Does Manufacturing Matter? Foreign investment and local linkages in the Malaysian solar industry

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Abstract

The US-China trade war created new opportunities for developing countries to attract foreign investment in solar manufacturing, which was historically concentrated in the United States, Germany, and China. To avoid United States and European Union tariffs on solar panel imports, China has moved solar panel manufacturing abroad to Malaysia, Vietnam, Thailand and Cambodia. Renewable energy technology presents an important opportunity for developing countries seeking to both decarbonize and level up in global value chains, and industrial policy historically places significant emphasis on manufacturing as the foundation of domestic industrial upgrading. But does this manufacturing relocation create local linkages for countries that receive FDI? This paper evaluates how and why renewable energy manufacturing struggles to create local linkages, most importantly, for local solar installation. Drawing upon bilateral solar panel trade data, interviews with local Malaysian firms, and descriptive evidence regarding spatial patterns in local solar installation, I find that Chinese production relocation had no effect on local solar installation nor significant impacts on backwards linkages to suppliers. Rather, Chinese panels manufactured in Malaysia are destined for export to Western countries, because Chinese manufacturers in Malaysia profit more from exporting to the United States rather 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 among the manufacturing facilities themselves. This calls into question existing industrial policy scholarship that emphasizes the localization of production for downstream market growth and indicates that escalating global trade tensions can lead to inefficient externalities that do little to benefit local markets via technology transfer.

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1 Introduction

Tariffs on Chinese exports to the United States and European Union have reshaped global supply chains across a variety of 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. After the US and EU escalated tariffs on the import of solar modules from China beginning in 2012 and 2013 respectively, Chinese firms rearranged supply chains to manage new transaction costs with these important Western trade partners (Bradsher 2014; Ball, Reicher, Sun, & Pollock 2017). While significant attention has been drawn to the impacts of tariffs on the energy transitions in the US, EU and China, these trade disputes also reshape solar value chains for often-overlooked middle-income countries caught in the crossfire of international competition (Yean Tham, Yi, & Ann 2019; Houde & Wang 2022).

In particular, tariffs on solar imports led Chinese firms to offshore and scale up existing solar panel manufacturing in Malaysia, Thailand, Cambodia and Vietnam to circumvent US and EU anti-dumping (AD) duties (Ball et al. 2017) on imports of solar panels from mainland China. These four countries, currently under investigation by the US Department of Commerce for a new round of anti-circumvention tariffs, received an inflow of Chinese solar manufacturing investment, albeit managed by Chinese firms seeking to reroute a large portion of solar panel trade to the US (Wong, Singh, & Casey 2022).

Manufacturing investment has long formed the cornerstone of industrial policy strategy (Amsden 1992; Wade 1992; Gereffi & Wyman 1990). In the 1990s, East Asian success in export oriented industrialization across Japan, Taiwan, and South Korea in technology intensive products like automobiles and semiconductors propelled these developing states up the value chain. In light of the resurgence of attention to industrial policy for the energy transition (Rodrik 2014; Harrison, Martin, & Nataraj 2017; Allan, Lewis, & Oatley 2021), solar energy manufacturing has received significant attention as a strategy to both enter global value chains and potentially promote domestic deployment (Nahm 2021; Jackson, Lewis, & Zhang 2021; Zhang & Gallagher 2016). China in particular has been very successful, relying on technology transfer in wind and solar from western countries seeking low labor costs in the early 2000s, and scaling up domestic production in subsequent years (Lewis & Wiser 2007; Lewis 2014; Ball et al. 2017).

In light of tariffs, then, China may now be transferring its solar manufacturing expertise to neighboring Southeast Asian states (Wong et al. 2022). 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 by reducing the material costs of inputs and transaction costs of procurement for domestic firms (Javorcik & Spatareanu 2005; Blalock & Gertler 2008).

On the other hand, evidence from emerging economies suggests that manufacturing may not always lead to local growth along the supply chain. While investment from foreign manufacturers and connection to global supply chains 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. 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) which may apply to solar as a nascent industry.

This paper evaluates the degree to which Chinese production localization shaped growth in the local solar industry across the value chain. I first introduce literature which emphasizes the potential benefits of foreign manufacturing investment on local economic growth, with a focus on employment and forward linkages to local firms.[1] I contrast this local linkage narrative with an alternative account emphasizing the limitations of manufacturing for meaningful technology transfer, in particular given the trade war context and small pro-solar coalition at the time of Chinese firm relocation. I propose that the unique circumstances surrounding Chinese production relocation - namely avoiding Western tariffs - complicate the likelihood of forward linkages to local solar firms despite the potential for technology transfer.

I assess these hypotheses through a combination of regression analysis, firm level descriptive statistics and interviews with Malaysian solar firms. I first draw upon interviews from 15 solar industry professionals (13 companies) to assess whether Chinese manufacturing led to solar indus-

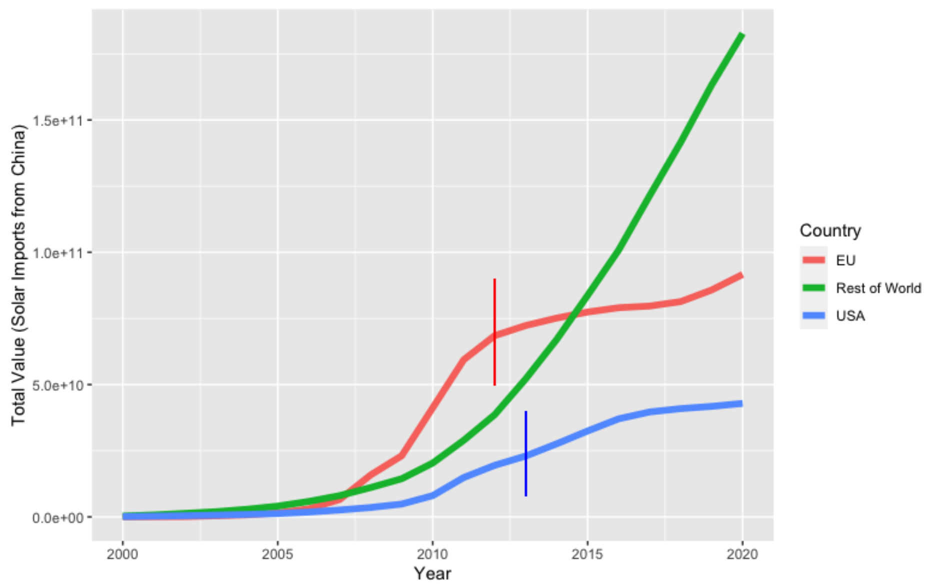
[1] As I elaborate below, backwards linkages are unlikely as the primary input for solar panels is poly-silicon, derived from quartz glass. This is very constrained by resource endowments, which are abundant in China itself.

try growth or a "middle income trap" outcome in Malaysia. Interviews confirm that Malaysian produced (Chinese-owned) solar was exported to the US and EU, with few connections to the local market beyond direct employment. Both the trade war context and national government's preference for a quick return on investment diminished the potential of negotiation for local linkages. Further, the solar industry was small at the time of production relocation, so there was not a strong coalition to push for local benefits from manufacturing facilities beyond the employment of local Malaysians.

