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Abstract

Governments are investing billions of dollars in low-carbon energy technologies in order to address climate change. Recently governments have also adopted protectionist measures in low-carbon energy technology sectors. In the solar photovoltaic industry, governments in both Europe and the United States responded to a rise in Chinese module exports through the imposition of tariffs, voluntary export restraints and other measures. The government in Japan, however - another major solar market - has not done so. We hypothesize that the position of firms in global value chains shape their preferences vis-àvis trade protection. Our findings show the policy positions of the majority of firms align with expectations. In doing so we provide evidence that industry specialization shapes firm demand for trade protection in a major green industry. More generally, our research suggests the globalization and fragmentation of supply chains creates important trade-offs for governments by pitting industrial interests against upstream and downstream firms and environmental interests seeking to maximize market penetration of renewable technologies.

Key Words: solar photovoltaics, trade politics, climate change

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Globalizing Solar: Industry Specialization and Firm Demands for Trade Protection

Jonas Meckling and Llewelyn Hughes¹

1. Introduction

Governments in the advanced industrialized states face two challenges: how to respond economically to the rise of China, and how to mitigate the risk of catastrophic climate change.² These challenges converge through green industrial policy—the attempt by governments in the advanced industrialized states to promote domestic renewable energy industries in order to create jobs, and to reduce greenhouse gas emissions (GHGs). The rise of China in renewable energy manufacturing challenges this effort, however. Renewable energy manufacturers in Europe and the United States (US) in particular have been suffering from Chinese import competition, and in response, an increasing number of bilateral and multilateral trade disputes have been initiated in renewable energy industries since 2010, with most of these involving China as respondent or complainant.³

Scholarly research suggests that industries tend to seek protection in response to increases in import competition. Yet evidence shows that firms have responded in markedly different ways to this rise in import competition. Some firms supported trade measures, some firms opposed protection, and other firms chose alternative strategies. How can we explain the different responses of firms to the rise in Chinese import competition in green industries? And what are the implications for our understanding of the politics of climate protectionism?

In this paper we test a number of hypotheses related to changes in the global

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² McNally 2012; Bernauer 2013.

³ Lewis 2014.

organization of production using data drawn from the global solar photovoltaic industry. We selected the solar photovoltaic industry for two reasons. First, the solar photovoltaic is the fastest-growing renewable energy segment in terms of investment, and is thus a key industry for global de-carbonization efforts.⁴ Second, our goal is to examine the effect of globalization and specialization on trade preferences of firms, and the solar photovoltaic sector is a highly globalized and vertically specialized. It is an appropriate case to examine how these changes affect the trade preferences of firms.

We argue the identified variation in firms' responses to the rise in Chinese solar exports can be explained by the effects of intra-industry fragmentation on the preferences of firms towards rising Chinese solar imports. In particular, we argue that the rise of vertical specialization - defined as when a good is produced in multiple, sequential stages, and when firms specialize in one, some, but not all, stages of the value-chain - introduced greater diversity in the characteristics of firms operating within the solar industry in countries experiencing rising imports from China. This led, we argue, to a less unified industry response to Chinese import penetration.

Our findings are significant for policy and theory. Efforts to mitigate climate change by supporting green industries matter for international competitiveness. Yet the implications of vertical specialization for the demands for trade protectionism in climaterelated industries remain understudied. We suggest that vertical specialization matters because it fragments industry lobbying coalitions responding to rapid increases in imports. For governments, intra-industry conflict within green industries thus creates new trade-offs between the protection of segments of domestic industries and the promotion of global trade in low-carbon energy technologies that can help mitigate climate change.

Theoretically, studies of the politics of trade protection often assume firms' policy preferences are homogeneous within single industries, or they distinguish between domestic firms and those that also have invested in production facilities located outside the domestic economy. Yet there are also important differences in the degree to which firms choose to outsource production, with implications for their preferences over a range of trade policy outcomes. We introduce data showing intra-industry firm heterogeneity extends to important climate related industries, and that these differences between firms

⁴ IEA 2014, 242.

has important implications for their non-market strategies, most notably the positions firms adopted towards the initiation of trade disputes in an important new area of state activity: government policies designed to mitigate the risk of catastrophic climate change.

We proceed in five sections. In the next section we describe changes in patterns of global solar photovoltaic production over the last decade, and describe our outcome variable, which focuses on the policy preferences of firms towards the rise in Chinese solar exports. In section three we develop a series of expectations for trade responses of firms operating in the solar photovoltaic industry. Thereafter, we lay out the methods and standards applied to data collection in section four. We then examine the validity of these hypotheses by segment—i.e., upstream, manufacturing, and downstream firms—in section five. In the fifth section we examine the outliers and engage with alternative explanations. In the sixth and final section we discuss the implications of our findings for the politics of protection in climate change.⁵

2. Globalization and Vertical Specialization in the Photovoltaic Industry

Renewable energy has emerged as a major sector in the global energy industry. In 2013, US\$192 billion of new investment went into renewable electric generating capacity. In comparison, US\$102 billion of investment into fossil fuel-based capacity went into new capacity. Renewable energy thus led global investment in new electric generating capacity. Of this, the solar industry received the largest share of US\$113.7 billion of investment in 2013, equivalent to 53 percent of total new investment into renewable power and fuels.⁶ It was followed by investments into wind, which were US\$80.1 billion or 37 percent of total renewable energy investments.⁷

The solar photovoltaic industry has grown rapidly as a result. Installed capacity increased to approximately 138 gigawatts (GW) in 2013, and 98 percent of that capacity was installed since 1994.⁸ Global revenues in solar manufacturing increased from US\$2.5 billion in 2000 to \$91.3 billion in 2013.⁹ The solar industry created 142,698 jobs in the

⁵ An appendix and attached file provides details on data collection.

⁶ The includes investment in both solar PV and concentrated solar power.

⁷ REN 21 2014, 70-72.

⁸ REN21 2014, 47.

⁹ Pernick, Wilder and Belcher 2014.

