Winter 12-19-2019

Failed Policy as Seen in the Solar Trade War

Emma Weirich

Failed Policy as Seen in the Solar Trade War

Emma Weirich

December, 2019

Senior thesis submitted in partial fulfillment
of the requirements for a
Bachelor of Arts degree in Economics
at the University of Puget Sound

Failed Policy as Seen in the Solar Trade War

Emma Weirich

Abstract

Increasing protectionist policies in the United States has attempted to protect solar manufacturing jobs; however, it has created negative repercussions for the majority of the industry. This paper aims to analyze the 2018 30% US tariff on all imported photovoltaic cells and modules and whether or not it has been an effective policy to protect and encourage the solar industry. To do so, the paper will analyze similar tariffs enacted in 2012 and 2014 by the United States to understand how the tariffs have been impacting the solar energy's labor market and photovoltaic module and cell price fluctuations. By researching past trends, this paper will argue the 2018 tariff is a failed policy because it negatively impacts the majority of the solar market by increasing the price of photovoltaic cells and modules, and the tariff is set at an insufficient rate to protect domestic solar manufacturers efficiently. Future policy change is then needed to encourage solar jobs by focusing more on the installation sector, rather than the manufacturing industry.

KEYWORDS: United States Solar Market, Tariffs, Labor Market

INTRODUCTION

The solar panel industry has been experiencing recent high tariffs since January 2018, beginning at 30%, with plans to decrease 5% each year until 15% is reached in 2021. Such a protective measure marked the beginning phases of the current trade war between China and the United States and has potentially impacted the growth of the solar panel market in the United States. Before the tariff was implemented, domestic solar panel jobs had been increasing from 2010 to 2016. The next two years showed the first decrease in solar panel jobs (The Solar Foundation, 2019). During 2017, solar panel manufacturing industries urged the federal government to impose the current tariffs, while the installation sector fought against.

It was predicted the tariff would not add jobs to the manufacturing sector and instead hurt the installation business because they rely on imported solar panels. The Solar Energy Industries Association predicted in 2018 the tariff would negatively impact the solar market by decreasing more jobs in the market ("President's Decision on Solar Tariffs is a Loss for America," 2018). Solar panel manufacturing companies in the United States compete directly with foreign-made panels, mainly less expensive Chinese solar panels. The current tariff on solar panels benefits domestic solar panel manufacturing companies because the increasing prices of foreign-made solar panels decrease price competition. Theoretically, this would make foreign-made solar panels compete at the same price as domestic made ones; thus, consumption of domestically produced solar panels would increase. However, the tariff harms companies who install solar panels because they often import the less expensive, foreign-made solar panels. With the tariff in place, the installation companies now have to purchase more costly solar panels and potentially lay-off workers due to the increased cost of production. In fact, Reuters called public attention to the tariffs, explaining the tariff cost the loss of 62,000 solar jobs and $19 billion in investment, and they increased the price of panels, thus damaging the health of the solar industry (Groom, 2019). With fewer jobs and investment in the solar market and more expensive solar panels, consumers will be less inclined to install them. The tariff then creates an opportunity cost whereby carbon emission increases as potential consumers are deterred by this now more expensive renewable energy. In a world with growing climate change, especially regarding humankind's carbon footprint, a push towards renewable energy is essential to curtail its effect; however, the tariff appears to discourage solar installation and encourage more expensive, domestically-made solar panels.

Given the different reactions of the solar panel tariff on the solar panel market, further research is warranted into how the tariff is affecting the solar market which prompts the current research project. This project will investigate if the solar tariff is a failed policy by analyzing the jobs lost in the industry and its relations to increased photovoltaic cell and modules pricings, and what it could mean for further development in reusable energy.

This paper is organized into three main sections: the growing solar market, the beginning of solar tariffs, and analysis. The first section discusses the global production chain of photovoltaic (PV) cells and modules and explains why China has a comparative advantage in the solar manufacturing sector. It will also discuss the historical rise of solar modules and how China became a large producer of PV cells and modules, as well as the policies they created to encourage the market. The United States involvement in the solar panel market will also be discussed, and their trade relationship they formed with China. The second section discusses the trade tension beginning in 2011 between the United States and China over Chinese-made PV cells and modules. It will analyze the political involvement over the creation of tariffs and how the 2012 and 2014 tariff affected both countries. The last section will be the analysis that will use the 2012 and 2014 tariff as a reference for how the 2018 tariff has affected the solar market.

THE GROWING SOLAR MARKET

Global Supply Chain of Photovoltaic Modules

The global demand for solar energy stemming from photovoltaic (PV) cells did not notably begin until 1997 and has grown exponentially since 2003 (de la Tour, Glachant & Ménière, 2010). To understand PV cells and modules and why certain countries, such as China, have been able to dominate the manufacturing sector, it is essential to understand its supply chain. To create PV modules, the supply chain is broken up into four manufacturing segments: silicon, wafers, PV cells, PV modules. De la Tour (2010) analyzes the global chain of PV modules and finds the percentage cost of each segment seen in Figure 1 below. For example, 27% of the cost for a solar panel comes from the cell section of the production chain, and it accounts for only 11% of the panel's profit. Creating the cells into modules is 33% of the final panel costs, and it is the least profitable section at only 7%.

Figure 1: PV Chain of Production as of 2007

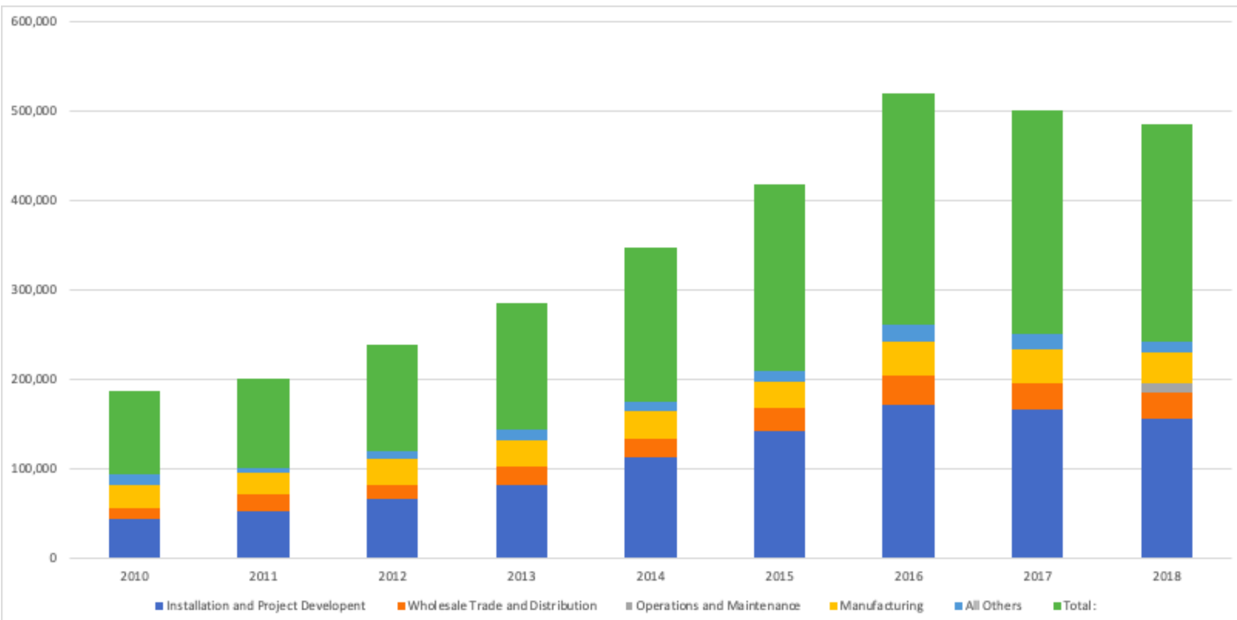
Segment	% Cost in a Panel	Market Concentration (HHI)	Investment Cost (Millions/USD)	Technological Barrier Height	% of Profit
Silicon	13%	0.19	140	High	41%
Ingot and Wafer	27%	0.24	95	Medium/High	41%
Cells	27%	0.04	125	Medium/Low	11%
Module	33%	<0.04	25	Low	7%

