Trade Protection and Firm Innovation:

Impact from U.S. Anti-Dumping Sanctions on Innovation Output in China

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Abstract

This study examines how trade protections, such as anti-dumping sanctions on foreign exports, impact innovations developed by affected foreign firms. Using data on U.S. anti-dumping sanctions levied on Chinese exports from 1985 to 2015 and domestic patents developed by Chinese firms in China that are associated with the sanctioned products, we found that anti-dumping sanctions led to an increase in the overall number of domestic patents in China in technology classes that were most relevant to the sanctioned products. This result is consistent with our theory that anti-dumping sanctions enlarge the gap between the pre-innovation and post-innovation rents, thereby providing greater incentives for sanctioned firms to innovate. Furthermore, this effect was boosted by a major national-level pro-innovation campaign instituted by the Chinese central government to promote domestic innovations that further increased the post-innovation rent. However, we also found that anti-dumping sanctions decreased the production of novel patents in China that were most relevant to sanctioned products, which is consistent with the theory that anti-dumping duties reduce the resources available to firms to develop innovations. To sum up, these findings suggest that affected Chinese firms produce more innovations to escape competition and future sanctions, but that they can go only so far to produce more incremental innovations than novel innovations due to resource constraints. This study addresses the literature gap concerning how trade protections affect sanctioned firms' innovation and generate important strategy and policy implications from such protections' unintended consequences.

Keywords: Anti-dumping sanctions; U.S.-China trade conflict; innovation; patents

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1. Introduction

Trade conflicts have become a central issue in global business and international relations. Complaints from domestic firms about unfair competition from low-price foreign exporters often prompt home country governments to use protectionist policy instruments, such as tariffs and anti-dumping duties, to raise costs on foreign competitors. For example, trade tensions between the U.S. and China have taken center stage in international trade, with the U.S. government levying anti-dumping duties on Chinese firms more frequently than any other countries (Roberts 2008, Chandra and Long 2013, Chandra 2016). About 70 to 80 percent of total anti-dumping investigations against Chinese imports are concentrated on labor-intensive, low-price, and low-value-added products, such as chemicals, steel, and mineral products (Li 2005).

How do trade protections affect firms? Among a myriad of firm outcomes, innovation has attracted much attention because it crucially determines firms' long-term value and competitiveness (e.g., McGahan and Silverman 2006, Henderson and Clark 1990). Most extant research has focused on how free trade with or trade protections against low-price manufacturers, particularly those from China, affect *domestic* or *protected* firms in European and U.S. markets. Scholars such as Bloom, Draca, and van Reenen (2016) showed that free trade and the inflow of Chinese exports increase innovations at European firms. However, Autor, Dorn, Hanson, Pisano, and Shu (2020) found that the opposite effect occurs for U.S. firms. More directly, Lenway, Morck, and Yeung (1996) showed that trade protection reduces R&D investment made by protected firms in the U.S., thereby reaching a conclusion similar to that of Bloom et al. (2016).

However, to the best of our knowledge, prior research has not examined how trade protections affect innovation on *the other side* of the table—low-price foreign firms that are sanctioned by protectionist policies. This is an important literature gap because research that addresses it can hold crucial implications for potential wealth redistribution outcomes in home countries that wield protectionist policy tools. Protectionist policies commonly aim to enhance the competitiveness of domestic firms that compete directly with low-price exporters and, thus, very likely produce *low* value-added products. If these policies end up increasing foreign exporters' innovations, which enable these foreign competitors to compete in higher-end markets, the policies inadvertently will increase competitive pressure on domestic firms that produce *higher* value-added products. In other words, an unintended consequence of the protection of lower-end domestic manufacturers may be to intensify competition faced by higher-end domestic manufacturers by shaping affected foreign firms' innovations. More broadly, this mechanism may sow the seeds of international competition over technology in the future.

To address this gap, we examine how plausibly exogenous anti-dumping duties imposed by the U.S. government against Chinese exports to the U.S. affect the quantity and novelty of patents associated with affected products in China. First, we argue that anti-dumping duties strengthen Chinese firms' incentives to "escape competition" (Aghion, Bloom, Blundell, Griffith, and Howitt 2005) and reduce the risk of future anti-dumping sanctions by way of increasing innovations, which could help them move into higher value-added markets. As a result, the quantity of Chinese innovations associated with the affected products will increase. Second, following the Schumpeterian argument, we also recognize that anti-dumping duties reduce affected Chinese firms' revenue and, thus, the resources available for developing innovations (Aghion et al. 2005). The trade-off is that innovations' novelty would decrease as a result of reduced resources that are available to develop breakthrough or novel innovations. To sum up, we argue that foreign firms facing anti-dumping sanctions will try to increase their innovations to escape competition and sanctions, but they can only go so far to produce more incremental innovations than novel innovations (whereas the latter could increase the value-added of their products to a greater extent than the former).

We collected information on all anti-dumping duties that the U.S. levied on Chinese firms from 1985 to 2015, and all domestic patents granted by China's patent office, the China National Intellectual Property Administration (CNIPA), during the same time period.[1] Patents provide a reliable proxy for domestic innovation output in China (e.g., Huang, Geng, and Wang 2017, Wang, Li, and Furman 2017). Each anti-dumping case only named one product, and we matched each product to a primary patent technology class, i.e., a three-digit International Patent Classification (IPC) code.[2]

[1] This agency was known as the State Intellectual Property Office of China (SIPO) prior to August 28, 2018.
[2] We provide a detailed discussion of this process in the methods section.

We examined the quantity and novelty of the CNIPA patents produced by Chinese firms in the affected technology classes before and after they were "shocked" for the first time (i.e., the first time any product matched to this technology class was targeted by a U.S. anti-dumping investigation). Following the international trade literature (e.g., Lu, Tao, and Zhang 2013), we took the U.S. government's top-down decision to levy an anti-dumping sanction on Chinese imports as a plausibly exogenous event to relevant firms in China, and we adopted a difference-in-differences estimation strategy. We followed prior studies (Fleming et al. 2007, Jia et al. 2019) to identify a focal patent as a novel patent if it contains the first occurrence of a new combination of patent classes compared with all the patents that have ever been granted by the CNIPA until the focal patent's application year.

We found that a U.S. anti-dumping sanction on a product from China increased the number of CNIPA patents developed by Chinese firms in the technological class that was a primary match for the affected product, both within the affected technology class and compared with unaffected, but otherwise comparable, technology classes. These results are consistent with the "escaping competition" theory (Aghion et al. 2005, Bloom et al. 2016). Moreover, we found that anti-dumping sanctions reduced the number of novel patents in affected technology classes compared with unaffected ones, which is consistent with our second theoretical arguments. The positive effect from U.S. anti-dumping sanctions was more pronounced after the launch of the national pro-innovation campaign in China in 2006, which provided extra rewards and resources for domestic innovations.

This study generated several interesting insights. The fact that trade protections increase the quantity of affected foreign firms' innovation output is possibly an unexpected and unintended outcome that potentially could lead to the escalation of technology competition. However, an interesting nuance exists, in that trade protection decreases targeted foreign competitors' novel innovations, highlighting an inherent trade-off between the quantity and novelty of the innovations that low-price foreign firms produced under resource constraints. This means that overall, trade protection drives affected foreign firms to produce a larger quantity of more-incremental innovations. While this outcome might not affect competition over frontier technologies immediately, it foreseeably could increase the added value of foreign competitors' products, which not only may alter the structure of product market competition, but also contribute to greater technological competition in the future.