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 in the solar market scaling up project investments in the in the last ten years, alongside a thriving market of local service providers. This is, in part, due to the fact that the tariffs which led to manufacturing relocation also pushed China to increase its exports to countries like Malaysia, as Western markets narrowed imports from mainland production facilities. While Chinese firms in Malaysia preferred to contract their product to Western buyers, Malaysians used the same firms' panels *from mainland China*. As one interviewee put it, Malaysians can wait six weeks for any leftover domestically-produced panels that did not make it to the US, or import panels two weeks from China. This qualitative evidence suggests that the trade war led to both unintended consequences in terms of production relocation, but also, increased availability of cheap technology for states without tariffs on imports from mainland China.

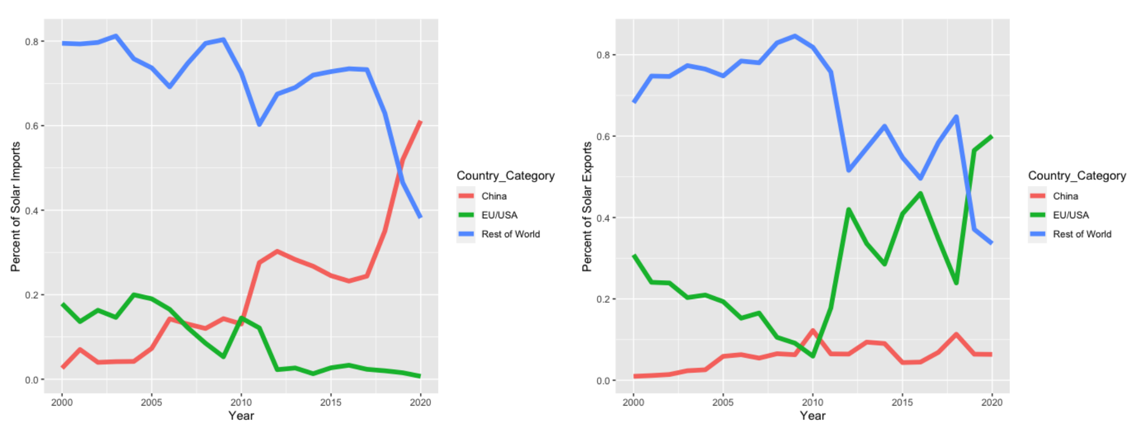
Quantitative evidence lends support for this explanation. I draw upon unique project-level data in Malaysia to demonstrate that manufacturing production relocation, in and of itself, had little impact on local solar installation. On the other hand, descriptive statistics indicate local job creation at manufacturing facilities. I then turn to global data on solar panel trade to assess evidence of tariff circumvention, which I propose explains the lack of local linkages from manufacturers in Malaysia. I show that while countries with an anti-dumping duty decreased solar module imports from mainland China, the rest of the world imported more Chinese products - countries like Malaysia found a new, low-cost source of solar panel supply. Figure 1 illustrates this trend, plotting total value of solar from China imports to the EU, US and rest of world over time. While the EU and US taper off in their shares of Chinese exports after tariffs (2012 and 2013, respectively, per the color-corresponding lines), imports elsewhere soared.

Figure 1: Solar Imports from China (2000-2020)



Second, exports from the four Southeast Asian countries (Malaysia, Thailand, Cambodia and Vietnam), now destinations under investigation by the US Department of Commerce for tariff circumvention, increased to countries with active AD duties, namely the US and EU. Simply put, panels manufactured in Malaysia were exported to countries with tariffs against China, not purchased by local firms for local solar installation. While Malaysian firms did use Chinese panels, they were imported from China, rather than produced locally. Figures 2A and 2B show that solar imports from China did increase to these four Southeast Asian countries, yet so did exports from these states to the US and EU, consistent with a strategy of tariff circumvention.

Figure 2: Imports (left) and Exports (right) of Solar Modules to/from Southeast Asia (2000-2018)



Taken together, these results diverge from both the "manufacturing miracle" and "middle income trap" development pathways. 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. However, the trade war created an unexpected positive externality for the pro-renewable energy political coalition in Malaysia, beyond its direct effect on the local economy. Manufacturing factories in mainland China faced lower profits from exporting to their top export destinations, the US and EU, after 2012 and 2013 respectively. 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, fueled in part by tariffs themselves, allowed Malaysian firms to to import low-cost modules from mainland China, leave costly German suppliers behind, and grow the coalition of solar project owners and service providers. Overall, the vast majority of local firms building solar projects imported panels directly from China, and indeed benefited significantly from cost declines - just not due to forward linkages from local manufacturers.

2 Background: Solar Industry Supply Chain Fragmentation

Chinese industrial policy for solar panel manufacturing and subsequent boom in the global supply of solar panels upended global value chains for modules, with unintended consequences for middle-income countries caught between US-China geopolitical rivalry. Successful subsidization of production throughout China created 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). Between 2005-2008, Chinese manufacturing expansion was 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 among localities with rapidly rising energy demand and existing 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 (IPO) 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, which received supportive finance from the China Development Bank (CDB), a Chinese development finance institution, which supported solar manufacturing export growth despite 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 the global recession, without significant national 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 struggling to match low-cost Chinese exports (Ball et al. 2017). Tariffs from the US were first enacted in 2012, 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 in 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.

3 Foreign Investment and Local Linkages

The relocation of Chinese manufacturing facilities to Southeast Asian countries provides an opportunity for host countries to gain experience and grow along the solar value chain. A robust economics literature foregrounds these industrial policy success cases, establishing that foreign investment in the manufacturing sector, in particular[2], can convey significant positive externalities to developing countries, including higher local wages (Feenstra & Hanson 1995; Lipsey & Sjöholm 2004) and local firm productivity both up and down the value chain (Blomström & Persson 1983; Javorcik 2004; Helpman 2006; Havranek & Irsova 2011). As the most productive firms from their respective countries of origin, multinational corporations (MNCs) can bring skills, technology, and production standards to developing countries with little prior experience with a technology (Greenhill, Mosley, & Prakash 2009; Malesky & Mosley 2018).