Figure from de la Tour et al., (2010)

In 2007, China was the world leader in cell production and module assembly, whereby they produced 27% of the world's PV cells and modules (de la Tour et al., 2010). Cell production in

China has minimum barriers because technology is easily accessible, and module production is labor-intensive and requires little investment (de la Tour et al., 2010). China has an abundance of labor, mainly stemming from migrants. While wages have been growing for the past decades, their salary is comparatively cheaper than the United States giving them a comparative advantage in the production of PV modules and cells (Pagnattaro, 2009).

Figure 2: Employment by Sector, 2010 - 2019



Data from Solar Foundation

The United States has been unable to dominate in the global market of PV cell and module manufacturing due to their lack of comparative advantage. Instead, the U.S. solar market is mainly comprised of the solar installation sector with products mostly coming from China. Figure 2 shows that since 2011, the manufacturing industry had grown from 24,064 employees to 33,726 in 2018. While increasing, its ratio to the whole solar market has been decreasing from once ~20% in 2011 to 13.92% in 2018. In contrast, the installation market had grown from 52,503 in 2011 to 155,157 in 2018; however, it has experienced a recent downturn since 2016.

The employment trends will be analyzed in more detail pertaining to the 2012 and 2014 tariffs in the following section, the beginning of solar tariffs: 2010-2014.

1996 - 2010 Solar Market

This section will review how China became a world producer of PV cells and modules by analyzing the government subsidies the manufacturing and installation sector obtained starting in 1996 and ending in 2010. It will also discuss how the United States subsidized its solar market through government programs but was unable to compete against Chinese made PV cells and modules due to competitive pricing.

China's role in the global supply chain of PV cells and modules began with government subsidies primarily in 1996. Chen (2015) discusses the different subsidies China conducted in the solar panel market, such as China's first solar policy first implemented in 1996 called the Brightness Program. The Brightness Program was China's first national policy to promote solar energy in specifically rural regions and pushed the manufacturing firms to expand their production (Zhang, Andrews-Speed & Ji, 2014). The 2017 Renewable Energy Law of the People's Republic of China and its Medium and Long-Term Development Plan for Renewable Energy (2007) encouraged the Chinese government to invest $263 billion in solar and other renewable energy projects which took "responsibility for developing national standards for solar systems in buildings…and management regulations of urban construction to create good conditions for the development of solar systems in buildings" in 2007 (Medium and Long-Term Development Plan for Renewable Energy in China, 2007). This plan lasted until 2020 with the expectation of creating 1800 MG more of solar power. Doing so spurred China's PV module installation sector, and in turn, encouraged its domestic manufacturing industry. Chen (2015) also notes other government subsidies, which took form as cheap land, tax cuts, and easy loan availability to manufacturers. One key example Chen (2015) discusses are the tax rebates many exporter solar manufacturing firms were given. It was found that Wuxi Suntech, a lead solar exporting firm, was given $1.42 billion in tax rebates and in other sources of refunds (Chen, 2015). By doing so, China enhanced its competitiveness in the global market by aiding technological advancements and infrastructure through financial assistance. Subsides allowed China to gain a stronger comparative advantage to focus on the module and cell production line of solar panels, compared to the United States.

Figure 3: World Production of Solar Modules/Cells

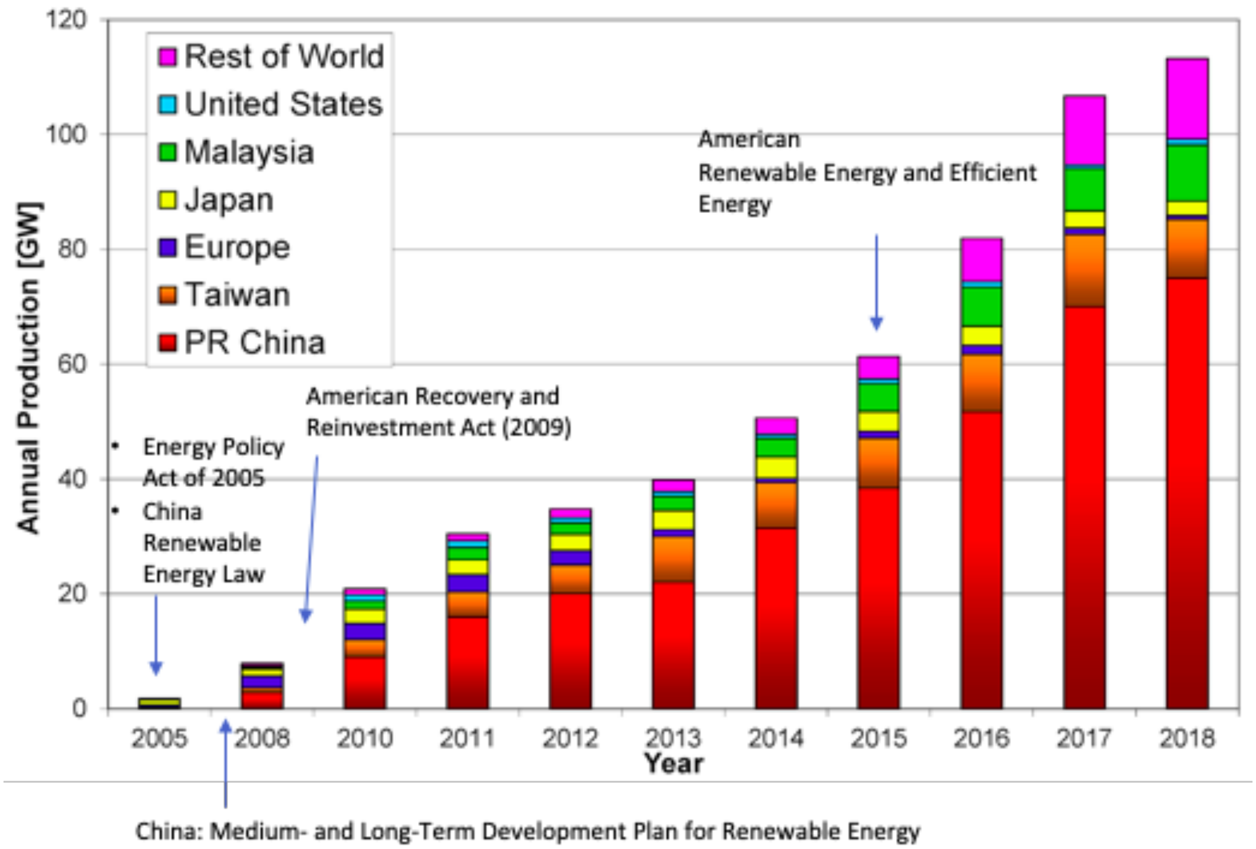


Figure from Jäger-Waldau (2019) with self-added policies

The amount subsidies Chinese manufacturing firms were given allowed the firms to mass produce solar cells and modules, which can be seen in Figure 3. Since China began supporting the industry before the United States and with large amounts of tax incentives and projects, the industry grew exponentially, making China dominate the business with little competition.