2. Theory and Hypotheses

2.1. Theoretical Background

Trade sanctions are a public policy tool that countries employ to increase the barriers that foreign competitors face when they compete in domestic markets (Marsh 1998). Levying anti-dumping duties is a primary form of trade sanctioning on low-price foreign competitors, on the theoretical basis that a foreign firm exports a product at a price that is significantly lower than the "fair value" (which often is measured by the price it normally charges within its home market or estimated marginal production costs). In practice, trade protection tools frequently are used for political or anti-competition purposes, which we discuss in the next section.

Anti-dumping sanctions alter the relative competitiveness of domestic vs. foreign firms, which should influence important firm strategies such as innovation. Two countervailing effects exist: On one hand, Bloom et al. (2016) show that in the absence of trade protection, free competition with low-price exporters, particularly those from China, increases firms' innovations in developed markets in Europe. The explanation is that price competition with low-price exporters increases the "gap" between pre- and post-innovation rents, thereby increasing the incentives of firms from developed markets to use innovation to "escape" competition with low-price exporters by moving to higher value-added product markets. Following the same argument, research shows that trade protection reduces innovations in protected firms in the U.S. because protection increases the return of rent-seeking activities relative to that of productive activities, thereby reducing protected firms' incentives to innovate (e.g., Lenway et al. 1996, Morck, Sepanski, and Yeung 2001). On the other hand, however, Autor et al. (2020) show that competition with low-price exporters decreases innovations at U.S. firms. The explanation is that price competition depletes firm resources that could be invested in innovations, consistent with the Schumpeterian view of innovation. Thus, a direct implication of this perspective is that trade protection should increase innovations in protected firms.

This study seeks to understand how an anti-dumping duty affects the quantity and novelty of affected foreign exporters' innovation output. To do this, we not only draw on the aforementioned theoretical arguments developed for domestic firms protected by protectionist trade policies, but also extend them to develop our own hypotheses about effects on foreign firms whose products that these policies sanctioned.

2.2. Hypotheses

2.2.1. Anti-Dumping Sanctions and Sanctioned Firms' Innovations

We theorize that the imposition of anti-dumping duties on foreign exporters raises the cost of the affected foreign firms' products, essentially reducing their competitive advantage relative to protected domestic firms—a cost that is expected to persist *if* the affected foreign firms continue with their previous low-price strategy selling focal products. This outcome has three implications.

First, the above analysis suggests that anti-dumping duties reduce *pre*-innovation (i.e., status quo) rents facing sanctioned foreign firms (but this does not affect protected domestic firms). Second, increasing products' value-added via innovation will allow affected foreign firms to charge a higher market price, thereby increasing *post*-innovation rents—the same driving force that shapes innovations at domestic firms that compete with low-price foreign exports (e.g., Nickell 1996, Blundell, Griffith, and Van Reenen 1999). Thus, within-firm investment shifts exist, in that facing competition, firms will increase their innovations (Bloom et al. 2016, Breinlich, Soderbery, and Wright 2018) and their products' quality (Khandelwal 2010). Finally, the post-innovation rent may be even greater for sanctioned foreign firms because selling higher valued-added products not only allows them to capture a higher price, but also helps them reduce the risks of future anti-dumping charges—a risk that protected domestic firms do not face. All three factors enlarge the gap between pre- and post-innovation rents for sanctioned foreign firms, thereby creating greater incentives for sanctioned foreign firms to innovate to both escape competition and avoid future anti-dumping sanctions.[3]

A selection effect also may exist. In studying the effect from trade on firms from developed markets, prior research points to a reallocation effect, in that, facing competition from low-price foreign exporters, less-efficient firms in developed markets exit and more efficient firms thrive (Melitz 2003).

[3] In theory, it is possible that after the anti-dumping duties are imposed on foreign exporters, these firms may avoid the U.S. market completely. However, the U.S. market comprises the lion's share of all the markets these firms export to, so it is difficult to ignore the U.S. market altogether, or to find substitutes of similar size and strategic importance.

Among the limited studies on how trade protection affects low-cost exporters from developing countries such as China, Lu et al. (2013) demonstrated that U.S. anti-dumping sanctions against Chinese firms increased competition among Chinese exporters, and between Chinese exporters and U.S. domestic producers, by "weeding out the weak," i.e., reducing the number of less-productive Chinese exporters, including direct exporters and single-product exporters, while increasing surviving exporters' volume of exports. Based on the two sets of arguments developed above, we propose the following hypothesis:

Hypothesis 1 (H1): *An anti-dumping sanction that the U.S. government imposes on a Chinese product will increase the production of innovations in general from China that are germane to the product that this sanction targets.*

Despite strengthened incentives to develop innovations after being targeted by anti-dumping sanctions, the question of whether firms have the capacity to do so remains. Chinese exporters that anti-dumping sanctions have targeted are generally low-cost manufacturers, possibly with resource constraints to start with, and anti-dumping sanctions further reduce these firms' current revenue. Even though the promise of a higher post-innovation rent is attractive, firms need resources to develop innovations to create such rent, which is the core mechanism within the Schumpeterian view of innovation (Schumpeter 1943). The fact that reduced competitive advantage decreases the resources available for innovation could be used to explain why, when facing intensified competition from Chinese exporters, U.S. manufacturers reduce (instead of increase) innovations (Autor et al. 2020).

We argue that such resource constraints do *not* necessarily mean that the foreign firms that anti-dumping sanctions targeted necessarily would decrease innovation, particularly given their heightened incentives to use innovation to escape competition and future sanctions. If we view innovation as a rich set of activities instead of just a binary choice for firms, then it is highly possible that greater resource constraints may force sanctioned firms to make trade-offs in allocating limited resources among different kinds of innovative activities.

One way to examine different types of innovation is to distinguish between incremental and novel innovations (e.g., Fleming et al. 2007). Novel and breakthrough innovations are highly uncertain, take years to develop and require significant investment in R&D, but they have the greatest potential to raise the value-added in firms' products (e.g., Jia et al. 2019). However, incremental innovations may require fewer resources and involve lower risks to develop, but they also may raise the value-added of firms' products to a lesser extent. Greater resource constraints resulting from anti-dumping duties may lead affected foreign firms to focus on more incremental innovations to generate just enough value to escape competition and future sanctions, but they may not have enough resources to engage in novel innovations that have the potential to increase their value-added to the largest extent. Therefore, the trade-offs may make it more economical to develop incremental innovations and gain just value-added to escape competition and sanctions. As a result, we postulate that anti-dumping sanctions produce an adverse effect on the production of novel innovations, as proposed in the following hypothesis:

> Hypothesis 2 (H2): *An anti-dumping sanction that the U.S. government imposes on a Chinese product will decrease the production of novel innovations from China that are germane to the product that this sanction targets.*

2.2.2. Role of Pro-Innovation National Policy in China

It is common for the state to use public policies to incentivize the development of domestic innovations (Block and Keller 2011). In our research context, China's central government initiated a major public policy campaign in 2006 to promote domestic innovations, the first of its kind in this country (Baark 2019, Jia et al. 2019). The China State Council issued two major national policy guidelines, including the "China's National Medium- to Long-term Plan for the Development of Science and Technology (2006–2020)" and the follow-up "National Intellectual Property Strategy (2008)",[4] both of which called for enhancing Chinese firms' overall innovation capabilities and transforming China into an innovative society by 2020 (Abrami et al. 2014). The innovation campaign represented a top-down effort, in that local governments answered the central government's call to generate their own plans to incentivize individuals and organizations to produce more domestic innovations (which were measured primarily by patents). Independent from and not as a response to

[4] "China's National Medium- to Long-term Plan for the Development of Science and Technology (2006–2020)," issued by the State Council of China (2006). A Chinese version of this document is available at http://www.gov.cn/jrzg/2006-02/09/content_183787.htm

any anti-dumping sanction imposed by foreign governments,[5] this pro-innovation policy campaign provided incentives for firms to develop innovations via multiple means (Jia et al. 2019): It increased the amount of resources available to firms to develop innovations through increased subsidies and grants, and provided rewards and bonuses for individuals and firms that successfully developed innovations (Lei, Sun, and Wright 2012).