While much attention has been paid to backwards linkages, when a multinational manufac-

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

turer sources inputs from local suppliers (Kim, Liao, & Miyano n.d.; Haskel, Pereira, & Slaughter 2007; Javorcik & Spatareanu 2004), I focus on forward linkages and local employment in solar manufacturing. Solar panel manufacturers most often require poly-silicon, which is derived from quartz glass (Mulvaney 2014). Poly-silicon availability, then, is constrained by countries' resource endowment in quartz - Malaysia and other Southeast Asian countries lack deposits of quartz, so are simply unable to become supplier firms to manufacturers. In fact, China primarily sources inputs domestically, given its vast poly-silicon resources in Xinjiang (Wang & Lloyd 2023) This lack of backward linkages is largely confirmed from interview evidence below, though Chinese manufacturers have diversified their source of poly-silicon in light of the Uyghur Forced Labor Prevention Act and recent government scrutiny (e.g. The Federal Bureau of Investigation's Raid on JinkoSolar Manufacturing facilities in Florida (Groom 2022)). As a result, the best cases for local linkages lie in the employment of local workers and forward linkages to domestic firms seeking to buy solar panels for installation.

Most directly, manufacturing can provide employment for local workers, especially skilled labor (Scheve & Slaughter 2004, (Pandya 2010; 2016; Walter 2010) FDI can transfer both unique skills and also offer higher wages than local competitors (Feenstra & Hanson 1995; Lipsey & Sjöholm 2004; Driffield 1999).[3] Of course, these employment benefits are conditional on the ability of foreign firms to actually find qualified local workers - in part linked to the absorptive capacity[4] of the domestic market (Blomström & Kokko 1998; Alfaro 2003). In Southeast Asian countries, particularly Malaysia and Thailand, there is good reason to expect local employment benefits given these states' existing expertise. Both upper-middle-income countries have experience with electronics, semiconductors, and medical device manufacturing, to provide a few specific examples (Raj-Reichert 2020; Intarakumnerd, Chairatana, & Chaiyanajit 2016). Furthermore, the costs of local manufacturing labor in SE Asia are comparable if not lower than in China, so there is little incentive for Chinese firms to bring their employees on a skill or cost basis (Born 2023). As a result, I expect manufacturers to directly employ locals in production facilities.

Hypothesis 1: *In Malaysia, solar manufacturing facilities employ local workers.*

In addition to local employment, foreign firms can introduce a technology to the local market

[3] XXX The job creation framing is new, and came out of recent interviews indicating positive employment benefits if not local linkages. Is this compelling and interesting, or should I focus on forward linkages only? XXX

[4] Broadly defined as ability of local market to uptake a foreign technology, both in terms of labor, domestic capital, and financinal market development (Perez 1997; Wang & Blomstrom 1992; Kinoshita & Mody 2001; Blomström, Lipsey, & Zejan 1996; Blomström, Kokko, & Globerman 2001; Alfaro et al. 2004)

via forward linkages, where FDI supplies local firms, in this case, buying solar panels. This linkage could result in lower costs of material inputs 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 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 reason to expect that foreign manufacturing investment would create linkages and growth in solar panel installation.

Hypothesis 2: *In Malaysia, areas near foreign solar manufacturing facilities should 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 regarding the benefits of foreign investment for long-term industry growth. Despite positive evidence from late industrialization in East Asia, recent cases of the "middle income trap" suggest that local linkages are not guaranteed. Either foreign firms or the government must to have an incentive to pursue local linkages that fuel industrial upgrading (R. F. Doner & Schneider 2016). In the case of solar, a nascent industry with a growing - but small - political coalition at the time of manufacturing relocation, the state perhaps had little incentive to push FDI for greater benefits. Furthermore, against the backdrop of the US-China trade war, the odds may be stacked all the higher against host countries seeking to leverage FDI for longer-term industrial upgrading.

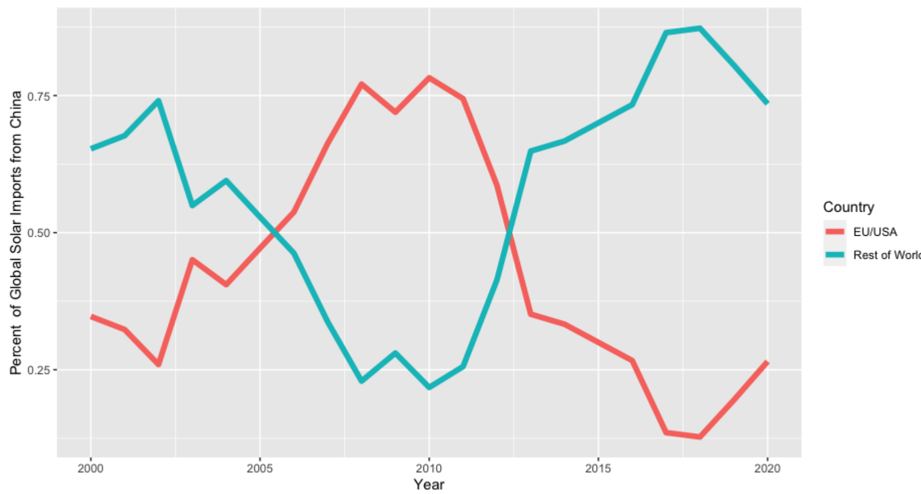
While late industrializers like Japan, South Korea, and Taiwan were able to leverage export industries in manufactured products to propel themselves up the global value chain and build the capacity for domestic innovation, this success has not carried over to all emerging markets. East Asian success 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 states including Vietnam, Thailand, and Mexico, for example, have struggled to make the step from export-oriented manufacturing under the leadership of foreign firms to indigenous innovation, otherwise known as the “middle income trap” (Ohno 2009; Kharas & Kohli 2011; Eichengreen et al. 2013; Paus 2012; 2020). These lackluster economic outcomes stem from a common political problem: a lack of “upgrading coalitions” between business and government to drive necessary reforms (R. F. Doner & Schneider 2016). Coalition (lack of) cohesion can be attributed to rising inequality in the labor force, reliance on politically inactive foreign companies, and neoliberal reforms that disempower state intervention in the market (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 and lack of industry coordination, along with a market-based approach to policy rather than strategic long-term plan, led to sectoral stagnation. Similarly, in the Malaysian electronic sector, reliance on foreign investment and lack of government negotiation has led to the persistence of low skilled, low wage jobs while upgrading takes place elsewhere (Raj-Reichert 2020). The solar industry shares many core competencies with these sectors, and is perhaps even a tougher case for political coalition-building, given it is a new industry where local firms had only recently entered the project ownership business at the time of manufacturing relocation.