(China	EU	Japan	United States
Global share of 16 capital investment (US\$ in PV in 2013 ¹¹	5.66 % 16.26 bn)	20.76 % (\$20.26 bn	27.3 %) (\$26.6 bn)	16 % (\$15.78 bn)
Share of global PV 13	8.26 %	51.39 %	10 %	8.6 %
capacity in 2013^{12} (19)	9.1 GW)	(74 GW)	(14.4 GW)	(12.4 GW)
Module production 4 capacity in 201313	5 GW	6 GW	3.4 GW	1.6 GW
in PV in 201311(000)Share of global PV13capacity in 201312(19)Module9production4capacity in 2013134	3.26 % 9.1 GW) 5 GW	51.39 % (74 GW) 6 GW	10 % (14.4 GW) 3.4 GW	

United States by 2012, 265,000 in the EU and 210,000 jobs in Japan.¹⁰

Table 1: Shares of Global PV Investment, Capacity, and Module Manufacturing

There was also a transformative change in the geography of production. The solar value chain can be divided into a number of segments, beginning with the manufacture of raw materials using machine tools, moving through wafer, cell, and module manufacturing, and finishing with system integration and project development (Table Two).¹⁴ In the early phase of the solar industry all segments of the value chain tended to be located in the same country or region, and were owned by vertically-integrated firms. Over time, however, firms shifted manufacturing facilities internationally. Firms also concentrated operations in a limited number of segments of the solar supply chain, rather than integrating vertically through the entire PV supply chain.

Table 2. The Solar Photovoltaic Supply Chain

Upstro	eam		Manufacturing		Downstream
Row motorials	Equipmont	Wafors	Colls	Modulos	Systems integration /
Rdw IIIdleIidis	Equipment	waters	Cells	wouldes	project development

Most notably, module manufacturing increasingly shifted to China, with producers exporting final products to Europe, Japan and other markets.¹⁵ The United States, Europe - predominantly Germany - and Japan provided 90 percent of global module production in 2005. Between 2006 and 2012, Chinese manufacturers captured 60

¹⁰ Solar Foundation 2014; European Photovoltaic Industry Association 2012; Japan Photovoltaic Energy Association 2014..

¹¹ The Pew Charitable Trust 2014.

¹² The Pew Charitable Trust 2014.

¹³ Mehta 2013.

¹⁴ The value-chain for thin-film silicon – a smaller share of the market - differs in the upstream.

¹⁵ REN21 2014, 48.

percent of the global module market.¹⁶ Europe's share of global production shrunk to 11 percent, Japan 5 percent and the United States 3 percent by 2012. Among the top 15 producers in 2012, 9 were from China, 3 from the North America, 2 from Japan and 1 from Europe.¹⁷ The increasing globalized and vertically specialized structure of the PV industry led to a significant increase in cross-border trade in solar goods: in 2006-08 the solar industry had a trade intensity of 60 to 90 percent, compared to a trade intensity of 10 percent in the market for wind technology.¹⁸

3. Explaining Variation in Firm Trade Preferences

The increase in module manufacturing in China induced a fall in firm profitability: 24 US manufacturers chose to exit the market by the end of 2012, with 10 European and 50 Chinese manufacturers doing so in 2012.¹⁹ Other firms chose a different strategy, integrating non-market responses - focused on lobbying policymakers to protect against rising Chinese module imports - with market-based responses such as concentrating on market segments less penetrated by Chinese imports.²⁰ Firms, and the industry groups that represent them, thus faced a choice of lobbying government in favor of, or against, measures designed to protect against rising Chinese PV production, or taking no action.

The decision by some firms to lobby for import protection matches expectations from sectoral trade theory.²¹ Under general conditions introducing barriers to trade changes the relative price of tradable goods and services, affecting the real income of different actors. When factors of production are immobile, and the expected benefits of the price change are greater than the threshold required for collective action, then we expect firms to mobilize politically. If the benefits do not meet this threshold, on the other hand, then we do not expect them to lobby in favor of the policy.

While the effects of changes in the composition of trade on trade preferences have

¹⁶ European Photovoltaic Industry Association 2013.

¹⁷ In 2012, the top 15 global PV module producers accounted for half of the 35.5 GW capacity installed that year. Yingli (China) was the largest producer, followed by Suntech (China) and First Solar (USA). REN21 2014.

¹⁸ Kirkegaard, Hanemann, Weischer and Miller 2010.

¹⁹ Mehta 2013.

²⁰ On integrated strategy see Baron 1997.

²¹ Milner 1999.

been examined to date, the effects of vertical specialization are less well studied.²² In general terms, if the distributive effects of a policy on firms operating in a sector are uniform, then we expect it to have unified trade policy preferences. In the solar photovoltaic industry, for example, the introduction of a feed-in tariff (FIT) led to an increase in demand, suggesting the industry will unite in support of this kind of policy instrument. If policy instruments have different distributive effects on firms, on the other hand, then we expect variation in policy preferences. An import tariff, for example, affects import competing firms within a sector differently to those that produce internationally. This should lead them to adopt different positions towards the tariff.

In this paper we focus on the effects of the globalization of production, and vertical specialization, on the lobbying behavior of firms. We propose that the rise of Chinese module production had markedly different distributive effects on firms, depending on a firm's position in global supply chains. Two aspects of a firm's position were particularly important in determining the ability of firms to benefit from the rise in Chinese manufacturing, and thus the policy position they adopted towards trade barriers: (i) the extent of ties to firms in the trading partner country, and; (ii) the stage of the supply chain in which the firm specializes.

Theoretical and empirical evidence support the first of these contentions.²³ The rise in multinational production and intra-firm trade is recognized to have reduced the demand among firms for protection because of factors such as the increased costs of trade barriers for firms that produce internationally, and concern about retaliation.

The role of vertical specialization, and particularly the position of firms in supply chains that are substantially globalized, on the other hand, remains under-theorized. This is an important gap in the literature given the rise in vertical specialization across many manufacturing industries.²⁴ Some theoretical and empirical evidence exists that the rise in vertical specialization induces changes in the trade preferences of firms.²⁵ Firms operating in the downstream of an industry, for example, are likely to oppose the introduction of measures that increase the costs of their inputs, and in doing so function

²² On the changing composition of trade and trade preferences see Goodman, Spar and Yoffie 1996. More recent studies on the effects of vertical specialization and trade preferences are Manger 2012; Kim 2014, ²³ Milner 1988; Levy and Prakash 2003.

²⁴ Hummels Ishii and Yi 2001.

²⁵ Martin 2015, 8.

as a counterweight to domestically-based import-competing producers that are more likely to support protection.²⁶ In addition, however, we propose that upstream firms are also likely to oppose protectionist measures, because a rise in manufacturing internationally represents a secular increase in demand for products they produce, and thus an increase in profits in the short to medium-run assuming some barriers to market to entry.

Taken together, we are thus left with a change in the composition of lobbying coalitions as a result of the globalization of production and increase in vertical specialization. Domestic import-competing manufacturers are left isolated against globalized manufacturers, domestic downstream firms, as well as domestic upstream firms.

We apply this logic to the solar photovoltaic industry below. The rise in Chinese module manufacturing represented a secular rise in productive capacity in the manufacturing segment of the solar photovoltaic supply chain. We argue that this change in the distribution of production had distinct distributive implications for firms operating in the upstream, in manufacturing, and in the downstream segments of the industry.