Such pro-innovation public policies produce two effects by increasing the returns from innovations and the resources available for innovative activities. First, they increase post-innovation rents that firms could capture because in addition to the advantage of escaping competition over low-end products and reducing the risk of future sanctions in foreign markets, firms receive rewards from their own home-country governments for developing innovations. As a result, the gap between pre- and post-innovation rents becomes even greater, thereby further enhancing sanctioned firms' incentives to develop innovations. Thus, we propose:

Hypothesis 3 (H3): *Pro-innovation government policy in China will enhance the positive effect produced by U.S. anti-dumping sanctions on the production of innovations in general from China that are germane to the products that these sanctions target.*

Considering that these pro-innovation public policies also provide greater resources to support investment in developing innovations, they help alleviate resource constraints that firms face, particularly those that anti-dumping duties affect. For firms whose resources available for innovation have dwindled as a result of anti-dumping sanctions, more government subsidies in support of innovation activities mean that these firms are less compelled to make trade-offs between developing incremental and novel innovations. As a result, the dampening effect on novel innovations from being targeted by anti-dumping sanctions will be alleviated when the government provides policy support for innovations. Thus, we propose:

[5] Based on our review of the literature and informal interviews and conversations with legal and policy scholars, there is no evidence that the Chinese government would provide any direct subsidies to firms that received anti-dumping duties.

Hypothesis 4 (H4): *Pro-innovation government policy in China will weaken the negative effect produced by U.S. anti-dumping sanctions on the production of novel innovations from China that are germane to the products that these sanctions target.*

3. Research Context: U.S. Anti-Dumping Sanctions

Evidence shows that the U.S. carried out anti-dumping actions more frequently than any other countries in the world. For example, between 1980 and 1986, the U.S. was responsible for 90 percent of all countervailing duty[6] cases worldwide (Schott 1990). The U.S. targeted China, one of the largest export-oriented developing countries, with more anti-dumping duties than any other countries did (Roberts 2008). Furthermore, trade conflicts between the U.S. and China have intensified over time. Indeed, the percentage of anti-dumping sanctions that the U.S. government has imposed on Chinese exporters among all exporters has increased substantially over time, as shown in Figure 1.

[Insert Figure 1 about here]

How and why are anti-dumping sanctions levied in the U.S.? In the following sections, we provide background information on anti-dumping sanctions' administrative procedures and how they are used in practice. Then based on this information, we discuss the implications for anti-dumping sanctions' plausible exogeneity in relation to foreign firms' innovation activities.

3.1. Administrative Procedures on Levying Anti-Dumping Sanctions

U.S. anti-dumping policies date back to 1898, when the Countervailing Duty Law was first published. The establishment of the U.S. Revenue Act of 1916 (Section 800-801), also known as the Anti-Dumping Act of 1916, allows, under certain conditions, civil actions and criminal proceedings to be brought against importers who sell foreign-produced goods in the U.S. at prices substantially less than the prices at which the same products are sold in the relevant foreign market or below their

[6] Anti-dumping measures and countervailing duties share some similarities, as many countries handle the two under a single law, apply a similar process to deal with them, and provide a single authority with responsibility for investigations. Countervailing duties are tariffs on imported goods that are imposed to offset subsidies that the exporting country's government provides.

marginal costs (Niels 2000). Anti-dumping sanctions are top-down decisions made by U.S. government agencies, including the Department of Commerce (DoC) and the International Trade Commission (ITC).

The anti-dumping process starts by opening an anti-dumping investigation after U.S. manufacturers from an import-competing industry file a complaint with the DoC, an agency that also can open an investigation on its own, about possible dumping by foreign competitors. The DoC then calculates dumping margins and makes decisions on whether the foreign firm has carried out dumping actions, such as setting a price lower than fair value. Subsequently, the DoC uses the information on costs and sales collected through questionnaires from foreign firms to make assessments (Moore 2006). The ITC determines whether the products involved in dumping complaints have damaged relevant industries in the U.S.

A typical investigation usually lasts no more than one year from the filing of a complaint to the final decision over whether dumping has occurred (Taylor 2004). There are three critical stages. During the first stage, an investigation is initiated upon the filing of complaint. The launch date for the investigation and the product under investigation are announced, but the official announcements at this stage do not disclose the name of the foreign firm accused of dumping. Most of the cases (about 73%) accused all exporters of the focal product of dumping, whereas the remaining cases named specific firms. However, information on whether all or some firms are accused is released during the next stage. During the second stage, the DoC and ITC announce whether an "affirmative" preliminary decision has been made, i.e., whether it has ruled in favor of the plaintiff and dumping has been confirmed. If the determination is negative, the investigation is terminated. In the case of an affirmative preliminary decision, the foreign importers are required to pay a deposit as a bond for expected dumping duties (Lu et al. 2013). During the last stage, a final determination is made by the DoC, then the ITC. If the dumping activity is affirmed, an injury determination is made, and the U.S. Customs Service collects the duty for importing products on named firms or all firms that export the product. A high duty rate effectively will reduce imports on named products (Lu et al. 2013).

3.2. Political Drivers of Anti-Dumping Sanctions in Practice

In theory, anti-dumping sanctions are designed to punish foreign exporters that engage in unfair trade practices (dumping) to restore fair competition, and they possibly are used for these purposes in some cases. In addition to curtailing export volume, research shows that protectionist trade policies also are used for political and anti-competition purposes. Some scholars assert that anti-dumping sanctions have less to do with unfair trade (Davis 2009) and are used more often to defend mature and politically influential domestic industries from foreign competition (Jabbour et al. 2016).

Indeed, prior research shows that economic challenges, political forces, and institutional factors influence how governments use anti-dumping sanctions in trade. Tharakan and Waelbroeck (1994) found that the determinants of anti-dumping sanctions and injury in Europe and the U.S are influenced significantly by domestic political influence. They found that domestic political effects on industry concentration—i.e., whether the case is initiated by associations of industries with more than 25% output is from five firms—will dominate anti-dumping injury decisions. Francois and Niels (2004) showed that Mexican anti-dumping authorities favor industries dominated by large domestic firms with more significant political clout and lobbying efforts. Moore (1992) evaluated the ITC legislative process and found that commissioners use criteria outside of plausible interpretation of the law and were under heavy influence by special-interest groups and vote-seeking politicians. As a result, anti-dumping processes favor labor-intensive industries that face competition from labor-abundant developing countries more than other industries in the U.S., regardless of actual exporting situations.

