Marigo 2007).

[2]These constraints, however, were not present in early industrializers like Japan, South Korea, and Taiwan, affording governments greater discretion over the market.

[3]This stands in contrast to extractive, resource intensive sectors, which foster fewer positive economic spillovers (Nunnenkamp & Spatz 2003)

[4]The policies are respectively: the Feed in Tariff (2011-2016), Net Energy Metering (2016-2018), and three large scale auction rounds (2017-2018, 2019-2020, 2021) (SEDA 2018)

[5]A growing body of work assesses the degree to which Chinese investments and the structure of business interactions convey positive externalities to local markets, with mixed results (Bräutigam & Xiaoyang 2011; Brautigam, Farole,

& Xiaoyang 2010; Y. Chen 2019; Springer, Evans, & Teng 2021; Tang 2022).

[6]Both American firms have niches in upscale solar components, producing high efficiency, high-cost panels destined for US and European markets. Arizona-based First Solar produces thin film Cadmium Telluride (CadTel) panels and California-based SunPower specializes in high efficiency monocrystalline panels (Bradsher 2014). Both of these products sell at a premium relative to low-cost Chinese poly-silicon photovoltaic panels.

[7]Fifteen companies provide address information. Companies without information appear to be out of business, largely before the beginning of the sampling frame in 2011. I omit these facilities from my analysis.

[8]The full regression table is located in Appendix Table A3.

[9]I use share of Chinese imports based on quantity as a robustness check. However, there is greater missingness for this variable, particularly for imports from SE Asia, where positive Primary Value is recorded but no quantity (Appendix Table A.6-A.7).

A Appendix

A.1 Summary Statistics of Variables, Spatial Analysis

Table 1: Summary Statistics

Variable	Length	Mean	Min	Max
District Solar Capacity (MW)	1011	0.3	0	19
Chinese Manufacturing Dummy	1011	0.021	0	1
United States Manufacturing Dummy	1011	0.0099	0	1
Japan Manufacturing Dummy	1011	0.0099	0	1
South Korea Manufacturing Dummy	1011	0.012	0	1
Denmark Manufacturing Dummy	1011	0.0069	0	1
Median GDP	1011	3.5	0.13	45
Median Electricity Consumption	1011	11	10	16
Median District Area (Square Degrees)	1011	0.19	0.0021	1.8

A.2 Summary Statistics of Variables, Tariff Analysis

Table 2: Summary Statistics

Variable	Length	Mean	Min	Max
Percent Imports from SE Asia	3833	0.035	0	1
Percent Imports from China	3833	0.22	0	1
Antidumping	4012	0.048	0	1
Democracy (V Dem)	4010	0.52	0.015	0.93
Political Constraints	2891	0.3	0	0.73
GDP	3874	11534	100	123679
Population	3931	48086796	80410	1411100000
Land Area	3895	893181	300	16381390
Carbon Emissions	3865	4.4	0	48
Fossil Fuel Consumption	2308	66	0	100
Electricity Consumption	2258	3993	22	54799
Trade	3577	16	11	21
Net FDI Inflows	3852	11538069268	-330338474188	733826501995
Corruption (ICRG)	3090	2.7	0	6

A.3 Foreign Manufacturing and Local Installation

	Model 1	Model 2	Model 3	Model 4
(Intercept)	−1.066*	0.114	−1.782***	0.258**
	(0.431)	(0.079)	(0.428)	(0.080)
China	−0.481**	−0.469*	−0.409**	0.017
	(0.184)	(0.188)	(0.154)	(0.100)
United States	0.014	0.066	−0.060	−0.189**
	(0.137)	(0.133)	(0.112)	(0.072)
South Korea	−0.607**	−0.561*	−0.569**	−0.151
	(0.225)	(0.257)	(0.181)	(0.101)
Denmark	−0.028	−0.062	−0.022	−0.153
	(0.134)	(0.135)	(0.133)	(0.137)
Median GDP	0.016	0.032***		
	(0.011)	(0.008)		
Electricity Consumption (Log)	0.106*		0.172***	
	(0.042)		(0.038)	
Land Area	−0.054	−0.197***	−0.002	−0.425***
	(0.050)	(0.052)	(0.057)	(0.078)
Num.Obs.	1011	1011	1011	1011
R2	0.087	0.081	0.083	0.032
R2 Adj.	0.075	0.070	0.072	0.021
Log.Lik.	−1531.722	−1535.315	−1533.847	−1561.358
RMSE	1.10	1.10	1.10	1.13
Std.Errors	HC2	HC2	HC2	HC2

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

Note: The dependent variable is the amount of solar installed in a district in Malaysia (2011-2018). The main variable is a dummy variable for each different manufacturer. I employ OLS with cluster robust standard errors to estimate the relationship between presence of foreign manufacturing in a district and solar installation.