In contrast, the United States did not focus on solar energy in earnest until 2005 with the Energy Policy Act of 2005 (Scully Capital, 2018). The Act created a tax credit up to 30% for those who installed solar projects and created the Loan Guarantee Program (LPG). The LGP gave loans for projects with high technology risks to "avoid, reduce or sequester air pollutants or anthropogenic emissions of greenhouse gases; and employ new or significantly improved technologies as compared to commercial technologies in service in the United States at the time the guarantee is issued" (Scully Capital, 2018, p.6). Such loan programs were not intended to improve technology but instead encouraged commercial use of solar panels through installations. This then encouraged the installation market for PV modules, but not necessarily the domestic manufacturing sector, because installers focused on importing PV cells and modules.

It was not until 2009 with the creation of the American Recovery and Reinvestment Act (ARRA) that the solar manufacturing industry was given a tax incentive. The report specifies a 30% tax credit was given to specific projects that focused on the manufacturing of renewable energy. At the same time, the ARRA provided additional tax credits to facilities producing energy from renewable energy, which was approximately $13 billion. This would mainly benefit the installation industry because it incentivized the demand for solar modules nationwide. The report also specifies that during Barack Obama's presidency, the Renewable Energy and Efficient Energy (REEE) projects "added $500 million of loan guarantee authority, making the total available approximately $4.5 billion" (Scully Capital, 2018, p. 6). The REEE project again encouraged commercial use; hence, it incentivized the installation sector.

Compared to China, there were little U.S. policies to incentivize the manufacturing of solar cells and modules, causing the sector to grow slowly and have low production output compared to the rest of the world. Figure 3 demonstrates the United States had a small presence in the world market and was greatly outcompeted by China's production. The United States' comparative advantage for solar cell and module manufacturing is small; as such, the U.S. would gain more from encouraging the installation sector to grow. The policies then promoted the installation sector, which grew over the years seen in Figure 2.

THE BEGINNING OF SOLAR TARIFFS: 2012-2014

This section is broken into three parts: theory of tariffs, 2012 tariff, and 2014 tariff. The first section will analyze how tariffs are formed in the political realm and connect it to the solar tariffs. The next two parts are important in understanding how tariffs have impacted the domestic solar market, and their results will be used later in the analysis. The second section will review the 2012 tariff by analyzing how it was created, the terms of the tariff, and its impact on both the United States and China by looking specifically at investment levels in China, employment in the United States, and level of PV cell and module imports from China. It will also look at the tariff’s political repercussions. By doing so, the section uses previous scholarly articles that argue that the tariff only created negative results for the U.S., making it a failed policy. The third section will explain the 2014 tariff’s effect on the solar market by analyzing its impact on import levels, pricings of PV cells and modules, and political backlashes it created.

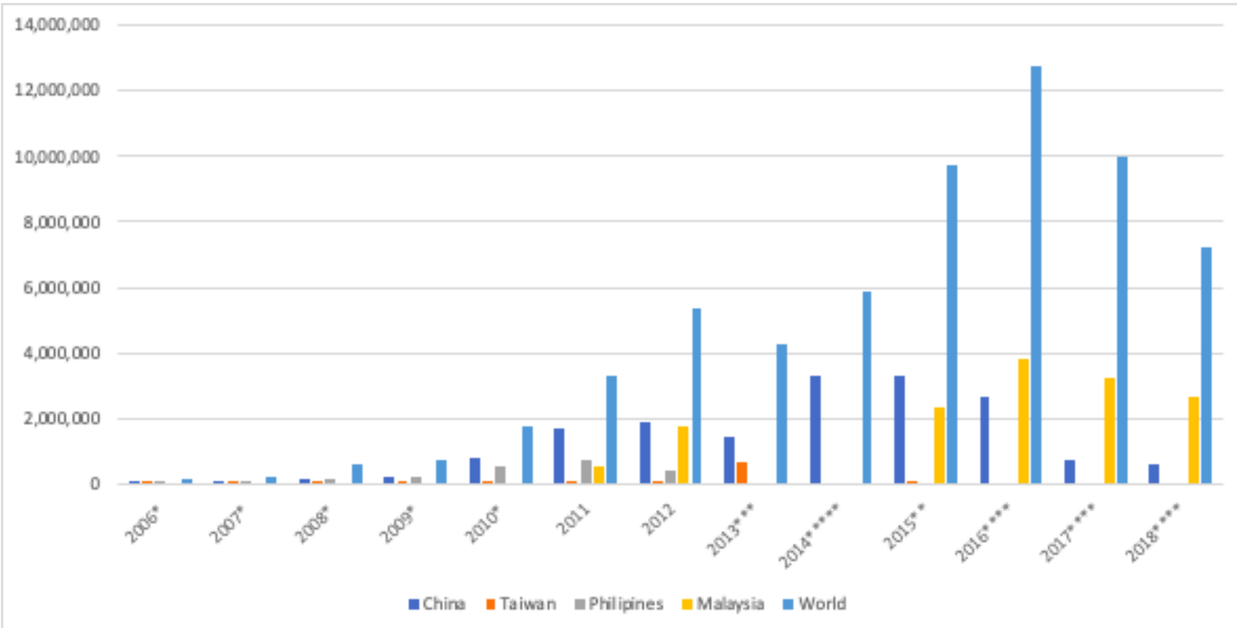
Theory of Tariffs

To understand how the manufacturing industry gained political power, it is vital to know how and why tariffs are formed. Ray (1987) analyzes how interest groups can give rise to protectionism and views such special interest groups as the primary influencer behind protectionist policies, as politicians comply with their special interests to stay in office and hold support from dominant groups. Most interestingly, protectionist policies seem to be encouraged by a combination of special interest groups, political actors, and foreign policy (Ray 1987). More specifically, Hughes and Meckling (2017) see the increase of tariffs as stemming from a coalition created between select solar manufacturing firms and political members. What is most surprising about the coalition is the small proportion manufacturing firms make up when analyzing the solar market - 13.92% in 2018, seen in Figure 2. The figure explains how small factors can influence the market by using the Advocacy Coalition Framework (ACF). By using the ACF, Hughes and Meckling (2017) combine trade institutions into a function comprised of interactions from coalitions that are defined by actors within the political system. Manufacturing interest groups, such as SolarWorld, partners with government actors to create a coalition with the goal of a policy subsystem. Politicians do so because they gain an image as a “protector” of blue-collar jobs, which the United States values, and domestic manufacturing firms do so to gain price protection from foreign trade through tariffs. Politicians also obtain a defender image because since they are favoring the manufacturing industry, it appears they are protecting the few against the majority, in this case, the few U.S. manufacturers against the world manufacturers. Hughes and Meckling (2017) point to Senators, most notably Oregon Senator Ron Wyden, who pushed for a dumping investigation against China in 2011 because Solar World is based in Oregon. By pushing for such legislative action, Senator Wyden worked with the solar panel manufacturing sector, i.e., Solar World, and attempted to maintain a constituency’s interest in hopes of re-election. Senator Wyden also worked alongside the United States foreign policy agenda by targeting China’s use of subsidies, which are seen as unfair competitive practices.