3.3. Plausible Exogeneity of Anti-Dumping Decisions

In the international trade literature, scholars often consider decisions to start investigations of anti-dumping cases, preliminary and final decisions, and these events' timing to be plausibly exogenous shocks that are both outside the control of and difficult to be anticipated or influenced by foreign exporters (Lu et al. 2013). The process of anti-dumping sanctions outlined above and the time between filing a complaint and the decision to affirm dumping suggest that it is very challenging for Chinese firms exporting these products to know in advance which specific products might be sanctioned by the U.S. government and when the sanctions eventually could be imposed, lending further support to the event's exogeneity to firms in China.

Furthermore, to the extent that a significant portion of protectionist measures is adopted to protect politically influential domestic producers for rent-seeking purposes, it weakens concerns that levying anti-dumping sanctions is a natural outcome, or a proxy for growing exports or foreign competitors' business strength. Indeed, Lu, Tao, and Zhang (2013) showed that Chinese products' exporting volume under U.S. anti-dumping sanctions actually was smaller, rather than larger, than that of comparable products that were not sanctioned.

Finally, anti-dumping sanctions are levied most commonly on more labor-intensive and lower-value-added products. In the U.S., anti-dumping cases concentrate on textiles, chemicals, iron, steel and other metals, plastics, mechanical goods, machinery, and electrical equipment (Li 2005, Messerlin 2004, Egger and Nelson 2011, Pierce 2011). In Europe, 81% of anti-dumping cases have involved raw materials or low-skill manufacturing products that most frequently face competition from Asian exporters (Davis 2009). These are not the sectors in which firms and countries typically compete over innovation, thereby alleviating concerns that anti-dumping sanctions are levied to stall foreign competitors' innovative activities, or in anticipation of rising innovation by foreign competitors. Nevertheless, we will address the exogeneity issue by further examining an instrumental variable approach.

4. Methods

4.1. Data and Sample

We collected the following data sets to construct the variables needed to test our hypotheses. The first dataset comprises anti-dumping data from the World Trade Organization's (WTO) anti-dumping cases database, which includes all the anti-dumping cases that the U.S. levied against exporters from China from 1985 to 2015.[7] These cases all list the names of the products accused of being dumped on the U.S market by Chinese exporters, and the names of companies that are accused of dumping the products (or all Chinese exporters of the product). We recorded the date of the initiation of the

[7] From the definition of WTO: "If a company exports a product at a price lower than the price it normally charges on its home market, it is said to be 'dumping' the product." Thus, anti-dumping "focuses on how governments can or cannot react to dumping —and it is often called the 'Anti-dumping Agreement'" (*WTO | Anti-dumping—Gateway*, n.d.).

investigation, as well as the date of "affirmative" preliminary decisions mandated by the U.S. government – the first two stages of any anti-dumping case as discussed above. In our primary analysis, we used the date of the investigation's launch as the timing of the shock because the decision to start the investigations is announced immediately and published openly online by the ITC,[8] and nearly 90% of the cases investigated eventually were affirmed. Therefore, when a dumping investigation concerning a product is announced, exporters of the product would both know and expect a high likelihood that the accusation is affirmed and that anti-dumping duties will be levied in the near future.

Indeed, anti-dumping duties were levied at a later date than the time of announcement, so the affected firms did not face actual cost increases during the year of the announcement. However, firms act in anticipation that investigated dumping cases have a high likelihood of being affirmed, and that they need to pay the associated duties, which, as our theory suggests, would lead to changes in their decisions over innovation activities. In a robustness analysis, we used the date of affirmative preliminary decisions as the alternative date of the shock and found consistent results (see the Robustness Analyses section for details).

Furthermore, we noted two critical features of the context. First, every case included one (and only one) product accused of being dumped onto the U.S. market, and the accused product can implicate one or more specific Chinese companies, or all Chinese producers of the product (although the names of the specific companies are released only during the subsequent affirmation stage, as discussed above). Second, one product can be sanctioned multiple times. For our difference-in-differences estimation, we only focused on the products that any anti-dumping investigation targeted for the first time. That is, from this data source, we obtained the names of the products investigated for dumping by the U.S. government for the first time, and the dates when the investigation started.

The second data set includes all the invention patents granted by CNIPA between 1985 and 2015 to measure patented innovation outcomes, and the application dates for these (granted) patents. Invention patents are the most substantive and rigorously examined type of patents in China, compared with the other two categories: design patents and utility model patents (Huang et al. 2017, Wang et al.

[8] https://www.usitc.gov/ (Last accessed on September 19, 2020)

2017). Considering that our study focuses on trade protection's impact on innovation output from firms, we only included patents produced by firms from mainland China in our analyses and excluded those patents produced by universities, research institutes, and government agencies.

We connected the two data sets by adopting the following procedures to match sanctioned products with patents. We started with 182 anti-dumping cases that were investigated between 1985 and 2015. Of them, 160 cases received "affirmative" preliminary decisions mandated by the U.S. government, so we only examined them. Given that each case named only one product, these cases named 160 products, of which 156 were unique products (some products were investigated more than once). We then matched each of the 156 products to an IPC code (i.e., technology class). The IPC is an international classification system widely used by over 100 countries, including China, to classify the detailed industrial product attributes and technical content of patents.

We adopted the following steps to establish the match between each product and primary technology class (IPC code). First, we searched for the sanctioned product's name in the IPC classification content list and identified a unique three-digit IPC code[9] that can be linked most closely to the product.[10] Second, to further check the validity of the matching performed in the first step, we cross-checked the product name in the Google patent database to identify the most relevant patents to the given product, allowing us to further ascertain the IPC code assigned to the product in the first step. Third, as an additional check, we used the Reference Table of International Patent Classification and National Economic Industry Classification (2018)[11] provided by the CNIPA to double-check the accuracy of the IPC code linked to each product named in the anti-dumping cases. The resulting sample comprised 156 three-digit IPC codes. Finally, this sample contained 44 unique three-digit IPC codes whose matched products had been part of an anti-dumping investigation in the past. We considered, for

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[9] We linked each product description from the WTO anti-dumping cases database to a three-digit IPC code, which was the most fine-grained level we were able to link the product to without compromising on accuracy. That is, there usually would be more than one four-digit IPC code that may be linked to a specific product category. For example, the "Crystalline Silicon Photovoltaic" product category is linked to H01 (basic electric elements) at the three-digit IPC level. The product category would need to be matched to more than one IPC code, such as H01G and H01L had it been linked at the four-digit IPC level, thereby increasing the match's ambiguity. Doing this also would reduce accuracy and increase the difficulty in identifying a unique IPC code for the product category in the control group.

[10] A team of three Ph.D. engineering students led by a professor in engineering and technology management in a leading research university performed the search, matching and cross-checking in this step.

[11] http://www.sipo.gov.cn/gztz/1132609.htm (in Chinese)

each of these 44 IPC codes, the date of the first anti-dumping investigation of any product that was matched with the focal IPC code to mark the occurrence of the "shock" to this technology class. These IPC codes and their shock years form our treatment group. Figures 2 summarizes the above procedures we adopted to construct the treatment group.

[Insert Figure 2 about here]

We performed the analyses at the IPC (or product category) level instead of firm level for the following reasons. First, most of these anti-dumping sanction decisions targeted the entire product category or IPC instead of individual firms. As a result, we can conduct empirical analyses more precisely and cleanly at the IPC or product category level. Second, many of the firms in our sample (low-cost exporters from China) were small, private firms. As such, we did not have access to their detailed firm-level characteristics over time, so we conducted our empirical analyses at the IPC (or product category) level. That being said, in this study, we focused only on CNIPA patents that firms generate, accounting for more than 95 percent of the CNIPA patents.