A.4 Foreign Manufacturing and Local Installation (Grouped)

	Model 1	Model 2	Model 3	Model 4
(Intercept)	−1.061*	0.120	−1.795***	0.260**
	(0.431)	(0.079)	(0.430)	(0.081)
China	−0.575**	−0.563**	−0.491**	−0.013
	(0.205)	(0.209)	(0.170)	(0.111)
Denmark	−0.029	−0.062	−0.022	−0.153
	(0.134)	(0.135)	(0.134)	(0.137)
Japan, United States	−0.212**	−0.159*	−0.263***	−0.267***
	(0.075)	(0.064)	(0.070)	(0.071)
Japan, United States, China	0.052	0.115	−0.006	0.006
	(0.110)	(0.106)	(0.105)	(0.105)
South Korea	−0.614**	−0.568*	−0.574**	−0.151
	(0.227)	(0.259)	(0.182)	(0.102)
Median GDP	0.016	0.033***		
	(0.011)	(0.009)		
Electricity Consumption (Log)	0.106*		0.174***	
	(0.042)		(0.039)	
Land Area	−0.055	−0.197***	−0.001	−0.426***
	(0.050)	(0.052)	(0.058)	(0.078)
Num.Obs.	1011	1011	1011	1011
R2	0.088	0.082	0.084	0.032
R2 Adj.	0.075	0.070	0.072	0.021
Log.Lik.	−1531.184	−1534.784	−1533.419	−1561.299
F	5.393	5.746	5.844	6.728
RMSE	1.10	1.10	1.10	1.13
Std.Errors	HC2	HC2	HC2	HC2

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

Note: The dependent variable is the amount of solar installed in a district in Malaysia (2011-2018). As the independent variable, this analysis includes composite indicators where districts have more than one manufacturer present. I employ OLS with cluster robust standard errors to estimate the relationship between presence of foreign manufacturing in a district and solar installation.

A.5 Percent Imports from China and Tariffs

	Model 1	Model 2	Model 3	Model 4
(Intercept)	9.619*	7.104+	9.513**	−4.016
	(4.395)	(4.163)	(2.943)	(4.693)
Antidumping	−0.229***	−0.216***	−0.274***	−0.242***
	(0.040)	(0.040)	(0.036)	(0.024)
Democracy (V Dem)	0.035	0.045	0.045	−0.034
	(0.131)	(0.130)	(0.147)	(0.105)
FiT	0.037	0.035	0.044*	
	(0.023)	(0.023)	(0.022)	
Political Constraints	0.064	0.073	0.035	
	(0.055)	(0.056)	(0.054)	
GDP per capita (log)	−0.053	−0.001	0.004	0.032
	(0.036)	(0.041)	(0.037)	(0.029)
Population	0.128	0.089	0.103	0.061
	(0.148)	(0.141)	(0.147)	(0.076)
Land	−0.657*	−0.658**	−0.825***	0.196
	(0.291)	(0.247)	(0.196)	(0.331)
Carbon Emissions	0.002	−0.054		
	(0.131)	(0.124)		
Fossil Fuel Consumption	0.006*	0.003		
	(0.002)	(0.003)		
Electricity Consumption (Log)	0.030	0.091		
	(0.061)	(0.068)		
Trade (log)	−0.901		0.096	
	(1.066)		(0.969)	
Net FDI Inflows (log)	−0.007		−0.005	
	(0.006)		(0.006)	
Corruption	0.001	0.002	−0.007	
	(0.014)	(0.014)	(0.014)	
OECD Membership	0.086	0.088	0.063	0.045
	(0.070)	(0.068)	(0.077)	(0.065)
Kyoto Protocol	−0.042+	−0.054*	−0.054*	−0.052*
	(0.025)	(0.024)	(0.024)	(0.022)
Num.Obs.	1718	1894	2003	3677
R2	0.588	0.581	0.589	0.580
R2 Adj.	0.551	0.546	0.555	0.556
Log.Lik.	751.171	803.204	797.664	1019.700
RMSE	0.16	0.16	0.16	0.18
Std.Errors	by: PartnerISO	by: PartnerISO	by: PartnerISO	by: PartnerISO