Large manufacturing businesses have been able to successfully lobby for protectionist policies because there are few companies in the solar market, 24 to be exact (U.S. solar panel manufacturers, 2018). This makes it feasible for the companies to discuss similar trade goals and petition to key legislature figures for representation. In comparison, there are thousands of installation companies in the United States (Solar Industry Research Data, 2019). The large number of installation businesses creates a collective action problem, whereby the contribution of each company is perceived as insignificant when attempting to obtain a goal, creating a free-rider problem that creates less incentive for businesses to participate (Oatley, 2015). Oatley (2015) explains the greater the size of the group, the smaller the impact each individual creates, creating less incentive for businesses to participate. The collective action problem explains why installations companies are less likely to dominate trade policies for solar modules and cells because each installation company has a strong incentive to free ride. There are too many installation companies to effectively collaborate and petition against the tariff or create trade policies to benefit themselves.

<u>2012 Tariff</u>

Figure 4: Origin of Imported Solar Cells and Modules in the United States (Kilowatts)



* signifies data for Malaysia is unavailable
** signifies data for Philippines is unavailable
*** signifies data for Malaysia and Philippines is unavailable
**** signifies data for Taiwan and Philippines is unavailable
*****signifies data for Taiwan, Philippines, and Malaysia is unavailable

Data from IEA International Energy Agency

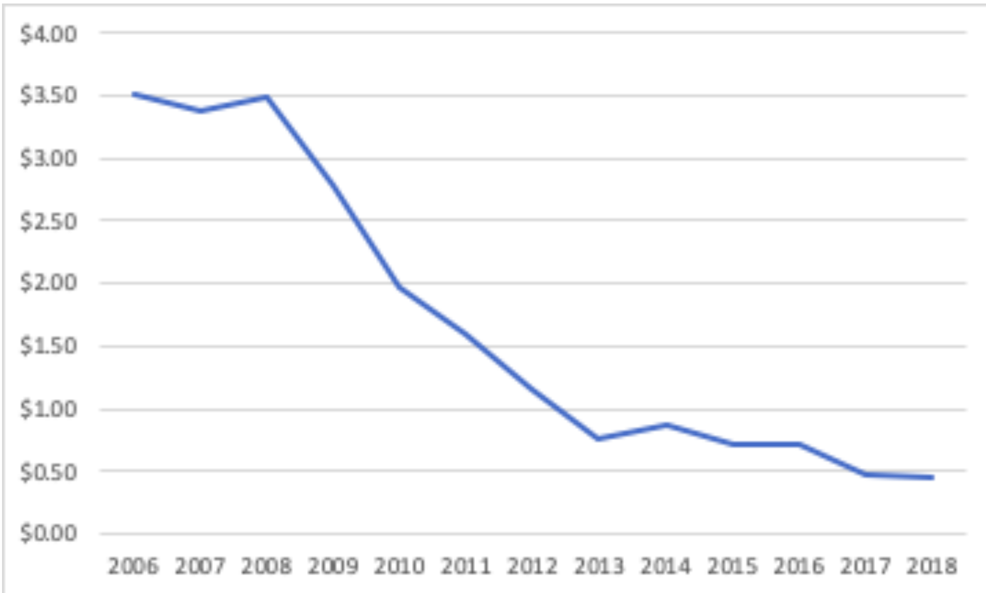
Even with U.S. tax and loan incentives for the solar manufacturing industry, imports of Chinese-produced solar cells and modules continued to rise, especially after 2008, as seen in Figure 4. Figure 4 demonstrates the growth of Chinese module imports into the United States, wherein 2014, Chinese solar modules represented over 50% of module imports. While imports increased beginning in 2010, a push against Chinese P.V. cells and modules grew from the domestic manufacturing sector in the United States. In 2011, a German subsidiary solar manufacturing company, SolarWorld, along with six other manufacturing companies, filed a petition against Chinese made solar panels for dumping the panels and cells into the United States, as previously mentioned (Hughes & Meckling, 2017). SolarWorld argued the U.S. manufacturing firms had been injured due to imported Chinese-made cells and modules that had been subsidized by the Chinese government, making them uncompetitive. The International Trade Commission (I.T.C.) ultimately found Chinese solar firms guilty of dumping certain crystalline silicon photovoltaic products and imposed a 31% tariff on certain Chinese made cells and modules and a 250% tariff on others, going into effect in 2012 (Commerce Preliminarily Finds Countervailable Subsidization of Crystalline Silicon Photovoltaic Cells, Whether or Not Assembled into Modules from the People's Republic of China, 2012). While the U.S. manufacturing firms approved the I.T.C. investigation, there was considerable controversy from the U.S. installation companies who relied on the less expensive P.V. cells and modules.

The 2012 tariff was the beginning of a political and economic struggle between the domestic manufacturing and solar installation industry. The tariff was celebrated by the manufacturing industry — with represented 24% of the solar labor market — because it was expected to increase the price of Chinese made panels and encourage the purchase of domestically made ones (The Solar Foundation, 2019). However, Caprotti (2014) argues the tariff ignores the installation sector — which represented 55% of the solar labor market — who benefited from importing Chinese-made solar modules because the modules "stimulate the U.S. solar installation industry, thus promoting the generation of new green-collar jobs in the USA" (Caprotti, 2014; The Solar Foundation).

The 2012 tariff effect on the solar labor market can be seen in Fondacaro, Harter, Matam, Redzepovic, and Tang's (2014) research, where they analyze the costs and benefits of the 2012 tariff. Fondacaro et al. (2014) examines the cost by accumulating data of the lost opportunity cost the tariff imposed, the social cost of increased carbon emissions from fossil fuels, and the economic impact of foregone job creation. The benefit was calculated by the U.S. revenue made and the amount of carbon emissions circumvented through the tariff. The research finds that

2012 solar tariff cost to the U.S. solar market is greater than the benefits by a margin of $1.24 billion, and, thus, the tariff was a failed policy.

Figure 5: Average Value of Photovoltaic Modules in the United States (USD per watt)



Data from Solar Photovoltaic Cell/Module Shipments—Energy Information Administration

While it was expected for the price of modules to increase, Figure 5 demonstrates the price continued to decline until 2014. The decline could be linked to China industries outsourcing to neighboring countries to circumvent the 2012 tariff.

As a reaction to the 2012 tariff, China also imposed its own tariffs on U.S.-made polysilicon, which is a crucial resource used to create solar energy; domestic investment thus fell from $27.6 billion to $8.8 billion. Stroup (2019) argues the consequences of the tariff in 2012 in the United States substantially outweighed the potential new manufacturing jobs, making it a failed policy. Meanwhile, Chinese solar manufacturing firms outsourced their production line to other Asian countries, allowing them to circumvent the tariff.