Furthermore, manufacturers themselves have little incentive to establish deep local roots conducting the majority of R&D in home countries rather than host countries (R. F. Doner & Schneider 2016; Naseemullah 2022), even more so given the trade war context. Despite ideal conditions for direct employment, with a skilled base of local engineers across host states in Southeast Asia, MNCs are seldom active in domestic politics, and careful to safeguard technology (R. F. Doner & Schneider 2016; Raj-Reichert 2020). Indeed, Chinese investors arrived in Malaysia by way of a tariff circumvention strategy, where the high cost of import tariffs decreased the price competitiveness of their product in American and European markets (Ball et al. 2017). While the cost of local labor in Malaysia is comparable to that in China in terms of manufacturing costs, which secures employment for local workers (Born 2023), the *profit from selling Malaysian-made solar panels* in the Malaysian market is assuredly lower in comparison to profit in the United States and Europe. Though recipient SE Asian countries are certainly well positioned to take advantage of local panel supply in terms of the demand for solar panels, it is less clear that foreign manufacturers have an incentive to sell to these local markets and assist local firms in making the most of their connection to global supply chains.

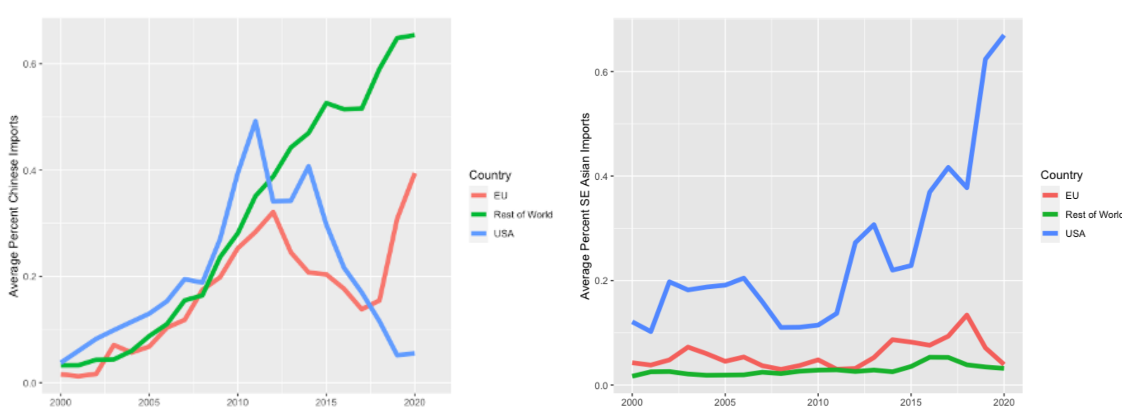
In light of the trade war, which only amplifies the already-arms-length approach favored by MNCs, there is an particularly pernicious "lack of incentive" to establish linkages with domestic solar companies down the value chain. First, import tariffs on Chinese-made panels to the United States and EU led to an increase in price, and therefore reduction in demand from Western consumers. European quota impositions in December 2013 a sharp increase in US tariffs in 2014 led to a jump in import tariffs from 26.71 to 78.42 percent on solar cells and 27.64 percent to 49.79 for modules (Bradsher 2014; Cardwell 2014; Commission 2013). As a result, the US and EU originally comprised 78.2 percent of China's total solar exports in 2010, but by 2015 accounted for a mere 29.9 percent of solar panels that the world imported from China, as shown by Figure 3 below (UN Comtrade 2023; Author's calculation). While imports to the US and EU declined, imports to the rest of the world soared, as mainland China-based factories faced lower profits from established partners. As revealed throughout interviews with local firms, Malaysian firms benefited in this sense, directly importing cheap panels from mainland China.

Figure 3: Percentage of Chinese Solar Imports to US and EU vs. Rest of World



The shift of solar cell and module manufacturing facilities to nearby Southeast Asian countries endeavored to offset these losses in American and European markets (Wong et al. 2022). In markets with import tariffs, Southeast-Asian made panels yield greater profit for solar manufacturing companies than Chinese-made panels. As a result, manufacturers would have little incentive to supply panels to local markets relative to exporting onwards to the US and EU. Descriptive figures suggest that on average, solar imports from China fell among tariff adopters, but rose from Southeast Asia. Figure 4 shows that the average fraction of solar imports from China declined precipitously for the US and EU after tariff imposition, while for the US in particular, imports from Southeast Asia rose rapidly following tariff imposition (Figure 4B).

Figure 4: Solar Imports: China (left) and Southeast Asia (right)



Evidence of trade diversion would cut against potential local linkages to downstream firms in the solar industry, and point towards an enclave effect consistent with the "middle income trap."

With both a lack of government and investor incentive to establish downstream relationships and share knowledge with local solar companies, I would expect that trade diversion dynamics hold out. First, we would observe that (1) AD-imposing countries would import a lower percentage of solar panels from China in comparison to countries that did not impose AD duties and (2) AD imposing countries import a greater percentage of solar panels from Southeast Asia, due to Chinese solar manufacturers' tariff circumvention-motivated production relocation. These hypotheses run counter to logic of forward linka ges, in light of both small pro-linkage political coalitions and the tariff-driven cost differentials for China-based and Southeast-Asia based manufacturers respectively.

Hypothesis 3: *Countries with an AD duty against China import significantly less solar from China than countries without AD duties.*

Hypothesis 4: *Countries with an AD duty against China import significantly more solar from Southeast Asia than countries without an AD duty against China.*

4 Case Study: Solar Manufacturing and Local Linkage in Malaysia

Solar supply chain fragmentation during the US-China trade war set the stage for Chinese solar manufacturing investment in Malaysia. This section focuses on the case of Malaysia, drawing upon interviews with 13 firms (15 individuals) conducted between spring 2023-winter 2024, and select secondary sources, to evaluate both hypotheses regarding employment, forward linkages (Hypothesis 1-2), and tariff circumvention (Hypothesis 3-4). 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 (as a best case scenario for local linkages) and richness of data on domestic household and firm-level solar installation under specific green industrial policies,[5] which I leverage in the following quantitative section. 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 bodes well for returns to local employment but less so for forward linkages with local firms.[6] While manufacturing firms drew upon local

[5]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)