Next, we constructed a control group of technology classes that are comparable to the treatment group, but whose matched products have never been named in any of the U.S. anti-dumping sanctions. We conducted the matching based on the following three conditions. First, the three-digit IPC codes in the treatment group and those in the control group must had the same first-digit IPC code to reflect the similarity in the broader technology class. Second, we identified the control group as the "closest technology neighbor" to the treatment group based on the similarity of the next two digits in the IPC codes. For example, the closest neighbor of three-digit IPC code H01 would be H02. Third, the matched IPC codes in the control group must not be associated with any products targeted by U.S. anti-dumping sanctions. This procedure resulted in the 44 IPC codes in the treatment group being matched to 44 comparable IPC codes in the control group.

As a robustness check, we constructed an alternative control group by randomly picking a "close technology neighbor" for each of the 44 IPC codes in the treatment group, i.e., a random selection of another three-digit IPC code that (1) shared the same first-digit IPC code for each IPC code in the treatment group, and (2) was not associated with any product targeted by U.S. anti-dumping sanctions.

Finally, we collected the information on the invention patents belonging to the technology classes (IPC codes) that comprised the treatment and control groups. We deemed a patent as belonging to the given technology class if it identified the given IPC code as one of its technology classes. The information on these patents included their application year, grant year, number of inventors, number of assignees, and number of claims. We took the average value of these variables from all identified patents within each IPC class and compared their average value between the treatment and control groups. We found that these variables' average values were not significantly different between the two groups, as shown in Table 1.

[Insert Table 1 about here]

To summarize, the unit of analysis is the technology class (IPC code)-year. The treatment group includes the technology classes that are most relevant to the products sanctioned for anti-dumping by the U.S. government, and we captured the year in which technology class was "shocked" for the first time (i.e., any of the products matched to this technology class were investigated for anti-dumping by the U.S. government for the first time). The control group comprises technology classes that are the closest neighbors of the technology classes in the treatment group, but whose matched products never have been investigated by the U.S. government for dumping.

4.2. Estimation Strategy

Difference-in-differences estimates commonly are employed to examine the effects from government policies or exogenous events on innovation activities (e.g., Murray and Stern 2007, Jia et al. 2019). We followed this approach and used a staggered difference-in-differences estimation method to assess the impact from plausibly exogenous anti-dumping sanctions imposed by the U.S. government on products from China.

In the main analysis, we deemed the shock as occurring during the year in which the anti-dumping investigation was initiated. Given that announcements of the initiation of investigations do not name specific firms (recall that this information is released at the subsequent affirmation stage), we considered that the shock affected all Chinese manufacturers of the named product. In subsequent robustness checks, we restricted our sample to anti-dumping cases that targeted all firms and excluded cases that named specific manufacturers at the affirmation stage.

In the main models, we conducted difference-in-differences estimations for the full sample to compare differences in innovation output between the treatment group and control group before and after the anti-dumping sanction was announced. In alternative models, we examined the "treatment effect on the treated", i.e., the differences only within the treatment group before and after the anti-dumping sanction was announced. The alternative models with IPC fixed effects allowed us to observe temporal effects before and after the anti-dumping sanction within a given industry in the treatment group, which helps mitigate any industry-specific attribute (such as growth rate) of the treatment group compared with the control group. The alternative models also have the advantage of holding the affected products' characteristics constant.

4.3. Variables

Dependent variables. The *number of patents* is the number of invention patents granted by CNIPA to which the given IPC code was assigned in the given year. (Note that more than one IPC code may be assigned to a patent). The *number of novel patents* is the number of novel invention patents granted by CNIPA to which the given IPC code was assigned in the given year. Following Fleming et al. (2007) and Jia et al. (2019), we viewed a patent as novel if it involves the first occurrence of a new combination of technology classes compared with all the patents that have ever been granted by the CNIPA prior to the focal year. The theoretical basis of this approach is that new innovations often are generated from new combinations of existing knowledge (Fleming and Sorenson 2004, Gruber, Harhoff, and Hoisl 2013), and that the more distant the existing combined knowledge is, the more novel the new knowledge is, a theory also known as "recombinant growth" of knowledge, or "recombinant innovation" (Weitzman 1998).

Explanatory variable. Our key explanatory variable, *post-anti-dumping*, is an indicator variable coded as 0 in the years before the "shock," or the initiation of the first anti-dumping sanction that affects the technology class, and coded as 1 in the first and subsequent years after the shock occurred, for the treatment group. For the control group, the variable is always coded as 0. This variable lags by one year in our regression models. This approach follows closely with that taken by prior studies (Singh and Agrawal 2011, Murray and Stern 2007).

Control variables. We included the following control variables in our models. The *Average number of inventors per patent* is the average number of inventors of the CNIPA patents in the given IPC code in the given year. This variable captures the complexity and sophistication of the technologies in the given technology class (Huang and Murray 2010). The *Average number of assignees per patent* is the average number of assignees of the CNIPA patents in the given IPC in the given year. This variable captures the size and external support provided to the technology in the given technology class (Lei et al. 2013). The *Average number of claims per patent* is the average number of claims allowed and granted to the CNIPA patents in the given IPC and the given year. It captures the average strength of the CNIPA patents in the given technology class (Scotchmer 1991). *Accumulated patents* is the cumulative number of invention patents in the given technology class (IPC code) until the focal year of observation. This variable controls for the cumulative technology stock in this technology class (Furman et al. 2002). We also included IPC fixed effects and year fixed effects in all models. All the explanatory variables and control variables (except the IPC fixed effects and year fixed effects) lag by one year. As robustness checks, we lag these variables by two or three years, and the results are consistent.

4.4. Model Specification and Estimation

Our dependent variables – *number of patents* and *number of novel patents* – are both count variables that take on non-negative integer values; therefore, we employ a nonlinear regression approach to avoid heteroskedastic, non-normal residuals (Hausman et al. 1984). Specifically, we employed conditional quasi-maximum likelihood (QML) estimates based on the fixed-effects Poisson model developed by Hausman, Hall, and Griliches (1984). The fixed-effects Poisson estimator produces consistent estimates of the parameters in an unobserved-component multiplicative panel data model under very general conditions and provides a consistent estimate of the conditional mean function even if the variances are specified wrongly (Wooldridge 1999).

We also incorporated robust standard errors in the fixed-effects Poisson models based on Wooldridge (1999), using the Huber-White sandwich estimator (Allison and Waterman 2002, Greene 2004) in all models to account for possible heteroscedasticity and lack of normality in the error terms. QML (i.e., "robust") standard errors are consistent even if the underlying data-generating process is not Poisson. Furthermore, QML standard errors are robust to arbitrary patterns of serial correlation (Wooldridge 1999) and, thus, are immune to the issues raised by Bertrand, Duflo, and Mullainathan (2004) concerning inferences in difference-in-differences estimations. We clustered the standard errors around IPC to adjust for potential non-independence across same-IPC observations over time. This approach is consistent with those of prior studies (e.g., Azoulay et al. 2010, Simcoe and Waguespack 2011). As a robustness check, we also used negative binomial regression models with robust standard errors, yielding largely consistent results (details available upon request).