Upstream Segment

For vertically specialized firms that operated in the upstream – either by producing raw material or tools used to manufacture and test modules – the rise in Chinese manufacturing was not a competitive threat. Instead, the rise in Chinese module manufacturing represented an increase in demand for their products. This should be the case when they have direct ties to China such as sales contracts. But it also applies to firms that do not have long-standing sales relationships with Chinese firms. For polysilicon producers producing the raw materials used in solar wafer production, aggregate global demand shapes prices given that they operate in commodity markets. Additional demand from China thus drives prices up, which is favorable to them. Firms manufacturing machine tools, testing and measuring equipment used in module manufacturing produce products that are less commoditized than polysilicon. Their equipment is not specific to particular module manufacturers, however, meaning the

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²⁶ Gawande, Hoekman and Cui 2014: 8.

option of selling to Chinese customers is similarly likely to lead to an increase in demand for their products.

Because of this, in both cases we should expect firms specialized in the manufacture of these products to gain from an increase in module manufacturing capacity in China. Accordingly, they should oppose any attempts to impose barriers to imports that may harm the competitiveness of these new market entrants, regardless of whether they have existing contracts with firms based in China (hypothesis 1).

We expect firms to adopt this position for a second reason. Even if the rise in China's module production leads firms based in China to take market share away from domestic module production, the imposition of import barriers is likely to reduce domestic demand for solar power relative to alternative sources of electricity generation. This means that even if imports are substituted for domestic producers, aggregate demand for upstream products are expected to fall. Firms that are vertically specialized in the production of machine tools, or polysilicon, should thus be expected to oppose the imposition of import barriers.

Manufacturing Segment

For firms operating in the manufacture of modules, on the other hand, we expect heterogeneity in firm preferences. Most obviously, module manufacturers firms that do not have ties to manufacturing in China should have the most intense preferences in favor of import protection. Solar modules are an undifferentiated product. This makes Chinese module producers direct competitors for these firms. Import protection increases the cost of imports relative to domestic modules, leading us to expect these firms will support protection (hypothesis 2). We expect firms that are integrated over wafer, cell and module production, and those that specialize in module production alone, to take this position.

We do not expect all module manufacturers to support the imposition of barriers to imports. Instead, two types of firm characteristics should lead manufacturers to oppose the imposition of barriers to imports (hypothesis 3). First, firms that have globalized module production through owning module production in China should oppose protection, given that their products will lose competitiveness relative to domestic producers through the imposition of import barriers. Second, we expect that even in the absence of direct ties such as the direct ownership of module production facilities in China, vertically specialized module manufacturers have an incentive to oppose import barriers when they have less direct ties, in the form of supply contracts for cells, wafers, or modules. If a specialized module producer buys cells from China, for example, trade barriers would increase the cost of those supplies, reducing the competitiveness of their products. Similarly, if a module producer supplies meets part of its demand through production outsourced to an Original Equipment Manufacturer (OEM, or Original Design Manufacturer (ODM) (Sturgeon 2001), then we expect them to oppose the imposition of barriers to imports given that it will reduce their competitiveness relative to purely domestic module manufacturers, as well as reducing the competitiveness of solar power compared to alternative sources of electricity supply.²⁷

Downstream Segment

The effect of the expected costs of import protection for vertically specialized upstream producers is mirrored in our expectations for downstream firms involved in project development and the installation of solar photovoltaic systems. Most obviously, firms that have ties to China through supply contracts with Chinese module manufacturers are affected negatively by import barriers as it increases their costs of inputs. We also expect, however, that downstream firms that purchase from non-Chinese module manufacturers are incentivized to oppose trade barriers; solar modules are largely commoditized, meaning additional supply from Chinese producers to third markets reduces the price of modules, which is positive for developers and installers that do not directly supply from China. In this case, firms have an incentive to oppose trade barriers because of the expected impact of trade barriers on the cost of inputs (hypothesis 4). We thus expect firms that are vertically specialized and operating in the upstream and downstream segments of the market to have unified preferences in opposition to the imposition of trade barriers, for the reasons outlined above.

²⁷ The intensity of preferences for vertically integrated firms should be weaker than vertically specialized firms that are in direct competition with PV module manufacturers with a presence in China, because the losses of the division producing modules should be balanced against the fall in input prices for downstream divisions within the firm that benefit from falling module prices. Lack of data on preference intensity makes it impossible to test this against data, however.

Summary

Considering the extent of global ties (domestic vs. globalized) and the level of specialization (upstream—manufacturing—downstream), from the above we can state four hypotheses regarding firms' expected positions towards restraining imports from China. These are summarized, and in Table 3, below.

 H_1 : Vertically specialized firms with upstream operations should oppose the imposition of trade barriers.

*H*₂: *Module manufacturers without China ties should support the imposition of trade barriers.*

H₃: Module manufacturers with China ties should oppose the imposition of trade barriers.

*H*₄: Downstream firms manufacturers should oppose the imposition of trade barriers, regardless of whether they have ties to solar PV production in China

		Extent of Ties with Trading Partner		
		Domestic	Globalized	
Segment of Specialization	Upstream	H ₁ : oppose		
	Manufacturing	H2: support	H₃: oppose	
	Downstream	H4: oppose		

Table 3: Expectations for Firm Preferences in Global PV Industry

To summarize, we propose there is an association between the nature of firm ties with the trading partner, and the form of vertical specialization, and the position firms adopt towards import barriers. Firms that are vertically specialized in module manufacturing and purely domestic should have policy preferences in favor of protection. Firms with production located in China should oppose the imposition of trade barriers, regardless of whether they are vertically integrated or specialized. Vertically specialized firms that are linked directly or indirectly with China should oppose the imposition of trade barriers. The primary effect of globalization and vertical specialization was thus to increase greater heterogeneity in intra-industry firm preferences, depending on whether firms are in a position to take advantage of the globalization and vertical specialization in production. Industry lobbying coalitions are thus fragmented in responding to rapid increases in imports.

4. Empirical Section

Why did firms within the PV industry adopt different strategies towards the extraordinarily rapid increase in Chinese module imports? We expect the positions firms took towards the imposition of a tariff differed systematically according on their characteristics. In this section we examine the characteristics of firms and their policy preferences for each of the market segments that make up the photovoltaic supply chain: the upstream, manufacturing, and the downstream, for the European, U.S. and Japanese markets. We then summarize how well our empirical model explains the positions adopted by firms towards the rise in Chinese photovoltaic module manufacturing.