[6]XXX The job creation framing is new, and came out of a two particularly detailed interviews with seasoned industry experts XXX. If this is compelling and interesting, I will try to do more interviews with manufacturing

talent for employment, there was little interaction with the market outside production enclaves. This arose due to both lack of pro-linkage political coalitions within Malaysia, and little incentive on the part of MNCs. Below, I leverage 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 have been documented to serve as production enclaves where foreign-manufactured goods are destined for export rather than domestic consumption (Alkon 2018).[7] Interviews with solar industry businessmen indicate that facility siting was strategic to make the most of Malaysian expertise (Interviews # XXX-13, January 25, 2024). 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, Penang, where both JinkoSolar and JA Solar are located, is the Chinese speaking part of Malaysia - this only further reduces the transaction costs of local employment. Interviewees indicate that locals account for a majority of positions, with only the uppermost managerial staff brought in from abroad (Interview #13, January 25, 2024). 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)

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 quick deal over the negotiation of benefits like a local content requirement, or local sales, for example (Interview #15, January 2024).[8] Furthermore, at the time of Chinese relocation, the local solar industry was small, so there was not a strong coalition of firms to push policymakers, particularly in the context of the trade war (Interview 13, June

company employees themselves.

[7] 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; Chen 2019; Springer, Evans, & Teng 2021; Tang 2022).

[8] XXX I need to do more interviews on this mechanism! XXX

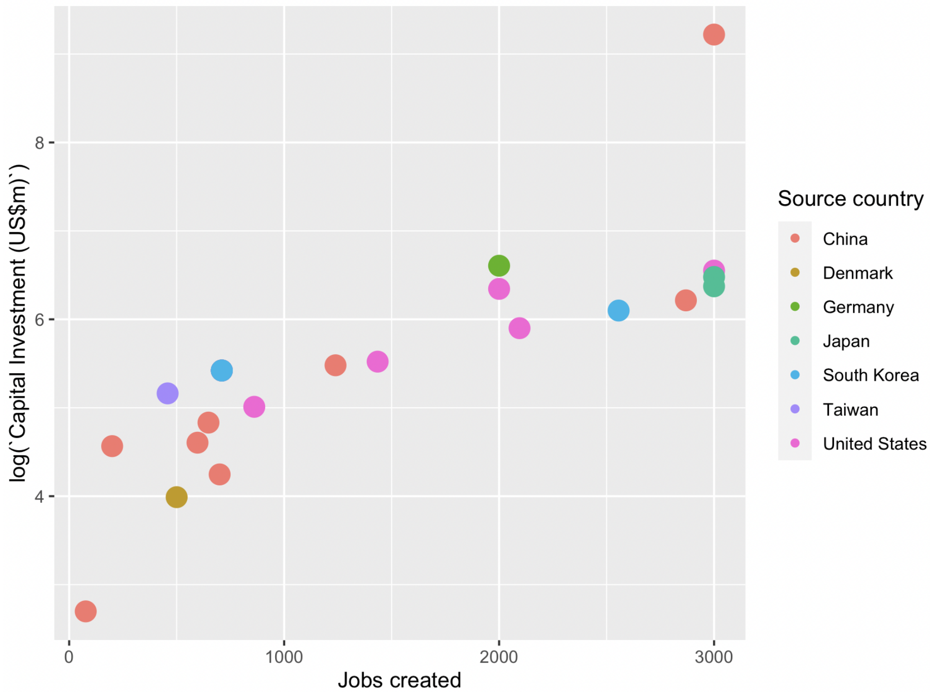
2023; Interview 15, January 2024). This echoes middle income trap scholarship, which emphasizes that weakness among political coalitions in favor of industrial upgrading can lead to stagnation in manufacturing.

Other solar panel manufacturers operating in Malaysia serve as a useful point of comparison in terms of employment generated by manufacturing facilities. While these other manufacturers are unlikely to foster forward linkages due to the comparatively high cost of their products relative to China, they have been operating in the Malaysian market much longer, and offer a useful reference against which to benchmark job creation. Two 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 respectively.[9] 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 (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 fdiMarkets, I provide a simple visualization of the jobs created-to-capital ratio for each production facility, color coded by investor country of origin. The figure below, with jobs created on the x-axis and capital investment (logged) on the y-axis provides suggestive evidence that Chinese manufacturers create a similar number of jobs per dollar invested in comparison to their counterparts.

[9]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.

Figure 5: Investment and Jobs Creation in Malaysia



Forward Linkages for Solar Panels?

While solar panel manufacturing appears to have created jobs for locals, interviews paint a less positive portrait for local supplier-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. 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) (Joshi 2018). As solar manufacturing relocation occurred in the middle of solar subsidy implementation, Malaysia is an ideal case to examine whether manufacturing production positively impacted local solar installation. The FiT and NEM policies allowed firms to sell solar back to the grid, and were both limited to small scale projects (maximum of 5 megawatts in size) and firms with domestic holdings.

The average Malaysian investor in solar power generation is a domestic firm, with operations in construction, electrical engineering, warehousing or manufacturing (Interview #3, May 30, 2023; Interview #4, May 31, 2023; Interview #9, June 22, 2023; Interview #12, July 8, 2023). These firms range from small firms operating in one industrial park to engineering, procurement, and construction (EPC) firms that work both in Malaysia and more recently in neighboring Asian countries like the Philippines and Thailand (Interview #5, May 31, 2023). 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 building large scale projects (Interview # 15, January 2024). 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 (i.e., importing panels from mainland China versus sourcing local panels) varies by firm size.

Even with such 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 (Interview #1, May 15, 2023; Interview #2, May 16, 2023; Interview #3, May 30, 2023; Interview #4, May 31, 2023; Interview #6, June 6, 2023; Interview #7, June 7, 2023; Interview #10, June 26, 2023; Interview #11, July 4, 2023; Interview #12, July 7, 2023). 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 (Interview #1, May 15, 2023; Interview #3, May 30, 2023; Interview #4, May 31, 2023; Interview #6, June 6, 2023; Interview #7, June 7, 2023).

Chinese factories on the mainland profit more from selling to Malaysia, and the rest of the world, relative to the US and EU after the imposition of tariffs. Chinese firms producing in Malaysia, on the other hand, reap a higher profit from exporting solar back to the US instead of selling to locals (Interview #1, May 15, 2023; Interview #3, May 30, 2023; Interview #8, June 10, 2023). Yet despite the lack of local linkages, interviewees do not report difficulty in accessing imported Chinese equipment. This is, perhaps, most surprising for small firms that do not have established connections to global solar component suppliers. But even for smaller firms like warehouse owners and boutique construction companies, importing solar panels from mainland China is the most cost-effective solution (Interview #2, May 16, 2023; Interview #6, June 6, 2023). A large firm reports being contacted by Chinese suppliers in search of likely customers (Interview #1, May 15, 2023), while smaller companies work with EPCs with connections to China and can easily source panels from abroad (Interview #2, May 16, 2023).