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

Note: The dependent variable is the percentage of solar panels (quantity) imported from mainland China. I employ OLS with country and year fixed effects to estimate the relationship between the imposition of tariffs on Chinese solar panel imports and share of solar panels imported from mainland China.

A.6 Percent Imports from SE Asia and Tariffs

	Model 1	Model 2	Model 3	Model 4
(Intercept)	−7.218+	−6.996*	1.061	1.436
	(3.803)	(3.430)	(1.982)	(1.477)
Antidumping	0.049**	0.052**	0.067***	0.066***
	(0.018)	(0.016)	(0.016)	(0.016)
Democracy (V Dem)	−0.076	−0.094	−0.056	−0.031
	(0.061)	(0.071)	(0.042)	(0.026)
FiT	−0.008	−0.012	−0.010	
	(0.010)	(0.010)	(0.007)	
GDP per capita (log)	−0.027+	−0.026*	0.006	0.011
	(0.016)	(0.013)	(0.011)	(0.010)
Population	0.119*	0.123*	0.079+	0.067+
	(0.055)	(0.048)	(0.042)	(0.039)
Land	0.137	0.083	−0.055	−0.040
	(0.109)	(0.076)	(0.077)	(0.060)
Carbon Emissions	0.073	0.078*		
	(0.047)	(0.035)		
Fossil Fuel Consumption	0.000	0.000		
	(0.001)	(0.001)		
Electricity Consumption (Log)	0.011			
	(0.015)			
Trade (log)	0.115		0.269	
	(0.379)		(0.290)	
Net FDI Inflows (log)	0.000		0.002	
	(0.002)		(0.002)	
Corruption	0.006	0.006	0.011*	
	(0.004)	(0.004)	(0.005)	
OECD Membership	−0.038	−0.044	−0.029	−0.031
	(0.062)	(0.065)	(0.046)	(0.046)
Kyoto Protocol	−0.005	−0.003	−0.001	−0.002
	(0.011)	(0.010)	(0.009)	(0.007)
Num.Obs.	1749	1988	2523	3677
R2	0.528	0.515	0.464	0.441
R2 Adj.	0.489	0.479	0.433	0.412
AIC	−4558.6	−5107.8	−5955.9	−8950.7
BIC	−3831.5	−4330.1	−5127.6	−7820.5
Log.Lik.	2412.279	2692.878	3119.947	4657.330
RMSE	0.06	0.06	0.07	0.07
Std.Errors	by: PartnerISO	by: PartnerISO	by: PartnerISO	by: PartnerISO

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

Note: The dependent variable is the percentage of solar panels (quantity) imported from Southeast Asia (Malaysia, Thailand, Vietnam, Cambodia). I employ OLS with country and year fixed effects to estimate the relationship between the imposition of tariffs on Chinese solar panel imports and share of solar panels imported from SE Asia.