Data and Methods

We focus on three major photovoltaic markets: Europe, the United States, and Japan. In addition to being important PV markets globally, each experienced a substantial increase in imports from China. This makes them appropriate as comparable cases when examining how firm structure affects trade preferences in the global PV market.

It is also noteworthy that governments in each of these regions/countries adopted different approaches to the rise in production from China. In the European Union a price floor was established on solar panels in 2012, along with voluntary export restraints (VERs). The agreement established a price floor of 56 cents per watt, with a total annual import limit of 2,000 GW. In the United States the Department of Commerce published a notice in October 2012 setting forth the final determination in its countervailing subsidy and anti-dumping investigation, with tariffs ranging from 24 to 36 percent. An important contrast is Japan, where there has been no policy response.

Our hypotheses focus on the effects of differences in firm characteristics in the global PV market on the preferences of these firms towards the imposition of barriers to imports of Chinese PV modules. Two kinds of data are used to assess the hypotheses empirically.

The first is the type of firms' vertical specialization, and the degree of globalization, which here refers to ties to solar PV production in China. To identify relevant firms and code their characteristics we used membership lists from the major industry associations headquartered in each country or region. We used a global database of PV manufacturers, supplemented with corporate websites, to identify the module production capacity of the firms, and the stages of the supply chain they participated in, from silicon, equipment to wafers, cells, modules, and systems integration/project development. We also coded whether the firms had ties to Chinese PV production. We considered ties in the form of sales to China, supply purchases from China, production facilities in China, and Chinese ownership. ²⁸The presence of any of these links was coded as the existence of such ties.²⁹ In table 3, we refer to firms that have any of the above ties as 'globalized,' whereas we code firms that do not have any such ties to China as 'domestic.' We also used a global database of PV manufacturers to ensure large firms were included in the analysis.³⁰ For upstream and downstream segments, we sampled firms drawn from the ad-hoc industry associations' member lists to identify the characteristics of firm members.

The second type of data is the trade preferences of firms. We used three sources of data to hand-code firms' trade preferences. First, we used primary documents in which firms state a position towards the use of barriers to trade against China imports. Second, we used member lists from associations in each market, coupled with formal statements by those associations, assuming members agree to the position taken by the association of which they are members. Third, we conducted interviews – summarized in the appendix – with market participants in the European, US, and Japanese markets. We carried out a

²⁸ All types of global ties discussed above could theoretically occur within one multinational firm.

²⁹ The data used in the analysis are included for reviewers.

³⁰ These firms were included under the assumption that larger firms are likely to be more influential politically A justification for this assumption is that PV manufacturing exhibits economies of scale. Larger firms are thus more likely to have higher net revenues, enabling them to allocate greater funds to political activities such as lobbying. A total of 64 manufacturers were coded across the three markets.

total of 29 interviews across the three markets with senior firms and industry association representatives. Standards for evidence when identifying firms' trade preferences are shown in the table below. In cases where direct statements by market participants were unavailable, we used third-party statements about observed firm preferences.³¹ Taken together, evidence collected for the manufacturing sector represents 89 percent of total module production capacity at year end 2012 for the European market, 93 percent for the United States, and 100 percent for Japan.

Firm Preference	Indicator
Support Protection	 Written documentation of support for increasing trade barriers against rise in PV imports from China, including press releases (self- reporting) and articles in major newspapers or industry magazines (third-party reporting). Statement of support for increasing trader barriers against rise in PV imports from China by firm or industry association representative in on-the-record interview. Two independent third-party interview statements that a firm supported increasing trade barriers against rise in PV imports from China. Membership of industry organization that adopts position in support of increasing trade barriers against rise in PV imports from China
Oppose Protection	 Written documentation of opposition to increasing trade barriers against rise in PV imports from China, including press releases (self- reporting) and articles in major newspapers or industry magazines (third-party reporting). Statement of opposition increasing trader barriers against rise in PV imports from China by firm or industry association representative in on-the-record interview. Two independent third-party interview statements that a firm opposed increasing trade barriers against rise in PV imports from China. Membership of industry organization that adopts position against increasing trade barriers against rise in PV imports from China.
Indifferent	1) Explicit statement of neutrality towards increasing trade barriers against rise in PV imports from China.

Table 4: Dependent Variable – Firm Preferences³²

³¹ Further details on data collection are in appendix 2.

³² We record cases where information is not available as missing data. While this could also be construed as representing indifference, we have no way to determine which is the more appropriate outcome.

Upstream Segment – Firm Preferences and Characteristics

In this section we assess hypothesis one, which focused on the upstream segment. This segment of the market is made up of polysilicon producers and the manufacturers of machine tools. As noted above, we expect firms operating in this segment of the market to oppose the imposition of trade barriers, regardless of whether they have ties to solar photovoltaic module production in China.

The evidence is consistent with expectations. The Semiconductor Equipment and Materials International (SEMI) - the global industry body of manufacturers in the microand nano-electronic industries has firm membership across the U.S., European, and Japanese markets. SEMI represented the interests of toolmakers and polysilicon producers globally, and identifies 170 members to belong to the solar equipment industry. A sample of 124 firm members of SEMI found all but seven firms manufactured some kind of production equipment for the solar wafer, cell and module industry, implying the organization represented the interests of upstream suppliers of solar equipment.³³ Statements from the organization expressed opposition to the imposition of barriers to module imports from China, as expected.³⁴ In addition, individual manufacturers in the United States expressed opposition to import barriers. Applied Materials, for example, is a toolmaker that exports machines for crystalline silicon photovoltaic cell production to China, and opposed US trade measures early on in the case.³⁵ This was also the case in the European market. The major industry association representing the upstream sector in Germany - in this case toolmakers - is the Verband Deutscher Maschinen- und Anlagenbau (VDMA) PV, the photovoltaic branch of the German Engineering Association. Data shows that 50 of the 52 members of VDMA produce some kind of machinery for the production of solar wafers, cells and modules.³⁶ Also like the United States, upstream equipment producers in Europe commonly sold their products to China. The European Commission examined a sample of eight upstream producers in Europe, finding that on average firms sold 20 percent of their solar-related products to the EU, 50

³³ The position in the supply chain was unclear for four firms from the sample. When extrapolated to the entire population, this suggests that 170 member firms were engaged in peripheral equipment manufacturing.

³⁴ Kaften 2012. Anonymous interviewee. Telephone interview with author. 2014. July 31.

³⁵ Mufson 2012; Schwartz 2011.