Our model specification is captured by Equation (1) below, and Y_{it} is the dependent variable. β_1 captures the effect from the anti-dumping sanction on patenting outcomes in the affected technology class.

$$Y_{it} = \beta_1 Post\_antidumping_{it} + \beta_2 IPC\ fixed\ effect_i + \beta_3 Year\ fixed\ effect_t + \beta_4 control\ variables + \varepsilon_i \quad (1)$$

5. Results

5.1. Effects from Anti-Dumping Sanctions on Quantity of Patents

Table 2 reports the descriptive statistics and correlation matrix of the variables. We had 2,728 IPC-year observations in our sample, with 44 unique three-digit IPC codes in the treatment group matched to 44 IPC codes in the control groups from 1985 to 2015. In an average year, an average technology class (IPC code) has 359 granted invention patents and 0.651 granted novel invention patents. An average patent in the sample has about three inventors, one assignee, and four claims.

[Insert Table 2 about here]

Table 3 shows the results from our fixed-effects Poisson regression models for the difference-in-differences estimation. Model 3-1 includes both the treatment and control groups, and the dependent variable is the *number of patents*. The results show that *post-anti-dumping* leads to a significant (p <

0.01) increase of 43% ($e^{0.355}$-1) on the number of patents in the IPC. Model 3-2 uses the alternative control group, as described previously. The estimated effect from *post-anti-dumping* is significant (p < 0.01) and positive (44%), similar to the estimation using the main control group shown in Model 3-1. We also estimate the effect from *post-anti-dumping* on the treatment group only (but not the control group) and report the results in Model 3-3. This model uses the difference in the year the anti-dumping sanctions were imposed on different IPCs in the treatment group. The effect from *post-anti-dumping* continues to be positive (43%) and significant (p < 0.01). These results support H1.

[Insert Table 3 about here]

We further demonstrated the temporal effect from U.S. anti-dumping sanctions on the number of CNIPA patents by generating coefficient estimates analogous to those from *post-anti-dumping* on the *number of patents*, but for each year preceding and following the anti-dumping sanction shock (instead of for the entire period after anti-dumping). Figure 3 shows the coefficient from each time period using the specification in Model 3-1 (with main control group, solid lines) and that in Model 3-2 (with an alternative control group, dash lines). Noticeable pre-trends do not appear to exist before the shock of anti-dumping sanction occurs, and the coefficient estimates fluctuate over time. However, a notable, systematic "jump" exists during the year after the shock occurs, in that the coefficient estimates become systematically larger than those in post-shock years. These results further indicate that the anti-dumping shock produces a positive and significant effect on *number of patents*.

[Insert Figure 3 about here]

5.2. Effects from Anti-Dumping Sanctions on Quantity of Novel Patents

Table 4 reports the regression results using the *number of novel patents* as the dependent variable. Model 4-1 shows that *post-anti-dumping* leads to a significant decrease of 24% (p < 0.05) on the *number of novel patents* when we compare the treatment and the main control groups. Conducting the same analysis using the alternative control group similarly yields a significant decrease of 22% (p < 0.1), as shown in Model 4-2. The estimated effect from anti-dumping sanctions on the treatment group only, as shown in Model 4-3 is, however, not statistically significant. Taken together, these results support H2.

[Insert Table 4 about here]

We also illustrated the temporal effect from U.S. anti-dumping sanctions on the number of novel CNIPA patents by plotting the coefficient estimates analogous to those of *post-anti-dumping* on the *number of novel patents,* but for each year preceding and following the anti-dumping sanction shock. Figure 4 shows the coefficient from each time period using the specifications in Model 4-1 (with main control group, solid lines) and Model 4-2 (with alternative control group, dash lines). Noticeable pre-trends before the shock of anti-dumping sanctions occur do not appear to exist, and the coefficient estimates fluctuate over time. However, there seems to be a decrease in the estimated effect from after the shock occurs. These results are consistent with the finding that the anti-dumping shock produces a negative effect on the number of novel patents from the period T+1 to T+4. In period T+5, this effect appears to diminish.

[Insert Figure 4 about here]

5.3. Effect from Pro-innovation National Campaign in China

We used split-sample analysis to assess the effects from anti-dumping sanctions on Chinese firms' innovation output before and after 2006, when the pro-innovation national campaign started, to demonstrate whether and how anti-dumping sanctions' effect on the *number of patents* and the *number of novel patents* changes before and after 2006 to examine H3 and H4, respectively.

Table 5 reports the results from the split sample analysis of the *number of patents*. The results in Model 5-1 suggest that U.S. anti-dumping investigations generate a marginally significant ($p < 0.1$) decrease in the *number of patents* before 2006. By contrast, this effect becomes significant and positive on or after 2006, as shown in Model 5-3. The estimated treatment effect demonstrates a similar pattern only on the treated group. Within the treated group, while anti-dumping sanctions produce a negative and significant effect on the number of patents before 2006 (Model 5-2), this effect becomes positive and statistically significant after 2006 (Model 5-4). Taken together, these results suggest that the positive effect from anti-dumping sanctions on the number of patents in the full sample, as demonstrated in Table 3, was boosted during the pro-innovation national campaign launched in 2006. Specifically, the post-2006 effect is so strong that it overwhelms the negative effects from anti-dumping sanctions on the number of patents before 2006 (which would be consistent with a Schumpeterian view) and reverses the estimated effect. This result is consistent with H3, which postulates that pro-innovation public policy increases the post-innovation rent, thereby further enlarging the gap between pre- and post-innovation rents and providing greater incentives for firms targeted by anti-dumping sanctions to engage in more innovations. Thus, these results support H3.

[Insert Table 5 about here]

Table 6 reports the results from split-sample analysis on the *number of novel patents* before and after the launch of the pro-innovation national campaign in 2006. Models 6-1 and 6-3 show the results from the treatment and control groups, while Models 6-2 and 6-4 only show the results from the anti-dumping sanctions on the treatment group. The estimated coefficient of *post-anti-dumping* is not significant in the subsample analysis. A possible explanation for this result is the lack of statistical power due to the smaller sample sizes in each subsample, i.e., we were unable to obtain the same statistical power from Models 6-1 and 6-3 compared with Model 4-1. Thus, our results do not support H4.

[Insert Table 6 about here]

5.4. An Instrumental Variable Approach

We have provided conceptual arguments based on the procedures concerning anti-dumping sanctions and the prior literature on international trade that found anti-dumping investigations initiated by the U.S. government to be plausibly exogenous to Chinese firms. That is, the Chinese firms exporting to the U.S. have little control over whether or when the specific products will incur U.S. government sanctions. It is also challenging for them to predict when an anti-dumping investigation targeting their products will occur. Nevertheless, we cannot completely rule out potential endogeneity between U.S. anti-dumping sanctions and innovations in China. For example, one may wonder whether the U.S. government levies anti-dumping sanctions on Chinese products that it views as having the potential to become more innovative in the future.

To address this issue, we conducted an instrumental variable analysis using a two-stage least squares (2SLS) regression analysis. We aimed to find an instrument rooted in the U.S. political system that could affect the likelihood of U.S. governments opening anti-dumping investigations, but for reasons that are unrelated to anticipation of innovation in China.

We used the instrumental variable *presidential turnover year*, which is defined as the last year of the administration of the incumbent U.S. president. Presidential turnover can happen either when the incumbent loses re-election or at the end of his eight-year term when a new president (from either the Democratic Party or Republican Party) must be elected. Our logic is that based on the outcome of presidential turnover, we can infer that the political competition and campaign pressure during the election year should be more intense than in other years. Tremendous uncertainties exist during U.S. presidential election years, and tension is particularly high during election years in which an incumbent president is at high risk of losing re-election (e.g., George H. W. Bush in 1992, when he lost the presidential election to Bill Clinton). Even when a president is near the end of his second term and is expected to step down (and even if history suggests that candidates from the opposing party usually win the election), great uncertainties remain among the presidential nominees from both parties and concerning whether the opposing party can win the election (e.g., the "surprise" win by Donald Trump vs. Hillary Clinton in 2016).