Furthermore, 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 specifically 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, May 16, 2023). Interviewees also noted that other companies, First Solar in particular, 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 (Interview #3, May 30, 2023; Interview #4, May 31, 2023). Notably, no interviewees mentioned significant quality differentials between different suppliers.

While solar firms in Malaysia have 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 (Interview #3, May 30, 2023; Interview #4 , May 31, 2023). 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, May 30, 2023). Another noted the availability of finance as a key area for improvement in order to boost market growth (Interview #5, May 31, 2023). While Chinese manufacturing overcapacity has allowed Malaysian firms to swap out costly German panels for low-cost alternatives (Interview #2, May 16, 2023; Interview #10, June 13, 2023), 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. While in the early stages of industry growth, the Malaysia Photovoltaic Industry Association (MPIA) and its members were seen as tree-huggers, now the group wields substantial policy influence (Interview #15, January 2024). 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. This predicts better outcomes for future negotiations over the distributive benefits of FDI 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 Research Design: 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, complementary analysis provides descriptive evidence as to whether the EU and US significantly 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. I use product-level trade data from UN Comtrade to find support both hypotheses; 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 et al. 2022)

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. Second, trade-data results indicate a significant relationship between (1) anti-dumping (AD) duty imposition and a decrease in imports from China and (2) the adoption of AD duties and increased imports from the Southeast Asian states. 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.), given that each entered the market at a different date. I include a robustness check where the IV 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, Kulim, where there are Chinese, American, and Japanese facilities.

I draw upon the fdiMarkets database 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.[10]

I leverage spatial (raster) data superimposed over the administrative level 2 boundaries of Malaysia to calculate sub-national control variables: population, gross domestic product, infant mortality, and land area. This information 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.

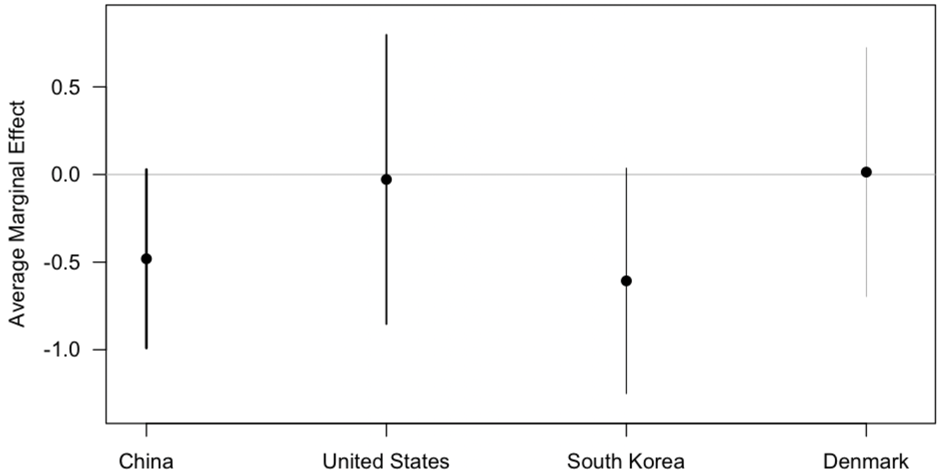
$$\text{SOLAR INSTALLATION}_{it} = \beta_0 + \beta_1 \cdot \text{CHINA MANUFACTURER}_{it} + \text{DISTRICT-YEAR FE} + \epsilon_{it}$$

Figure 6 (left) shows the average marginal effect of the presence of a given manufacturer in a Malaysian district on installed solar capacity, with significant lines bolded. Each country variable takes the value of 1 in years a manufacturer from a given country operates in a district and 0 otherwise.[11] Overall, manufacturing facility operation in a given district is not associated with higher levels of solar installation across different manufacturers.

[10]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.

[11]The full regression table is located in Appendix Table A2, robustness check in Appendix Table A3

Figure 6: Chinese Manufacturing and Spatial Solar Installation



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

In the second two analyses, I assess whether countries that imposed tariffs on Chinese imports decreased imports from China and increased imports from Southeast Asian states respectively. My primary independent variable 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 the second and third analysis 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 first analysis' DV measures the percent of solar imports from China as a fraction of total imports based on primary value (Appendix Table A3-A4).[12] 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.

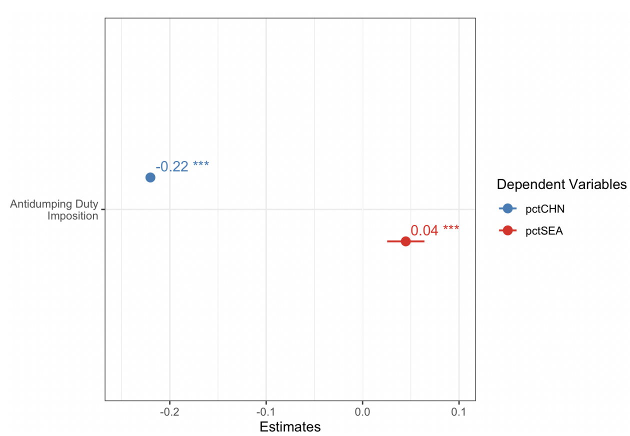
$$\text{SOLAR IMPORTS (CHINA)}_{it} = \beta_0 + \beta_1 \cdot \text{ANTIDUMPING DUTY}_{it} + \text{COUNTRY-YEAR FE} + \epsilon_{it}$$

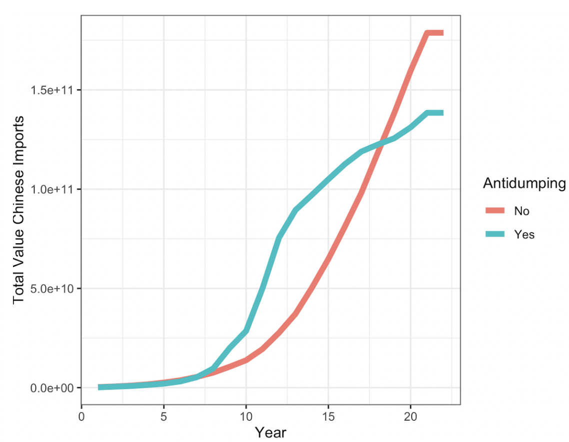
[12] I use share of Chinese imports based on quantity as a robustness check. However, there is greater missingness for this variable, particularly for imports from SE Asia, where positive Primary Value is recorded but no quantity (Appendix Table A5-A6).