³⁶ Representative of trade association. 2014. Telephone interview with author. July 8.

percent to China and 30 percent to other third countries. Documentary evidence from the VDMA shows they also opposed the imposition of trade barriers in Europe.³⁷

This extends to polysilicon. In the United States, the two major vertically specialized polysilicon producers - Hemlock Semiconductor and REC Silicon - both rejected tariffs.³⁸ Although we expect them to hold this trade policy preference regardless of whether they have sales in China or not, evidence shows both firms sell polysilicon to Chinese customers.³⁹ Firms operating in this market segment and headquartered in Europe showed the same preference. Evidence shows Wacker Chemie AG, Europe's largest polysilicon producer, lobbied against tariffs.⁴⁰ In Japan, the major Japanese producer Tokuyama produced silicon in China in addition to Japan and Malaysia, and shifted productive capacity from Japan to China.⁴¹ Given the lack of support for manufacturers for trade protection, as described below, they were not required to state their opposition to trade protection is consistent with expectations given the focus of the firm on the upstream segment of the solar supply chain.

Manufacturing Segment – Firm Characteristics and Preferences

In this section we assess hypotheses two and three, which focus on the manufacturing segment of the solar supply chain. Our expectations are that module manufacturers without China ties should support the imposition of trade barriers, regardless of whether they are vertically integrated or specialized. We expect this to be balanced against manufacturers with China ties, who are more likely to be in a lobbying coalition in opposition to the imposition of trade barriers, regardless of whether they are vertically integrated or specialized.

Evidence shows that the manufacturing segment was divided along the lines of ties with China.⁴² In the United States, the Coalition of American Solar Manufacturers

³⁷ Wessendorf 2013.

³⁸ Kaften 2012; Ma 2012. Executive at a company involved in the dispute. 2014. Telephone interview with author. August 18.

³⁹ Ma 2013.

⁴⁰ Peel and Chaffin 2013. Author's phone interview with representative of trade association, April 10, 2014.

⁴¹ Tokuyama Corporation 2014.

⁴² See attached data source for reviewers.

(CASM) was created as an ad-hoc industry alliance that supported the imposition of trade sanctions.⁴³ Founded in October 2011, it initially represented seven US cell and panel manufacturers and was spearheaded by SolarWorld America.⁴⁴ Over the course of the two US trade cases, CASM grew to 256 official members by November 2014, including downstream firms. Key supporters included both vertically integrated firms such as SolarWorld and non-integrated firms such as Helios, both of which data shows did not have China ties. In the United States Suniva, a vertically-integrated manufacturer, lobbied against the imposition of trade barriers. It sold cells to China and also had contract module manufacturing in China, and thus had an interest in open trade with China.⁴⁵

Support for protection by vertically integrated and non-integrated firms without China ties was mirrored in the European market. EU ProSun was an alliance brokered by SolarWorld after lobbying of other manufacturers.⁴⁶ It claimed to represent the majority of EU solar industrial production. According to Milan Nitzschke, head of the group, it had 40 supporters, of which 25 participated in the complaint; five of those are Germanybased.⁴⁷ SolarWorld is integrated over cells, modules and partially downstream segments but does not have any China ties.⁴⁸ Sovello also supported tariffs, and was a manufacturer without any trade ties to Chinese firms.⁴⁹ Calyxo, a German module manufacturer, is non-integrated, and did not have any China ties at the time. It also supported the trade case.⁵⁰ Solarfabrik, on the other hand, opposed trade measures.⁵¹ Solarfabrik is a module manufacturer with a strategic alliance and supply agreement for cells with Chinese manufacturer JA Solar since 2008.⁵²

In contrast to the European and US markets, in Japan there was no pressure from module manufacturing firms to implement barriers to trade.⁵³ The lack of evidence for

⁴³ SolarWorld 2011.

⁴⁴ Mufson 2011b. Of the original members only SolarWorld, Helios USA and MX Solar USA are officially known.

⁴⁵ Wesoff 2014; Cheyney 2011. Author's phone interview with executive at company involved in the solar trade case. 2014.

⁴⁶ Chaffin 2012.

⁴⁷ Pauly and Amann 2013. Many members chose to stay anonymous.

⁴⁸ SolarWorld 2015.

⁴⁹ Pauly and Amann 2013.

⁵⁰ Calyxo 2013.

⁵¹ Neidlein 2013.

⁵² Solarfabrik 2008.

⁵³ Inoue Yasumi of Japan Photovoltaic Energy Association. 2014. Interview by author. Tokyo, Japan,

support for trade protection from manufacturing firms operating in the Japanese market contrasts with that of the US and European markets. Data shows, however, that of 32 firms operating in the solar sector with some manufacturing capabilities in Japan, just two firms were vertically specialized in module manufacturing without some form of international ties in China, and of these only Sanyo/Panasonic was a major manufacturer.⁵⁴

In contrast, a large number of firms – including all the major module manufacturers - had linkages with China. Of 32 firms operating with some module manufacturing capacity, 24 had some link with China, either by being headquartered in China, having a sales office there, or directly owning manufacturing facilities.⁵⁵ Among the integrated manufacturing firms headquartered in Japan, 17 firms had facilities in China either through direct ownership of module fabrication plants, or through a contract with an OEM or ODM based in China, headed by market leader Kyocera.

There were thus only a small subset of firms that were both located in Japan and that were directly competing with Chinese manufacturers, giving them preferences towards implementing trade barriers against Chinese imports. If we take into account market share, then only three of the photovoltaic manufacturers identified as firms with significant market share in Japan are focused on the photovoltaic market alone, with the rest diversified.⁵⁶

It is thus unsurprising that there was no pressure to implement barriers to trade in the case of Japan, in contrast to both the United States and Europe.⁵⁷ The Japanese government did not record any demands from firms or industry to push for protection from the rise in imports.⁵⁸ Interviews with manufacturing firms also suggested they did not support protectionism.⁵⁹ Examining the record of all press conferences between

November 5; Director, Renewable Energy Division, Ministry of Economy, Trade and Industry, Tokyo Japan. 2014. Interview with authors. 5 November.

⁵⁴ GTM Research 2013.

⁵⁵ No data was available for two further firms, of which one was Taiwanese manufacturer Topper Sun.

⁵⁶ Figures calculated from major manufacturers identified in Mehta 2013.

⁵⁷ Japan Photovoltaic Industry Association, Tokyo, Japan. 2014. Interview with authors. 11 November..

⁵⁸ Director, Renewable Energy Division, Ministry of Economy, Trade and Industry . 2014. Interview with authors. Tokyo Japan. 5 November.