A.7 Total Value of Imports from China and Tariffs

	Model 1	Model 2	Model 3	Model 4
(Intercept)	−0.983	−2.163	−9.168	−5.282
	(7.854)	(8.310)	(8.751)	(4.616)
Antidumping	−0.074*	−0.084**	−0.102***	−0.108***
	(0.029)	(0.027)	(0.027)	(0.018)
Democracy (V Dem)	−0.170	−0.106	−0.122	0.074
	(0.158)	(0.160)	(0.128)	(0.100)
FiT	−0.032	−0.029	−0.031	
	(0.023)	(0.022)	(0.023)	
Political Constraints	0.094	0.113	0.113	
	(0.079)	(0.077)	(0.073)	
GDP per capita (log)	0.126*	0.114*	0.139**	0.100***
	(0.059)	(0.050)	(0.054)	(0.030)
Population	0.030	−0.026	0.017	−0.080
	(0.132)	(0.118)	(0.127)	(0.067)
Land	−0.129	0.142	0.604	0.447
	(0.539)	(0.562)	(0.608)	(0.318)
Carbon Emissions	0.314*	0.222+		
	(0.143)	(0.122)		
Fossil Fuel Consumption	−0.002	−0.001		
	(0.003)	(0.003)		
Electricity Consumption (Log)	−0.138*	−0.082		
	(0.069)	(0.072)		
Trade (log)	0.695		−0.147	
	(1.102)		(0.993)	
Net FDI Inflows (log)	−0.008+		−0.006	
	(0.005)		(0.004)	
Corruption	0.008	0.009	0.001	
	(0.012)	(0.010)	(0.011)	
OECD Membership	−0.034	−0.031	−0.018	−0.082+
	(0.045)	(0.044)	(0.048)	(0.048)
Kyoto Protocol	−0.011	−0.018	−0.014	−0.032
	(0.028)	(0.025)	(0.026)	(0.020)
Num.Obs.	1718	1894	2003	3677
R2	0.684	0.670	0.658	0.594
R2 Adj.	0.656	0.642	0.630	0.570
Log.Lik.	802.602	883.911	829.270	1191.077
RMSE	0.15	0.15	0.16	0.18
Std.Errors	by: PartnerISO	by: PartnerISO	by: PartnerISO	by: PartnerISO

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

Note: The dependent variable is the total value of solar panels imported from mainland China. I employ OLS with country and year fixed effects to estimate the relationship between the imposition of tariffs on Chinese solar panel imports and share of solar panels imported from mainland China.

A.8 Total Value of Imports from SE Asia and Tariffs

	Model 1	Model 2	Model 3	Model 4
(Intercept)	0.653	2.407	5.955*	4.225**
	(3.995)	(2.892)	(2.691)	(1.592)
Antidumping	−0.008	−0.009	−0.006	−0.008
	(0.015)	(0.015)	(0.016)	(0.015)
Democracy (V Dem)	0.080	0.061	0.004	0.006
	(0.065)	(0.067)	(0.043)	(0.026)
FiT	−0.006	−0.004	−0.005	
	(0.005)	(0.005)	(0.005)	
GDP per capita (log)	−0.019	−0.005	0.007	0.007
	(0.016)	(0.011)	(0.009)	(0.006)
Population	0.044	0.029	0.040+	0.029*
	(0.028)	(0.023)	(0.021)	(0.014)
Land	−0.019	−0.077	−0.142	−0.076
	(0.154)	(0.101)	(0.144)	(0.082)
Carbon Emissions	0.051+	0.035		
	(0.030)	(0.024)		
Fossil Fuel Consumption	−0.001	0.000		
	(0.001)	(0.001)		
Electricity Consumption (Log)	0.009			
	(0.019)			
Trade (log)	−0.354		−0.010	
	(0.343)		(0.244)	
Net FDI Inflows (log)	0.000		0.000	
	(0.002)		(0.002)	
Corruption	0.003	0.001	0.001	
	(0.004)	(0.004)	(0.003)	
OECD Membership	0.011	0.010	0.018**	0.013*
	(0.007)	(0.007)	(0.007)	(0.006)
Kyoto Protocol	0.000	−0.003	0.000	0.001
	(0.010)	(0.010)	(0.010)	(0.006)
Num.Obs.	1749	1988	2523	3677
R2	0.713	0.676	0.627	0.585
R2 Adj.	0.690	0.652	0.605	0.563
AIC	−4782.1	−5243.4	−6842.4	−10 384.7
BIC	−4055.1	−4465.7	−6014.1	−9254.5
Log.Lik.	2524.072	2760.676	3563.221	5374.329
RMSE	0.06	0.06	0.06	0.06
Std.Errors	by: PartnerISO	by: PartnerISO	by: PartnerISO	by: PartnerISO

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

Note: The dependent variable is the total value of solar panels imported from Southeast Asia (Malaysia, Thailand, Vietnam, Cambodia). I employ OLS with country and year fixed effects to estimate the relationship between the imposition of tariffs on Chinese solar panel imports and total value of solar panels imported from SE Asia.

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