Understanding the effect of the 2012 U.S. tariffs on China is necessary to realize the E.U. implemented a similar tariff in 2013. Zhang et al. (2014) found that Chinese solar firms, such as

Suntech Power, defaulted on their debt in response to the United State's and additional E.U.'s tariff, ultimately pushing the Chinese government to assist the struggling solar firms. It was revealed that Chinese solar firms over-relied on exporting as a source of revenue, and the domestic industry was not a viable substitute for the loss of revenue. As a result, Zhang et al. (2014) note that from 2012 to 2013, DPV - distributed photovoltaic - programs were executed by Chinese officials to increase demand for P.V. cells and modules by increasing the number and sizes of solar power plants into a State Grid. The program allowed smaller solar farms to connect to the State Grid and waived approval requirements; by doing so, legal technicalities and paperwork were drastically decreased, thus, encouraging solar farms to expand. The State Grid project strengthened China's installation sector as well as its manufacturing industry. Such subsidized policies also helped improve the stock performances of Chinese manufacturing solar firms and increase domestic demand for solar panels (Crowley, Meng, & Song, 2019). By doing so, large solar firms who had connections to the government were less affected than smaller firms by focusing on supplying their domestic installation sector. With this said, Crowley et al. (2019) found that smaller firms lacking government connections experienced a greater negative effect than SOE's (State Owned Enterprises) in their stock market performance in response to the E.U. tariff. The authors tie the negative impacts private firms faced to the subsidies that the government prioritized to SOE's over private firms.

Chinese solar panel imports began to diminish after 2012, as shown in Figure 4 because Chinese solar firms outsourced their production line of PV cells and modules to other Asian countries (Haley & Schuler, 2011). Stroup (2019) explains the PV cells and panels could be built outside of China but assembled in China and still be considered a non-Chinese made product. Due to the loophole, Chinese firms began to circumvent the tariff by outsourcing their chain of production to neighboring countries, specifically to Taiwan (Stroup, 2019). Fondacaro et al. (2014) found that nearly 70% of imports coming from China had cells manufactured in Taiwan in 2013, making them an exemption to the 2012 tariff. While the tariff attempted to protect the solar panel industry, it was considered ineffective because Chinese solar manufacturing companies could relocate their production to other Asian countries, such as Thailand or Vietnam, effectively avoiding the tariff altogether (Jeong & Hultman, 2018).

3. 2014 Tariff

Due to the loophole, SolarWorld filed another petition in 2013, resulting in a new anti-dumping investigation but against Taiwan and China. The ITC found dumping and issued a tariff in June 2014 on certain Taiwan PV products as well as Chinese made PV products (Jeong & Hultman, 2018). The new 2014 U.S. tariff targeted Taiwan-made PV products with 11.45% and 27.55% tariff and China with a 26.71% to 165% tariff (Commerce Finds Dumping of Imports of Certain Crystalline Silicon Photovoltaic Products from China and Taiwan and Countervailable Subsidization of Imports of Certain Crystalline Silicon Photovoltaic Products from China, 2014).

While the tariff did affect Taiwan made crystalline silicon photovoltaic products, Chinese companies continued to outsource their production to neighboring countries. Nguyen and Kinnucan (2019) explain the 2014 tariff affected China less so than the 2012 tariff because Chinese firms had already built other manufacturing facilities in neighboring countries, such as Malaysia, South Korea, and Singapore. Ngugyen and Kinnucan (2019) suggest 40,713 jobs were lost in the United States on average due to the discriminatory 2014 tariff, while it only created 22,402 jobs in the manufacturing industry. The drastic differences in the number of jobs created and lost stems from the unbalanced representation of manufacturing jobs in the solar market, where manufacturing represents roughly 20% of the market. They argue that the number of jobs the tariff created does not compensate for the loss "from installation, sales and distribution, project development, and the other components of the solar energy industry" (Nguyen & Kinnucan, 2019).

The 2014 tariff on Taiwan and Chinese made PV cells and modules appeared to have had an impact on the pricing of modules because it grew from $0.75 in 2013, to $0.87, as seen in Figure 5. This could be because of China's reliance on Taiwan made PV cells in their product, which made up 70% of its solar exports to the US (Fondacaro et al., 2014). In response to the tariff, the United States was hit with another polysilicon tariff from China in 2014, which had long-term consequences. Feldman and Margolis (2019) found that China's 57% tariff on US-made polysilicon as a significant burden to the US silicone manufacturing industry because production was 55% lower in 2018 than it was in 2014. The effect of the 2014 tariff did not only affect the PV cell and module sector but indirectly the polysilicon industry as well. This then made the 2014 tariff a failed policy because the costs greatly outweighed its benefits.

ANALYSIS

This paper's analysis will be based on research findings of the 2012 and 2014 tariffs to develop an understanding of how they have been affecting the solar panel labor market. I will first analyze the explain the 2018 tariff and the arguments surrounding its impact. I will then use an economic model representing the supply and demand for solar cells and modules and indicate what the 2012, 2014, and 2018 tariff has done. By doing so, I can explain their impacts and elaborate on how the recent 2018 tariff can potentially impact the domestic solar industry negatively.

2018 Tariff

As discussed previously, Suniva and SolarWorld, both manufacturing companies in the United States, petitioned for an anti-dumping case in May 2017. The ITC determined the "increased solar cell and module imports are a substantial cause of serious injury to the domestic industry," resulting in a 30% tariff against all global imports of PV cell and module products. The first 2.5 GW - Gigawatts - of imported PV products would be excluded from the tariff, but after such, a 5% decrease per year would occur for the next three years.

The previous tariffs in 2012 and 2014 continue to impact different sectors of the solar market, and the efficacy of achieving their primary goals of protecting the domestic manufacturing industries have been inefficient. Jeong and Hultman (2018) argue the newly implemented 2018 tariff is doing little to promote the manufacturing industry because of how dominant Chinese solar modules and cells are in the world market. Their dominance is demonstrated in the pricings of modules, whereby Chinese modules are $0.18 cheaper than Californian-made ones in 2017 (IRENA 2018).