Tremendous political rivalries and heightened political uncertainties during these presidential turnover years create two outcomes. First, the tension and uncertainties they create are exogenous to exporting firms in China. Second, they may be correlated with anti-dumping sanctions launched during these years, in that the incumbent president's administration might act more (or less) aggressively to impose anti-dumping trade sanctions on foreign imports to fit his political narratives. There are reasons to believe that either direction might occur. For example, if the incumbent administration wants to signal a hawkish trade policy to pivotal voters, they may increase protectionism policies. If they need to address other issues that pivotal voters care more about at the time, they may shift attention away from trade protection to these issues. Either way, changes to their trade protection policies during these years are more likely to occur to please the voters whom they target than to curb anticipated innovation trends regarding certain Chinese products.

Table 7 shows the results generated by the estimation using this instrumental approach. Model 7-1 shows the first-stage results from regressing anti-dumping shocks on the instrumental variable *presidential turnover year*. The instrumental variable is, indeed, a significant predictor ($p < 0.01$) of announcing anti-dumping investigations. The estimated effect is also economically significant, and its F-statistic during the first stage of the 2SLS regression is 9.764, which exceeds 8.96 (Stock-Yogo weak ID test critical values 15% maximal IV size),[12] a rule of thumb suggested by Staiger and Stock (1997). Therefore, these results show that our instrument is relevant to the suspected endogenous variable. It turns out that *presidential turnover year* is correlated negatively with the number of anti-dumping sanctions investigated during these years, which is consistent with the explanation that at least during our sample's time frame, incumbent administrations paid less attention to levying anti-dumping sanctions when they faced intense political rivalry and uncertainty in the election.

[Insert Table 7 about here]

Model 7-2 reports the results from the second stage of the 2SLS regression with the number of patents as the dependent variable. The coefficient *post-anti-dumping* is positive and significant ($p < 0.01$). The results are consistent with those in the difference-in-differences estimates shown in Table 3, but when we included year fixed effects during the second stage of the regression, which is reported in Model 7-3, the coefficient estimation of *post-anti-dumping* is no longer statistically significant. This outcome occurs possibly because our instrument primarily uses year variation in identifying the estimated results, whereas including year fixed effects consumes too much of the yearly variation that the instrumental variable approach relies on to generate an estimate.

Model 7-4 reports the second-stage result of the model with number of novel patents as the dependent variable. The *post-anti-dumping* coefficient is negative and significant ($p < 0.05$). The results are consistent with those generated by in the difference-in-differences estimates shown in Table 4 that anti-dumping shock negatively affects the number of novel patents. For the same reason discussed above, in Model 7-5, in which year fixed effects are included during the second-stage analysis, the coefficient estimate of *post-anti-dumping* is no longer significant.

In summary, our instrumental variable approach leverages the assumption that in years with the most intense partisan competition in the U.S., decisions to levy anti-dumping sanctions on foreign goods are more likely to be influenced by various political gestures to please domestic voters than the reason

[12] This value is also higher than any of the Stock-Yogo weak ID test-critical values, suggesting that this instrument is strong (Stock and Yogo, 2005).

for curbing anticipated innovation of foreign firms. In fact, we found that fewer anti-dumping sanctions are initiated during years with presidential turnover, which is consistent with the theory that during these years, the government's attention shifts away from anti-dumping sanctions to other activities that may have been deemed more important for incumbent politicians. The results show that during these politically contentious time periods, anti-dumping sanctions, which are less likely to have been driven by a need to preempt foreign innovation, continue to exert a positive effect on foreign patents, thereby alleviating aforementioned endogeneity concerns to some extent.

5.5. Robustness Analyses

We conducted a series of robustness checks on the timing of the treatment, sample selection, alternative dependent variable, and lags. First, instead of using the year of the initiation of investigations as our treatment, we viewed the shock as occurring during the year of affirmation of anti-dumping decisions (recall that affirmation occurs after the initiation of investigation as the second stage of an anti-dumping investigation). As shown in Models 8-1 and 8-2 of in Table 8, the estimated effects from *post-anti-dumping* on the *number of patents* remain positive and significant ($p < 0.01$), which are consistent with the results in Models 3-1 and 3-3, respectively. In Model 8-3, the estimated effect from *post-anti-dumping* on the *number of novel patents* remains negative and significant ($p < 0.05$), consistent with the results in Model 4-1. The effect from *post-anti-dumping* in Model 8-4 is not significant (as is with that in Model 4-3).

[Insert Table 8 about here]

Second, recall that each anti-dumping decision names a few or all firms, but this is disclosed only during the affirmation stage, not during the investigation announcement. Also recall that we considered all initial announcements in our main analysis regardless of whether a subset of firms was implicated at the subsequent affirmation stage. In the robustness analysis, we included only the anti-dumping cases that targeted all firms (and excluded cases that targeted a subset of firms). The results shown in Table 9 are consistent with those in the main analyses.

[Insert Table 9 about here]

Third, we conducted robustness checks using an alternative dependent variable, *number of patents* minus *number of novel patents*, which captured only the number of incremental patents. We reported the estimation results in Table 10. Models 10-1 and 10-2 include the main control group and alternative control group, respectively. The results are consistent with those shown in Models 3-1 and 3-2. Model 10-3 includes the treatment group only, and the result is also consistent with that shown in Model 3-3.

[Insert Table 10 about here]

Fourth, we also used a two-year lag and three-year lag for all explanatory variables, as shown in Tables A1 and A2, respectively, in the Appendices. The results largely are consistent with our main results in Tables 3 and 4.

Finally, we excluded outlier firms from our analyses, i.e., firms accounting for more than 10% of the patents in any given IPC in our sample, representing the most innovative firms in our sample. The results are consistent with our main analyses in Tables 3 and 4 (details available upon request). This approach alleviates concerns that the results are driven mostly by a handful of firms that are extremely active in developing innovations.

6. Discussion

This study examined how anti-dumping sanctions imposed by the U.S. government on Chinese exports affected production of patented innovations developed by Chinese firms in China that were germane to the sanctioned products. Our difference-in-differences estimates show that such anti-dumping sanctions significantly increased the number of domestic patents that were most relevant to the affected products in China, and this effect was boosted during the period of the pro-innovation national policy launched in 2006. Moreover, we found that the sanctions decreased the number of novel domestic patents associated with the affected products. Overall, these findings suggest that anti-dumping sanctions could lead to the unintended consequence of increasing the sanctioned products' value-added by increasing the amount of general or incremental innovations that are germane to the affected products. At the same time, these anti-dumping sanctions lead to a decrease in the amount of novel patents germane to the affected products, likely due to resource constraints.

This study makes the following contributions. First, while most studies in international trade examine how free trade or trade protection affects innovations of firms that either face greater competition from low-price foreign competitors or enjoy the protection (they tend to be those from developed markets), how such trade protections affect innovations developed by low-cost foreign exporters that are sanctioned is underexplored. We provided a theoretical framework and empirical evidence to shed light on this important, but understudied, question. An unintended consequence of such trade protections is that they increased innovations germane to the affected products developed by sanctioned foreign firms. This could lead to intensifying competition faced by higher-end domestic manufacturers and may even sow seeds of competition over technology in the future.