⁵⁹ Representative of Solar Photovoltaic Division, Sharp Inc. 2014. Interview with authors. Nara, Japan. 7 November; Kyocera, Kyoto, Japan, Interview with authors. 6 November, 2014; Representative of Denebre, 2014. Interview with authors. Tokyo, Japan. 11 March; Representative of Sun-Edison. 2014. Interview with

February and June 2014 with the Minister of Economy, Trade and Industry, which has regulatory competence over many energy-related laws, and who heads the ministry responsible for designing and implementing Japan's renewables policy, also shows no evidence of ministerial concern about rising imports from China.

Downstream Segment – Firm Preferences and Characteristics

In this section we assess the evidence regarding hypothesis four. In common with upstream firms, we expect downstream firms to oppose the imposition of trade barriers regardless of whether they have ties to solar PV production in China. Firms with ties to China through supply contracts with Chinese module manufacturers would thus be affected negatively by trade barriers. In addition given that solar modules are largely undifferentiated, additional supply from Chinese producers reduces the price of modules which increases profits for developers and installers even if they do not directly supply from China. Indeed, the fact that US imports of Chinese PV solar modules amounted to \$2.65 billion reflects that US project developers and installers draw on Chinese supplies to a considerable extent.⁶⁰

The data is largely consistent with expectations, although the preferences of some firms do not match expectations.⁶¹ The downstream segment of the industry—project developers and installers—are predominantly non-integrated firms. In the case of the United States, a broad alliance that represented project developers and installers, as well as some Chinese importers, was created in November 2011 under the title the Coalition for Affordable Solar Energy (CASE).⁶² Data shows 57 of a sample of 76 firms were downstream installers and project developers.⁶³ CASE opposed the imposition of trade measures against imports. The CASE president and SunEdison co-Founder Jigar Shah noted that the "decision will increase solar electricity prices in the U.S. precisely at the moment solar power is becoming competitive with fossil fuel generated electricity."⁶⁴ In

authors. Tokyo, Japan. 12 March,; Representative of Sun Pulse. 2014. Interview with authors. Tokyo, Japan.13 March.

⁶⁰ The Pew Charitable Trusts 2013, 12.

⁶¹ See attached data source for reviewers.

⁶² Stuart 2011b.

⁶³ Equivalent to 70 firms across total of 94 members.

⁶⁴ Solar Server 2012.

ITC hearings, Sheldon Kimber, Chief Operating Officer of Recurrent Energy, noted that "Recurrent is one of North America's leading solar project developers," and that "The antidumping and countervailing duties being considered in these investigations, instead of supporting the U.S. solar energy industry, in fact, threaten it."⁶⁵

The behavior of US developers is mirrored in the European market. In Europe the Alliance for Affordable Solar Energy (AFASE) was founded in March 2012. AFASE had many small developers among its supporters, and it was supported by Chinese manufacturers including Trina, Yingli und Suntech.⁶⁶ The initial press release of the ad hoc coalition stated, "[AFASE] was launched to protect free trade, an essential element for the sector's well-being."⁶⁷ It initially represented more than 70 companies.⁶⁸ By the time it merged with the Sustainable Energy Trade Initiative (SETI Alliance), a publicprivate group promoting free trade in clean technologies in December 2013, the alliance had more than 800 supporters.⁶⁹ Data shows that AFASE largely represented the interests of downstream firms: 190 of the sample of 275 firms, or 72 percent out of a total membership of 856 if we extrapolate from the sample to the population, participate in the downstream segment of the market.⁷⁰ A second set of firms were wholesalers of solar equipment and manufacturers that provided peripheral equipment for the installation of PV panels such as mounting systems. The opposition of downstream firms to trade measures is thus consistent with the expectation that the lowered cost of inputs – in the form of cheaper modules from China – could increase net income.

Japanese downstream firms did not create a distinct industry association to defend their interests. This is unsurprising given there was no evidence of an attempt by domestic module manufacturers to implement protectionist measures against rising imports. Aggregate data suggest that developers are taking advantage of imports, as in the US and European cases; in FY2012, 673 Megawatts (MW) of non-Japanese produced modules were sold within the Japanese market, from a total market of 3.2GW (20.7

⁶⁵ International Trade Commission 2012, 154, 157.

⁶⁶ Beetz 2012. Representative of solar lobby group. Telephone interview with author .2014. April 10.

⁶⁷ Alliance for Affordable Solar Energy 2012.

⁶⁸ Alliance for Affordable Solar Energy 2012.

⁶⁹ Alliance for Affordable Solar Energy 2013.

⁷⁰ See attached data source.

percent).71

Summary of Evidence

The evidence introduced shows there were cleavages within the solar industry with regard to whether to lobby for or against the imposition of trade barriers against Chinese module exports. Evidence also shows these divisions within the solar industry were largely consistent with expectations. Taken together, a lobbying coalition of upstream polysilicon and equipment manufacturers, along with the majority of downstream project developers and installers, opposed trade measures. In contrast, in Europe and the United States module manufacturers were divided, with some supporting, and some opposing, the imposition of trade barriers. This division among manufacturers was also consistent with expectations, with domestically focused firms lacking ties with China supporting protection, and those with some form of ties with China opposing. Finally, data on the characteristics of manufacturers in Japan shows the firms enjoying significant market share retained supply relations with China, or located manufacturing facilities there. It is thus unsurprising these firms did not lobby for protectionist measures, in contrast to a number of US and European firms.

How did our model of trade expectations perform? In the upstream segment, the ad-hoc industry associations that represented the interests of 233 firms adopted the expected position, opposing the imposition of tariffs. There is no direct record of the trade preferences of Japanese firms operating in the upstream segment with regard to the Japanese market. This is unsurprising given the characteristics of module manufacturers headquartered in Japan. It is also consistent with expectations: the major source of protectionist sentiment in Europe and the United States – domestic module producers that lacked ties with China – was absent in the case of Japan. Data from Japanese firms operating in the US market which were members of an industry organization opposing the imposition of trade barriers in the US market, is consistent with expectations.

In the manufacturing segment of the PV supply chain, of 32 manufacturers examined – both vertically specialized and vertically integrated - the preferences of 21 of the firms matched expectations. In the Japanese case there was no attempt to pursue

⁷¹ Japan Photovoltaic Energy Association 2013.

import barriers against Chinese manufacturing. While there is no direct evidence of the trade preferences of these firms in aggregate presented here, interviews with major manufacturers confirm they did not consider lobbying for this outcome. Further, given the extensive ties between module manufacturers and China, this outcome is consistent with expectations for all but six firms. Finally, industry associations that were dominated by downstream firms, with a total membership of 950 firms, also opposed trade barriers, which matches expectations.