I employ linear regression with country-year fixed effects and 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 investigations for tariff circumvention export a larger quantity of solar panels to countries after the 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 7a provides a plot comparing coefficients on the variable $ANTIDUMPING_{i,t}$ for $MODEL$ 2 and $MODEL$ 3 respectively, and 7b 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 escalating protection on production chains, 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 7: (a) Effects Plot (b) Antidumping and Imports Over Time





6 Conclusion

While Chinese industrial policy certainly has shaped the local solar industry in emerging markets, it is not through the relocation of production facilities and local linkages to domestic markets. There is some evidence to indicating benefits for local labor employed at manufacturing facilities, but less for 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 that likely occurred elsewhere in similar economies. Indeed, interviewees note that American and European solar components were relatively costly, and in addition to ever-important government subsidies, the cost reduction 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 earlier industrial policies, allowed for industry growth abroad.

There is a second lesson to be learned regarding the degree to which host countries can capture value and build a solar industry via manufacturing. Beyond employing a few thousand workers, there is limited evidence that multinationals' solar manufacturing production facilities provide additional value added to the local solar industry. Manufacturing alone is not sufficient to build a local solar industry, given that the structure of solar technology lends itself to concentrated economies of scale, currently dominated by Chinese producers. Both the lack of domestic "upgrading coalitions" and MNC incentives precluded the possibility of forwrad linkages. On the other hand, demand side policies like the FiT and NEM arose in every interview as key for getting the local solar market off the ground in the early stages of growth. Subsidies allowed business conglomerates with experience in construction to experiment with solar, and grow to become industry leaders, despite little assistance from potential foreign suppliers.

Malaysia is now past the need to subsidize many small firms. The state has moved on to large scale auctions, and many of the original local FiT recipients like Cypark and Gading Kencana have built large scale projects the size of several football fields. Small firms are continuing to expand in solar services and project ownership, which are both poised to expand as cross-border power trading with Singapore has been codified. Grid interconnection is yet another frontier that unlocks profit potential for renewable energy producers, as storage remains a cost barrier. While a replication of China's solar module cost reductions in these other segments of the supply chain is less than likely in the immediate future, it bears to keep in mind that for emerging markets, modular, affordable components are important 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 the experience of Malaysian locals in scaling up solar production 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 for reliance on manufacturing as a catalyst of green upgrading, but indicates opportunities for local self-determination as the costs of components declines.

Appendix

Table A1: Summary Statistics

Variable	Length	Mean	Min	Max
Percent Imports from SE Asia	3807	0.034	0	1
Percent Imports from China	3807	0.224	0	1
Antidumping	3986	0.048	0	1
Democracy (V Dem)	3985	0.52	0.015	0.926
Political Constraints	2887	0.301	0	0.726
GDP	3829	11586.488	99.757	123678.702
Population	3905	48338993.066	80410	1411100000
Land Area	3705	894738.922	300	16381390
Carbon Emissions	3664	4.43	0	47.656
Fossil Fuel Consumption	2305	66.073	0	100
Electricity Consumption	2255	3997.816	22.482	54799.175
Trade	3582	15.828	11.221	20.555
Net FDI Inflows	3839	11585046953.777	-330338474188.053	733826501994.516
Corruption (ICRG)	3080	2.66	0	6

Table A2: Foreign Manufacturing and Local Installation[13]

	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
AIC	3093.4	3098.6	3095.7	3148.7
BIC	3167.2	3167.5	3164.6	3212.7
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

Table A3: 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)
Country/China	−0.575**	−0.563**	−0.491**	−0.013
	(0.205)	(0.209)	(0.170)	(0.111)
Country/Denmark	−0.029	−0.062	−0.022	−0.153
	(0.134)	(0.135)	(0.134)	(0.137)
Country/Japan, United States	−0.212**	−0.159*	−0.263***	−0.267***
	(0.075)	(0.064)	(0.070)	(0.071)
Country/Japan, United States, China	0.052	0.115	−0.006	0.006
	(0.110)	(0.106)	(0.105)	(0.105)
Country/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
AIC	3094.4	3099.6	3096.8	3150.6
BIC	3173.1	3173.3	3170.6	3219.5
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

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

Table A4: Percent Imports from China and Antidumping

	Model 1	Model 2	Model 3	Model 4
(Intercept)	9.993*	6.798	8.734**	−4.815
	(4.723)	(4.361)	(3.216)	(4.651)
Antidumping	−0.233***	−0.218***	−0.278***	−0.241***
	(0.040)	(0.040)	(0.036)	(0.025)
Democracy (V Dem)	0.011	0.020	0.024	−0.022
	(0.126)	(0.129)	(0.143)	(0.106)
FiT	0.036	0.033	0.043+	
	(0.023)	(0.023)	(0.022)	
Political Constraints	0.059	0.075	0.029	
	(0.055)	(0.056)	(0.054)	
GDP per capita (log)	−0.054	0.016	0.009	0.038
	(0.037)	(0.042)	(0.038)	(0.031)
Population	0.124	0.097	0.106	0.083
	(0.148)	(0.143)	(0.149)	(0.080)
Land	−0.744*	−0.651*	−0.841***	0.223
	(0.298)	(0.258)	(0.180)	(0.323)
Carbon Emissions	0.000	−0.065		
	(0.132)	(0.123)		
Fossil Fuel Consumption	0.006*	0.003		
	(0.002)	(0.003)		
Electricity Consumption (Log)	0.037	0.084		
	(0.069)	(0.067)		
Trade (log)	−0.616		0.397	
	(1.053)		(0.965)	
Net FDI Inflows (log)	−0.004		−0.002	
	(0.004)		(0.004)	
Corruption	−0.002	0.001	−0.007	
	(0.014)	(0.014)	(0.014)	
OECD Membership	0.084	0.089	0.062	0.046
	(0.069)	(0.068)	(0.077)	(0.065)
Kyoto Protocol	−0.041	−0.054*	−0.053*	−0.047*
	(0.025)	(0.024)	(0.024)	(0.022)
Num.Obs.	1702	1892	1987	3637
R2	0.593	0.583	0.594	0.582
R2 Adj.	0.556	0.548	0.561	0.557
AIC	−1214.3	−1317.5	−1290.3	−1624.6
BIC	−431.0	−491.3	−434.4	−372.4
Log.Lik.	751.169	807.764	798.171	1014.277
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