<u>Theoretical 2018 Tariff Impact</u>

Figure 7: Economic Modul of 2012, 2014, and 2018 Tariff

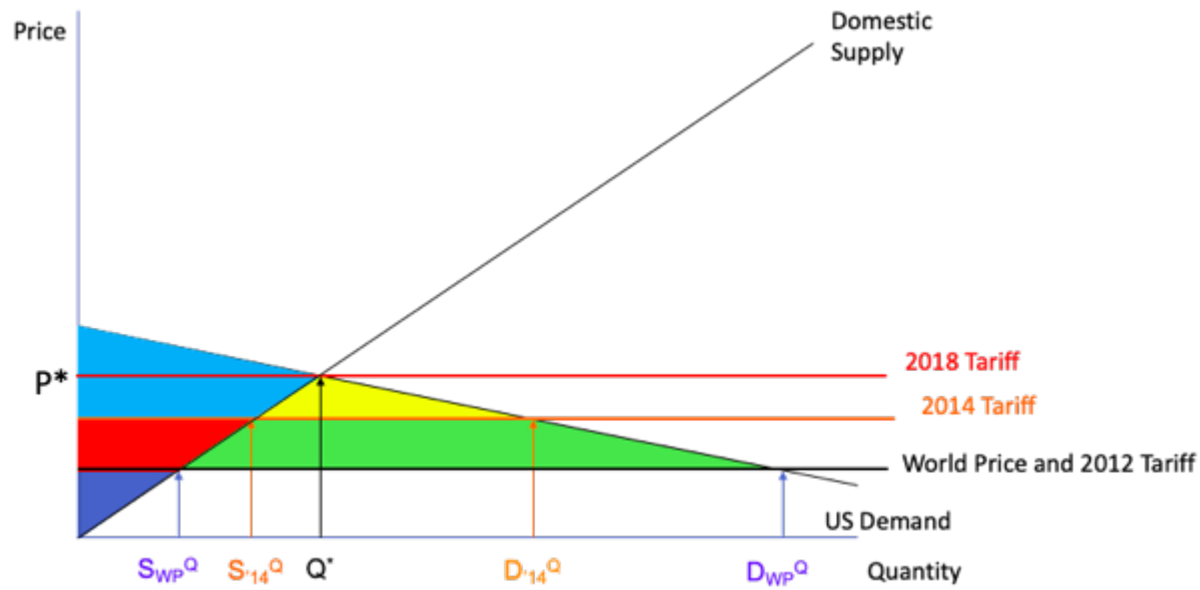
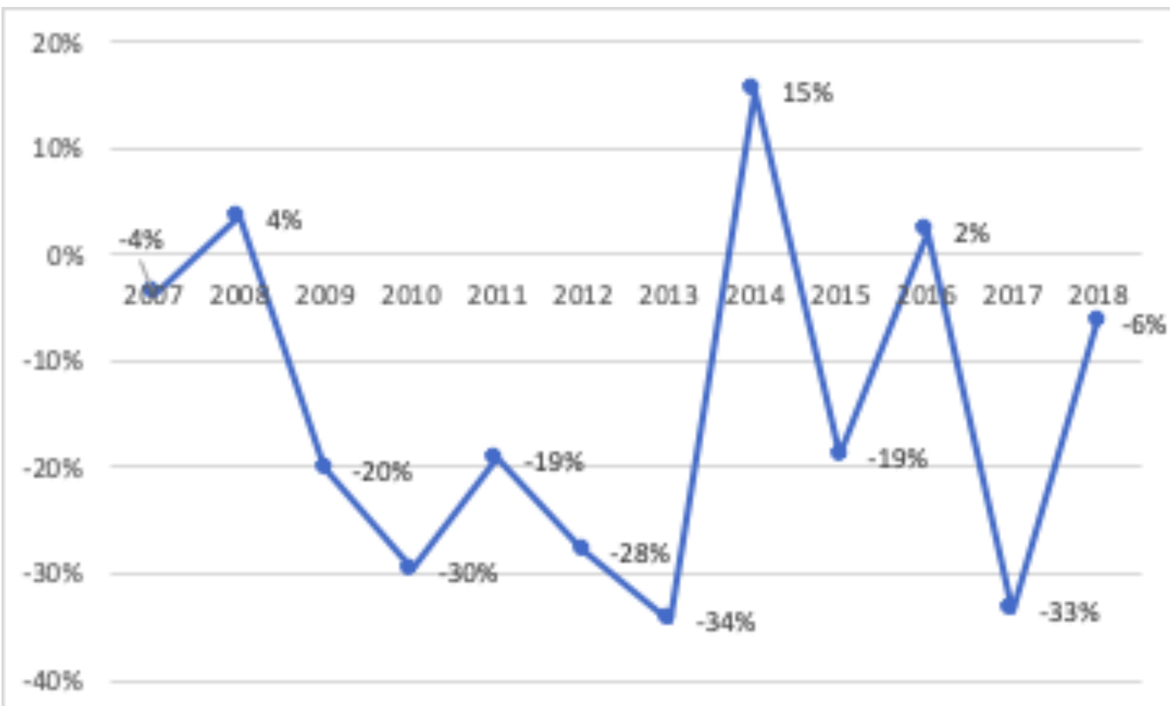


Figure 7 illustrates the effect of the 2012 and 2014 tariff and predicts what the 2018 tariff could hypothetically achieve. Abboushi (2014) notes the demand for PV cells and modules are price sensitive, making the demand curve flat to represent elasticity. Johnson (2011) researches the long-run price elasticity of supply for renewable generation. While their research includes all renewable energy, such as wind, biomass, and solar, they note supply elasticity is 2.7 for the combined markets. A 1% increase in price would then increase production by 2.7% for all renewable energy sectors combined. Johnson's (2011) research demonstrates how price can substantially change renewable energy production.

Before the 2018 tariff was in place, the World Price was far below P*, which represents market equilibrium in the domestic US market for PV cells and modules. The domestic suppliers, shown in line S, were only able to supply PV modules and cells at S_{WP}^{Q} before 2012 because of the World Price they were competing against. This created the producer surplus - shown as the dark blue triangle - and a larger consumer surplus - seen as the yellow, red, green, and light blue shapes combined. When the 2012 tariff was implemented, prices continued to decrease from $1.59 in 2011 to $0.75 in 2013, shown in Figure 5. The price continued to decrease due to outsourcing from Chinese companies, which decreased the cost of production and increased the supply of global imports in the year 2014. This caused the 2012 tariff to be a failed policy due to the continued decreasing price of U.S.-made products.

Figure 8: Percentage Change of the Average Price of Photovoltaic Modules in the United States (USD per watt)



Data from Solar Photovoltaic Cell/Module Shipments—Energy Information Administration

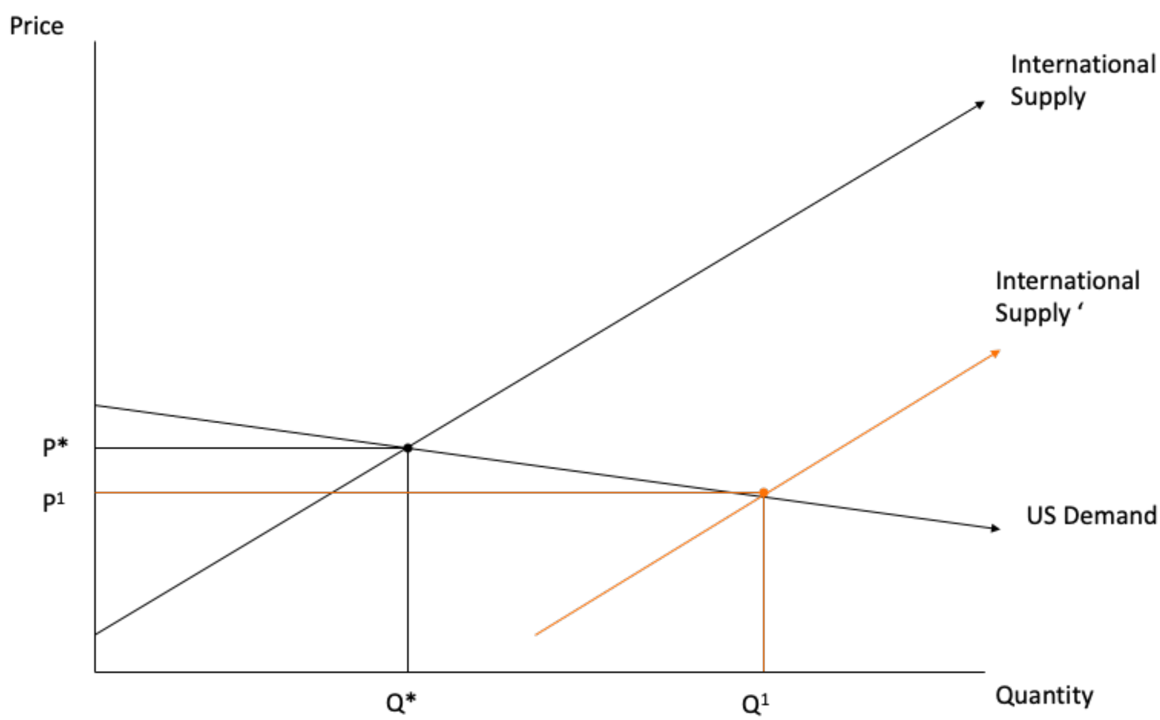
However, the 2014 tariff appeared to influence the US market because the price increased by 15% and in 2016 by 2%, seen in Figure 8. The increased prices led to a new price seen in Figure 7, which decreased consumer surplus to the yellow and light blue boxes and increased producer surplus to the dark blue and red boxes.