Data thus suggests that aside from the exceptions discussed below, a model focused on the degree of firm vertical specialization and globalization performs well in explaining the policy positions adopted by firms in the solar industry vis-à-vis Chinese solar imports. Lobbying coalitions formed centered on opponents of trade protection within the downstream and upstream sectors, allied with manufacturing firms that import from China, have facilities in China or are Chinese-owned. Against them, supporters of trade protection were overwhelmingly firms that were vertically specialized in manufacturing and did not have links with supply chain incorporating Chinese module production. The rise of vertical specialization in the solar photovoltaic industry thus increased the number of firms opposed to import protection, relative to those that supported such measures. By extension, this suggests that – in addition to the globalization of manufacturing – specialization is a second important factor that functions to mitigating against the introduction of barriers to trade.

		Extent of Ties with Trading Partner		
		Domestic	Globalized	
Segment of Specialization	Upstream	403 (0)		
	Manufacturing	24 (6)	17 (5)	
	Downstream	619 (5)		

Table 5: Summary of Firm Preferences (n = 1079 firms)

Note: Numbers in parentheses indicate number of firms not meeting expectations. Total number of firm observations lower than in attached datasheet because of exclusion of firms for which no data is available, and research institutes and other organizations that do not gain or lose from the imposition of import barriers. See appendix for calculation.

5. Explaining Outliers

The evidence introduced above demonstrates the data are consistent with our explanation for variation in firm preferences towards rising Chinese solar module imports, although the data also shows a number of firms behaved in ways inconsistent with expectations. In this section we summarize three potential explanations for why some firms did not behave according to expectations. We did so by analyzing the data using inductive methods, recognized as useful for developing new explanations for outcomes that do not meet expectations derived from existing theory.⁷² Doing so offers three potential explanations for why firms did not behave according to expectations.

Examining the characteristics of manufacturing firms that behaved contrary to expectations offers the first potential explanation for this outcome: five of the firms that remained neutral despite being domestic manufacturers in direct competition with Chinese exporters were in the process of takeover by a foreign firm. Manufacturers in the process of takeover negotiations may have been less profitable than those that were not, suggesting they may not have had adequate resources available to allocate to lobbying activities. It is also plausible that uncertainty about the future managements' policy preferences may have led firms to adopt a neutral stance. The German module manufacturer Sunways is a case in point, being taken over by the Chinese firm SDK Solar and adopting a neutral position.⁷³

Examining the characteristics of manufacturing firms that do not meet expectations offers a second possibility: that horizontal diversification into other sectors affects the costs and benefits associated with lobbying. The vertically integrated manufacturer Bosch Solar Energy, for example, opposed tariffs.⁷⁴ Its solar business would have benefitted from tariffs. Bosch is, however, a diversified industrial conglomerate, and the solar division played a minor role within Bosch's portfolio. Many of the other divisions have close China ties—they could plausibly have suffered from potential retaliation. This is also the case for a number of Japanese firms, as noted above,

⁷² George and Bennett 2005.

⁷³ Former Head of Communications. Telephone interview with author. 2014. September 25..

⁷⁴ Stromstra 2012.

suggesting horizontal diversification is a characteristic common to firms that adopt market and non-market strategies that are inconsistent with expectations.

A second form of horizontal integration also may have affected firm preferences. Two manufacturers with China ties supported trade measures: the Spanish firm Isofoton, for example, supported European trade measures while investing in Chinese manufacturing facilities and project development jointly with China National Offshore Oil Corporation, with joint project development occurring in Asia.⁷⁵ Spanish module manufacturer Solaria Energia also diversified its business by investing in solar power plants in China with a number of Chinese business partners, yet supported the case for trade protection.⁷⁶ This can plausibly be explained by the fact that joint manufacturing for the Asian market and project development in China affect the implications of trade protection in the European market for the two Spanish manufacturers. Their China ties and operations were focused on other markets, however, and therefore insulated from the trade dispute over wafers, cells, and modules.

A third and final plausible explanation for why a number of firms did not meet expectations is economic nationalism. Most notably, in the case of downstream firms in the United States, small firms – measured by numbers of employees, supported the imposition of trade barriers. Evidence suggests that a large number of these firms offered a rationale related to economic nationalism. Amped on Solar, a solar installer from New Jersey, argued that "From day one, our mission has included supporting American jobs and the American economy. Unfair practices by off-shore manufacturers and US companies who support those products has made it difficult for us to remain competitive." Century Roof and Solar of California noted: "Part of the goodwill of installing solar is using local manufacturing companies that inject dollars back into the local economy." Solar Works International of Oregon stated: "We need to protect and grow jobs here in the U.S.A. and the people of the United States need to buy Americanmade products."⁷⁷ For small developers such as these, the individual preferences of owners or senior management for domestic production appears to have influenced the position of the firm towards trade protection more than the potential economic benefits of

⁷⁵ Baigorri and Sills 2012; Isofoton 2012; Stuart 2011a.

⁷⁶ Solaria 2013a; Solaria 2013b.

⁷⁷ Coalition for American Solar Manufacturing 2015.

more open trade.

6. Conclusion

In this paper we have examined what explains differences in firm responses to a common economic shock: the rapid rise in Chinese photovoltaic module exports that began in the 2000s. We presented evidence that firms within the PV industry responded quite differently to this rise. We proposed that an important part of explaining this difference in responses lies in variation in firm characteristics across two dimensions: the type of vertical specialization, and the extent to which they are linked into supply chains that incorporate Chinese cell or module production.

We found substantial support for these hypotheses. Across the three major non-Chinese PV markets we found firms opposed or supported the imposition of trade barriers systematically depending on whether they were tied into global supply chains that incorporated China. Module manufacturers that are not integrated into global supply chains, on the other hand, overwhelmingly supported the imposition of trade barriers.

We also found that a smaller number of firms did not match expectations. Further investigation suggests a number of possible reasons for this. First, firms that were seeking outside investment, or were in the process of being taken over tended to remain neutral. Second, a number of firms that are diversified horizontally also appear to have made choices to leave the PV market, or not to respond politically. This can be explained by the different stakes that appear to exist for diversified firms for which solar is one of a number of businesses. When photovoltaics are a business unit within a firm that is diversified horizontally, exiting the market does not represent an existential threat, but is rather is a reallocation of capital to other parts of the business. Third, economic patriotism appears have affected the decision of a number of developer firms operating in the downstream segment of the supply chain. More generally, this suggests the characteristics of firm management can lead those firms to behave in ways that appear contrary to their economic interests.

Taken together, the evidence presented here suggests that vertical specialization and the globalization of supply chains offer an alternative mechanism through which the preferences of firms towards import competition can change. Given the rise of vertical

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specialization as an important characteristic of production across a wide range of industries, including many climate change-related industries, this suggests intra-industry disagreements over the merits of trade protectionism are likely to be an enduring feature of national politics.