Table A5: Percent Imports from SE Asia and Antidumping

	Model 1	Model 2	Model 3	Model 4
(Intercept)	−3.600*	−2.999*	−1.039	−0.477
	(1.469)	(1.215)	(0.810)	(0.880)
Antidumping	0.048*	0.045*	0.054**	0.054**
	(0.020)	(0.019)	(0.020)	(0.018)
Democracy (V Dem)	−0.063	−0.082	−0.066	−0.039
	(0.058)	(0.066)	(0.041)	(0.027)
FiT	−0.012	−0.012	−0.013+	
	(0.009)	(0.010)	(0.007)	
GDP per capita (log)	−0.020	−0.017	0.005	0.010
	(0.019)	(0.012)	(0.013)	(0.012)
Population	0.100+	0.123*	0.047	0.035+
	(0.057)	(0.049)	(0.031)	(0.020)
Land	0.115	0.072	0.001	−0.012
	(0.110)	(0.069)	(0.062)	(0.057)
Carbon Emissions	0.074	0.081*		
	(0.049)	(0.036)		
Fossil Fuel Consumption	0.000	0.000		
	(0.001)	(0.001)		
Electricity Consumption (Log)	0.013			
	(0.018)			
Trade (log)	0.118		0.065	
	(0.421)		(0.271)	
Net FDI Inflows (log)	0.000		0.001	
	(0.001)		(0.001)	
Corruption	0.004	0.003	0.006+	
	(0.004)	(0.004)	(0.003)	
OECD Membership	−0.040	−0.048	−0.030	−0.032
	(0.062)	(0.064)	(0.046)	(0.046)
Kyoto Protocol	0.001	0.003	0.000	0.001
	(0.010)	(0.010)	(0.010)	(0.007)
Num.Obs.	1735	1988	2499	3637
R2	0.549	0.523	0.511	0.469
R2 Adj.	0.508	0.483	0.478	0.438
AIC	−4622.1	−5111.3	−6366.5	−9233.8
BIC	−3825.1	−4249.7	−5428.9	−7981.7
Log.Lik.	2457.047	2709.637	3344.265	4818.916
RMSE	0.06	0.06	0.06	0.06
Std.Errors	by: PartnerISO	by: PartnerISO	by: PartnerISO	by: PartnerISO

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

Table A6: Total Value of Imports from China and Antidumping

	Model 1	Model 2	Model 3	Model 4
(Intercept)	−3.100	−4.230	−11.903	−6.685
	(7.756)	(8.079)	(8.515)	(4.542)
Antidumping	−0.077**	−0.091**	−0.103***	−0.109***
	(0.029)	(0.029)	(0.027)	(0.018)
Democracy (V Dem)	−0.199	−0.121	−0.147	0.081
	(0.162)	(0.162)	(0.130)	(0.103)
FiT	−0.031	−0.027	−0.028	
	(0.023)	(0.022)	(0.023)	
Political Constraints	0.092	0.111	0.111	
	(0.079)	(0.078)	(0.074)	
GDP per capita (log)	0.129*	0.102*	0.134*	0.092**
	(0.059)	(0.048)	(0.052)	(0.028)
Population	0.015	−0.037	0.000	−0.083
	(0.131)	(0.119)	(0.125)	(0.069)
Land	−0.008	0.308	0.789	0.558+
	(0.522)	(0.547)	(0.584)	(0.310)
Carbon Emissions	0.323*	0.222+		
	(0.141)	(0.125)		
Fossil Fuel Consumption	−0.002	−0.001		
	(0.003)	(0.003)		
Electricity Consumption (Log)	−0.158*	−0.085		
	(0.079)	(0.073)		
Trade (log)	0.929		−0.010	
	(1.122)		(1.017)	
Net FDI Inflows (log)	−0.005		−0.003	
	(0.003)		(0.003)	
Corruption	0.009	0.008	0.001	
	(0.012)	(0.010)	(0.011)	
OECD Membership	−0.036	−0.032	−0.019	−0.083+
	(0.045)	(0.044)	(0.048)	(0.048)
Kyoto Protocol	−0.014	−0.015	−0.012	−0.031
	(0.028)	(0.025)	(0.026)	(0.020)
Num.Obs.	1702	1892	1987	3637
R2	0.684	0.670	0.657	0.594
R2 Adj.	0.656	0.642	0.629	0.571
AIC	−1290.1	−1463.8	−1322.9	−1927.3
BIC	−506.9	−637.5	−467.0	−675.1
Log.Lik.	789.075	880.893	814.458	1165.645
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

Table A7: Total Value of Imports from SE Asia and Antidumping[14]

	Model 1	Model 2	Model 3	Model 4
(Intercept)	1.203	0.710	1.325	0.439
	(1.970)	(1.481)	(1.963)	(1.167)
Antidumping	0.000	−0.003	−0.009	−0.011
	(0.016)	(0.016)	(0.017)	(0.015)
Democracy (V Dem)	0.082	0.061	−0.004	0.002
	(0.067)	(0.069)	(0.044)	(0.027)
FiT	−0.006	−0.004	−0.006	
	(0.006)	(0.005)	(0.005)	
GDP per capita (log)	−0.025	−0.007	0.002	0.004
	(0.021)	(0.013)	(0.010)	(0.006)
Population	0.055+	0.031	0.040+	0.027+
	(0.030)	(0.023)	(0.022)	(0.014)
Land	−0.046	−0.085	−0.123	−0.069
	(0.146)	(0.097)	(0.144)	(0.082)
Carbon Emissions	0.064+	0.040		
	(0.033)	(0.027)		
Fossil Fuel Consumption	−0.001	0.000		
	(0.001)	(0.001)		
Electricity Consumption (Log)	0.010			
	(0.023)			
Trade (log)	−0.486		−0.093	
	(0.452)		(0.284)	
Net FDI Inflows (log)	0.000		0.000	
	(0.001)		(0.001)	
Corruption	0.003	0.001	0.001	
	(0.004)	(0.004)	(0.004)	
OECD Membership	0.009	0.009	0.018**	0.013*
	(0.008)	(0.007)	(0.007)	(0.006)
Kyoto Protocol	−0.002	−0.004	−0.004	−0.003
	(0.011)	(0.011)	(0.012)	(0.008)
Num.Obs.	1735	1988	2499	3637
R2	0.715	0.678	0.632	0.588
R2 Adj.	0.689	0.651	0.607	0.564
AIC	−4713.2	−5221.6	−6748.8	−10 222.5
BIC	−3916.2	−4359.9	−5811.2	−8970.3
Log.Lik.	2502.577	2764.777	3535.392	5313.258
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

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