The labor market was affected by the 2014 tariff by decreasing the labor market's installation and failing to assist the manufacturing sector in 2017. In 2017, employment in the solar installation industry fell by 1,235 and manufacturing by 974, seen in Figure 2. The tariff impacted the installation sector more so than the manufacturing because the installation sector represented 66% of the solar market in 2017, while manufacturing represented only 7%. Since installers rely on less expensive PC cell and module prices, the increased price stemming from the tariff impacted them more and did not raise the price high enough to encourage job growth in the manufacturing industry.

When the 2018 30% tariff was implemented, it did so to increase solar cell and module prices to a competitive market rate, represented as P* in Figure 7. The increase to P* would allow the domestic suppliers of PV cells and modules to compete against global competitors, not just Asian competitors because global competitors have to price the products at the same price as the US domestic manufacturing firms. Now producer surplus has increased to the dark blue, red, and lower lighter blue shapes, while consumer surplus has decreased to only the top light blue shape. Increasing the price of PV cells and modules to P* and sell at Q* would allow the manufacturing firms in the US to theoretically grow their industries, hire more employees and allow them to compete against Chinese and any other foreign nation firm. This would also decrease imports because domestic installation firms could now purchase more U.S.-made solar cells and modules at the same price as foreign-made products. However, this would come at a cost to consumers, as seen in the decreased consumer surplus. While the increased price allows domestic suppliers to sell more expensive PV cells and modules, consumers who cannot afford the higher-priced goods are left out of the market as they face financial constraints, leading to potential layoffs for installation employees. With fewer consumers and higher pricings, fewer solar panels will be installed, thus reducing the use of renewable energy, which is essential to curtail climate change and reduce humankind's carbon footprint.

Figure 7 does not consider how international suppliers of PV cells and modules are continuing to improve in technology, increase in production, and gain more subsidies through government policies. This allows International supply to shift right, seen in Figure 9.

Figure 9: Economic Model of International Supply of PV Cells and Modules in the United States



While the tax is on imported PV cells and modules, international competitors can continue lowering their price for the goods far below the U.S. price. Jeong and Hultman (2018) explain this price difference is one of the largest in the solar market, and the implemented 30% tariff in 2018 is not sufficient enough to close the price difference. International competitors can then continue to sell their cheaper, taxed PV cells and modules to domestic installers. The four-year tariff does not allow enough time to enact policy changes or incentivize the manufacturing of domestic solar panels. While the tariff may increase the price, it would negatively impact the majority of the solar market by cutting more labor jobs in the installation sector while only creating a limited number of jobs in manufacturing, which makes up 5% of the market as of 2018. SolarWorld and SunPower, two leading manufacturing solar firms pushing for tariffs, declared bankruptcies in 2018, signifying the previous tariffs (2012 and 2014) did little to protect these companies.

Figure 10: Monthly US Import of PV Cells and Modules (Thousand Kilowatts)

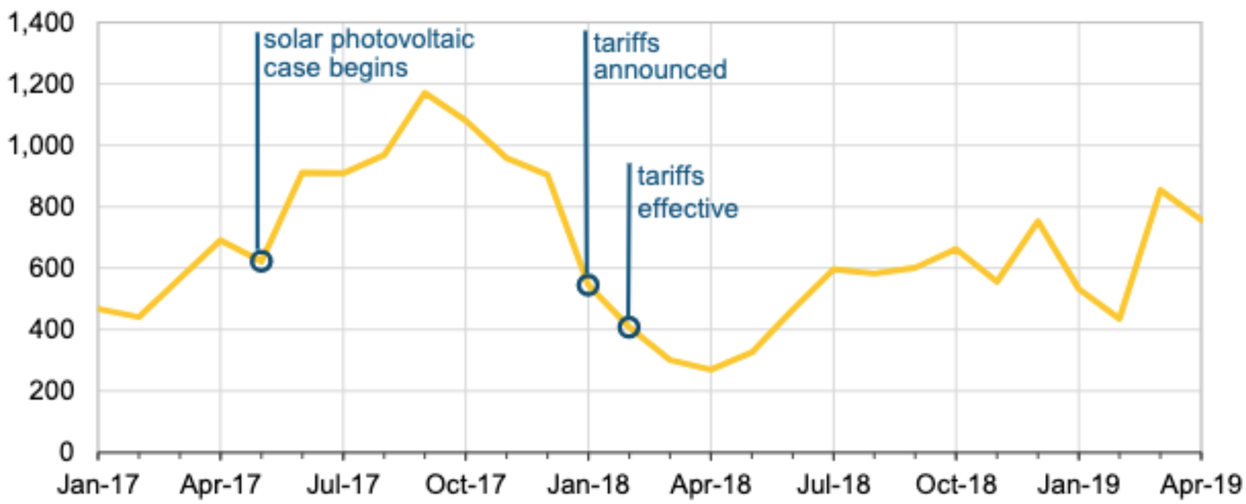


Figure from *U.S. solar module imports partially recover after tariffs were imposed in early 2018*

After the tariff was implemented, imports decreased as seen in Figure 10, but soon increased with a temporary dip in January and February of 2019. This could be because the 2018 30% tariff caused the price of solar modules and cells to fluctuate at the price of $0.45. While imports decreased from approximately 550,000KW to 300,000KW from January to April 2019, we can expect an increase in imports because the tariff at 30% will only last for one year, then decrease by 5% consecutively for the next three years. Its impact on the solar market labor market will reduce by year, allowing the solar installation sector not to feel as financially constrained over time, but will still result in continued layoffs due to the short-term increase in cost production. The manufacturing industry will not gain the entire benefits of the tariff due to the decreasing tariff rates and will most likely continue to decrease in employment size. The 2018 tariff will then be considered an ineffective policy because it does not protect the manufacturing industry and harms the majority of the solar market by raising PV cell and module rates.

LIMITATIONS

To remain transparent, this paper acknowledges that its analysis has some limitations. One of the main weaknesses in the analysis is assuming the change in price since 2012 is because of the tariffs of 2012, 2014, and 2018. It is impossible to point to a specific event or change in the cost to the change in price because so many variables are inputs of a good's final price. With PV cells and modules, there are many steps in its creation, and a change in either the cost of creating silicon, ingots and wafers could change the price of PV cells and modules since each step is needed to make the final product. This paper is also limited in understanding the full reasoning behind the labor market fluctuations. Again, many variables go into why the labor market fluctuates and is not always explicitly tied to the price of PV cells and modules in the solar market.