There are at least two policy implications for the relationship between trade and climate change that emerge from this study. First, the globalization of supply chains appears to have complicated domestic political responses for governments to climate change. Green industrial policies, such as support schemes for renewable energy, have been a key component of policy responses to climate change in industrialized countries. They rest on political bargains that link climate mitigation with the growth of domestic green industries. However, as we have demonstrated, governments in the United States and Europe, in particular, faced cross-cutting demands from industry with regards to trade policy in solar photovoltaics. This challenges the existing "green growth" bargains between policymakers and the solar industry. While open trade in low-carbon energy technologies is likely to spur the growth of green industries and reduce technology cost, it hurts vocal parts of the manufacturing segment in industrialized economies. Policymakers face new trade-offs.

Second, the cases presented here suggest that in the trade-off between promoting domestic jobs and manufacturing on the one hand and promoting climate mitigation through open trade in low-carbon energy technologies on the other, the globalization of supply chains appears to favor climate change mitigation. Upstream and downstream firms demanding open trade outnumber and outweigh economically the manufacturing firms calling for trade protection. The participation in global solar photovoltaic supply chains is beneficial for the majority of the solar industry in industrialized economies. If we consider policy outcomes, however, the degree of unanimity or division does not appear to be a perfect predictor of outcomes. In the Japanese case firms certainly were uniformly opposed to import barriers. In the US and European cases, on the other hand, we found more (the United States), and less (Europe) stringent import barriers erected despite intra-industry divisions. Indeed, industry divisions may have ironically enabled political entrepreneurs in the European Commission to act more freely in deciding when and how to respond to the rise in Chinese module imports.

Appendix 1: Data Collection

This appendix offers additional information on the methods used for data collection and analysis.

a. Measuring the Dependent Variable (trade preferences)

The unit of analysis is the individual firm, however we also use the preference of intra-industry associations as a proxy for the preferences of individual members. We do so based on the following assumptions.

- Ad hoc alliances (AFASE, CASE, CASM, EU ProSun): The four ad hoc alliances are special-purpose associations formed around a specific policy position—either in support or in opposition of trade protection. We thus assume that all members joined the group as a result of their individual trade preferences.
- Trade associations (SEMI, VDMA): We assume that the formulation of lobby positions within the associations is based either on majority or consensus rule. If consensus applies, member preferences equal association preference. If the majority rule applies, some member firms may still have different preferences. If those preferences are strong, we would assume that the firm join one of the ad hoc alliances in addition to its trade association membership. In that case, we would take membership in the ad hoc alliance as an indicator for the firm's preference.

b. Interviews

Sampling

We conducted 30 interviews with high-level industry executives and analysts. Interviewees were selected based on two methods. First, we employed snowball sampling to identify interviewees to discuss the general dynamics of the case. We first identified key actors involved in the main trade associations and ad hoc alliances through websites and major newspaper articles. We then asked those interviewees for referrals to other key actors. We made sure to interview representatives of each party in the dispute. However, the distribution of interviewees across the three positions—neutral, support, oppose—is not equal, as those that we could identify to support trade measures were less likely to agree to an interview than those who opposed trade measures. Second, we identified interviewees based on information need to establish trade preferences. If written documentation of a trade preference was unavailable, we contacted the firm directly. We identified the spokesperson or a senior executive through web research.

Questions

The interviews were conducted in a semi-structured way. The questions were somewhat tailored to the specific home market of the firm (EU, Japan, US). The following questions were at the core of the interviews:

- What was your organization's position at the beginning of the trade case?

- Do you support, or would you support, the imposition of import barriers?
- What was the rationale for taking that position?
- Did your position change over time?
- How would you describe the landscape of business interests in the trade dispute?
- Do you know what position firm X took?

Confidentiality rules

Confidentiality rules were discussed with each interviewee individually before the interview. The interviews are based on

- For background only: The formation cannot be used in writing. It only provided cues for who to interview and what to examine.
- Off the record: The information can be used, but not attributed.
- Attribution by role: The information can be used and attributed to the interviewee by her/his professional function as specified by the interviewee.
- Attribution by name: The information can be used and attributed to the interviewee by name.

c. Calculation of Outcomes (Table 5)

Table 5 reports the total number of firms in each segment, and the number of firms in each segment that did not meet expectations. The following procedure was used to calculate outcomes.

- First, all firms in the population were categorized by segment. In addition, firms
 operating in the manufacturing segment were categorized by ties with trading partner.
 Note that a number of region-specific industry associations had mixed membership.
 We therefore allocated using this procedure. Sources of data used to identify firms in
 the population are identified in the body of the paper.
- 2. Second, we coded the preferences of firms, and identified whether they confirmed, or did not confirm, with expectations. Sources of data for preferences for firms are identified in the attached data for reviewers file. Firms with no data, and organization members (such as organizations specializing in basic R&D, or research institutes) for which the policy had little distributive implications, were excluded from the final firm count included in Table 5.
- 3. For organizations with large memberships, firms were randomly sampled using sampling procedure for categorical data. (This is relevant in the upstream and downstream segments only). Sampled firms are identified in the attached data for reviewers file. In Table 5 we report the results for the mean number of firms of each type within the organization, and the mean number of firms matching (or not matching) expectations for the whole population. Range of total number of firms operating in upstream segment is 395-415 firms. Range of total number of firms operating in downstream segment is 609-639 firms.

4. Coding rules for preference outcomes in the Japan market differed from that for the European and US markets, given that no market participant brought a formal case to government. Interview data from the industry association, and from the government, confirmed there had been no demand for protection from firms. For manufacturing and downstream firms this interpretation is consistent with interview data with firm representatives. Given the position of the industry association, we coded member firms as opposed to the imposition of trade protection.

We believe this is the most appropriate strategy for interpreting this evidence. It is also possible to recode outcomes excluding firm observations from the Japan market that lack a direct statement for or against the possibility of the imposition of import barriers.(Individual interviews with manufacturers yielded this information.) Recalculating using this coding method reduces the total number of firm observations, as follows. It does not substantially change the number of firms that did not match expectations.

Table 5a: Summary of Firm Preferences (Exclude some Japan market observations) (n = 956 firms)

		Extent of Ties with Trading Partner		
		Domestic	Globalized	
Segment of Specialization	Upstream	350 (0)		
	Manufacturing	24 (6)	13 (5)	
	Downstream	553 (5)		

Note: Numbers in parentheses indicate number of firms not meeting expectations. See appendix below for calculation.

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