CONCLUSION

The United States and China have been experiencing a solar trade war since 2012, which has negatively affected both domestic markets. Investment and the solar employment market in the United States have felt the tariffs' effects, causing a decline in solar employment since 2017. The decline in jobs can be attributed to the price increase and stabilizing force in imported PV cells and modules due to the 2014 tariff and expected impact in the 2018 tariff. With increasing

PV cell and module prices, installment companies are forced to increase their cost of production and lay off workers due to financial constraints. The domestic manufacturing industry is still facing heavy global competition because Asian countries produce the majority of PV cells and modules. While the 2018 tariff is aimed to protect the solar market, it ultimately creates more costs than benefits because more jobs are lost in the installment sector than it saves in the manufacturing industry. The goal of protecting green jobs in the solar market should not be focused on the manufacturing industry, but instead on the installation sector because the sector makes up the bulk of the market and is connected to others such as marketing, wholesale, and maintenance. Policies such as state or federal government-funded solar fields in rural communities or requiring states to create solar energy initiatives could bolster the installation sector and, in turn, create a higher demand for employment. By encouraging the installation sector, a positive public externality can be generated because solar energy emits less carbon than fossil fuels. There is an increasing demand for renewable energy as humankind begins to understand carbon emissions are perpetuating climate change. If the United States encourages the installation sector, more affordable solar power would be available to a broader range of consumers and ultimately support the fight against climate change by decreasing carbon emissions. The economic progress of the solar market in the United States and for renewable energy is then dragged down by the tariff as it ends up increasing solar module and energy prices. The tariff should then be seen as a failed policy, and government change is needed to address the health of the solar market.

Bibliography

Abboushi, S. (n.d.). Solar trade tariffs. - University of Puget Sound. *Duquesne University*. Retrieved from https://alliance-primo.hosted.exlibrisgroup.com/primo-explore/openurl?isbn=&title=Competitiveness%20Review&volume=24&date=20140101&spage=59&pages=59-65&sid=EBSCO:Business%20Source%20Premier&aulast=Abboushi,%20Suhail&atitle=Solar%20trade%20tariffs.&issn=10595422&issue=1&vid=UPUGS&institution=UPUGS&url_ctx_val=&url_ctx_fmt=null&isSerivcesPage=true

Caprotti, F. (2015). Golden Sun, Green Economy: Market Security and the US/EU-China 'Solar Trade War.' *Asian Geographer*. https://doi.org/10.1080/10225706.2015.1057191

Chen, G. (2015). From Mercantile Strategy to Domestic Demand Stimulation: Changes in China's Solar PV Subsidies. *Asia Pacific Business Review*, *21*(1), 96–112.

Commerce Finds Dumping of Imports of Certain Crystalline Silicon Photovoltaic Products from China and Taiwan and Countervailable Subsidization of Imports of Certain Crystalline Silicon Photovoltaic Products from China. (n.d.-b). *International Trade Administration*, (2014), 9.

Commerce Preliminarily Finds Countervailable Subsidization of Crystalline Silicon Photovoltaic Cells, Whether or Not Assembled into Modules from the People's Republic of China. (2012). *International Trade Administration*, 3.

Crowley, M. A., Meng, N., & Song, H. (2019). Policy shocks and stock market returns: Evidence from Chinese solar panels. *Journal of the Japanese and International Economies*, *51*(C), 148–169.

de la Tour, A., Glachant, M., & Ménière, Y. (2010). Innovation and international technology transfer: The case of the Chinese photovoltaic industry. *Energy Policy*, *39*(2), 761–770. https://doi.org/10.1016/j.enpol.2010.10.050

Feldman, D., & Margolis, R. (2019). *Q4 2018 / Q1 2019 Solar Industry Update* (No. PR-6A20-73992; p. 74).

Fondacaro, M., Harter, J., Matam, D., Redzepovic, S., Sheth, A., & Tang, E. (n.d.). *Economic Analysis of Protectionist US Trade Policy on Chinese Solar Exports*. 87.

Groom, N. (2019, December 4). U.S. solar group says Trump tariffs killing jobs; White House says “fake news.” *Reuters*. Retrieved from https://www.reuters.com/article/us-usa-solar-tariffs-idUSKBN1Y71V8

Haley, U. C. V., & Schuler, D. A. (2011). Government Policy and Firm Strategy in the Solar Photovoltaic Industry. *California Management Review*, *54*(1), 17–38. https://doi.org/10.1525/cmr.2011.54.1.17

Hughes, L., & Meckling, J. (2017). The politics of renewable energy trade: The US-China solar dispute. *Energy Policy*, *105*, 256–262. https://doi.org/10.1016/j.enpol.2017.02.044

IEA International Energy Agency. (2018). *TRENDS 2018 IN PHOTOVOLTAIC APPLICATIONS* (Annual Report No. 978-3-906042-79–4).

IRENA. (2018). *Renewable power generation costs in 2017* (p. 160).

Jäger-Waldau, A. (2019). Snapshot of Photovoltaics—February 2019. *Energies*, *12*(5), 769. https://doi.org/10.3390/en12050769

Jeong, M., & Hultman, N. (2018, February 9). What past experience tells us about the impact of new American solar tariffs. Retrieved October 1, 2019, from Brookings website:

https://www.brookings.edu/blog/planetpolicy/2018/02/09/what-past-experience-tells-us-about-the-impact-of-new-american-solar-tariffs/

Johnson, E. (2011). *The price elasticity of supply of renewable electricity generation: Evidence from state renewable portfolio standards*.

Medium and Long-Term Development Plan for Renewable Energy in China [Sept. 2007]. (n.d.). Retrieved September 24, 2019, from National Development and Reform Commission website: http://www.china.org.cn/e-news/news070904-11.htm

Nguyen, L., & Kinnucan, H. (2019). The US solar panel anti-dumping duties versus uniform tariff. *Energy Policy*, *127*, 523–532.

Oatley, T. (2015). *International Political Economy*. Routledge.

Pagnattaro, M. A. (2009). *Is Labor Really Cheap in China—Compliance with Labor and Employment Laws*. 25.

President's Decision on Solar Tariffs is a Loss for America. (2018, January 22). Retrieved December 7, 2019, from SEIA website: /news/presidents-decision-solar-tariffs-loss-america

Ray, E. J. (1987). Changing Patterns of Protectionism: The Fall in Tariffs and the Rise in Non-Tariff Barriers Symposium: The Political Economy of International Trade Law and Policy. *Northwestern Journal of International Law & Business*, *8*(22), 44.

Scully Capital. (2018). *Examination of Federal Financial Assistance in Renewable Energy Market: Implications and Opportunities for Commercial Deployment of Smaller Modular Reactors*.

Solar Industry Research Data | SEIA. (n.d.). Retrieved December 17, 2019, from https://www.seia.org/solar-industry-research-data

Solar Photovoltaic Cell/Module Shipments—Energy Information Administration. (n.d.). Retrieved October 27, 2019, from https://www.eia.gov/renewable/annual/solar_photo/

Stroup, M. A. (2019). Draining the Flooded Markets: Tariffs, Suniva & Solar Energy Investment. *Indiana Journal of Global Legal Studies*, *26*(1), 317–334. Retrieved from JSTOR.

The Solar Foundation. (2019). *National Solar Jobs Census* (p. 80). Retrieved from https://www.thesolarfoundation.org/national/

U.S. solar module imports partially recover after tariffs were imposed in early 2018. (2019, August 13). Retrieved from https://www.eia.gov/todayinenergy/detail.php?id=40873

U.S. solar panel manufacturers. (2018, August 29). Retrieved December 17, 2019, from Solar Power World website: https://www.solarpowerworldonline.com/u-s-solar-panel-manufacturers/

Zhang, S., Andrews-Speed, P., & Ji, M. (2014). The erratic path of the low-carbon transition in China: Evolution of solar PV policy. *Energy Policy*, *67*, 903–912. https://doi.org/10.1016/j.enpol.2013.12.063