Second, this study sheds light on the theoretical tension developed in the competition and innovation literature, upon which we drew to develop our hypotheses. While we acknowledge the tension raised in the literature that greater competitive pressure (which results from having to pay additional anti-dumping duties in our context) both provides greater incentives to innovate and diminishes the resources needed to do so (Aghion et al. 2005), we do not view innovation as a binary choice. Instead, firms have choices over *which* type of innovation to develop, and we focused on the distinction between incremental vs. novel innovations. This study generates new insights that while trade sanctions increase the overall innovation developed by affected low-cost foreign firms, this effect appears to be driven primarily by the increase in incremental innovations, whereas trade sanctions decrease the development of affected foreign firms' novel innovations.

6.1. Policy Implications

This study yields important policy implications related to the (unintended) effects from trade protection on wealth redistribution in developed markets and on future technology competition among countries. Most trade protection policies are designed to protect firms from home markets that directly compete with low-cost foreign exporters; these firms tend to be lower value-added manufacturers themselves. The finding that such protection drives sanctioned foreign firms to increase their innovations, presumably to increase their products' value-added, suggests that higher value-added manufacturers from developed markets likely will face greater competition, comprising an unintended wealth redistribution effect. Moreover, this effect also may increase the likelihood that product competition evolves into technology competition—with the caveat that such technology competition may not occur immediately on the technology frontiers.

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Figure 1. Anti-dumping Duties Imposed by the U.S. Government on Chinese Exporters as a Percentage of All Anti-dumping Duties Levied by the U.S. Government by Year

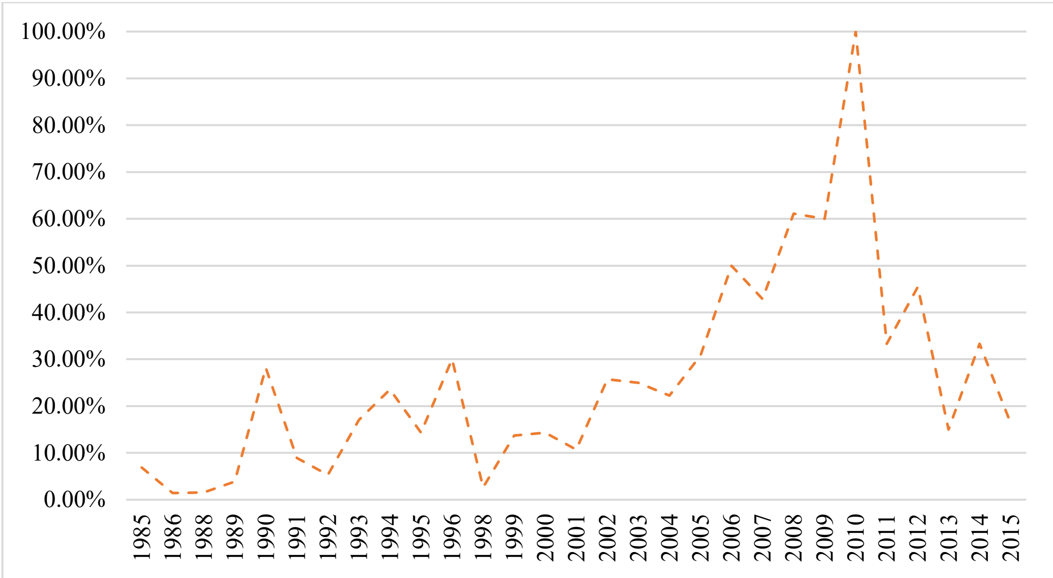


Figure 2. Data Construction Process

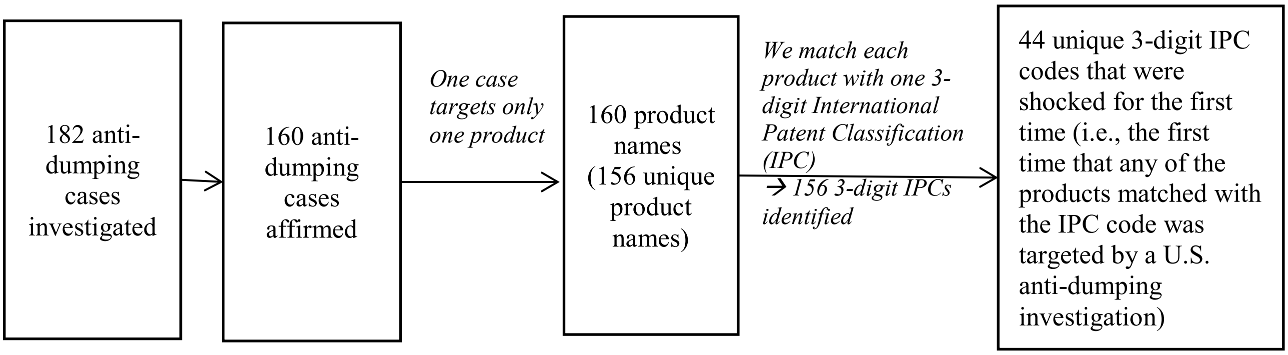
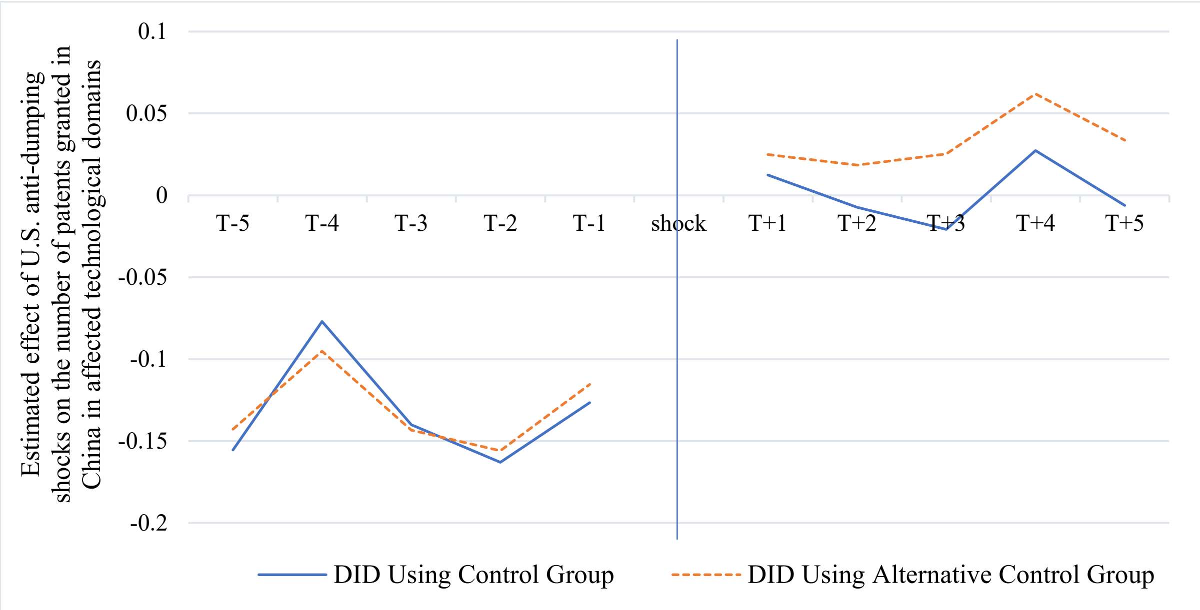
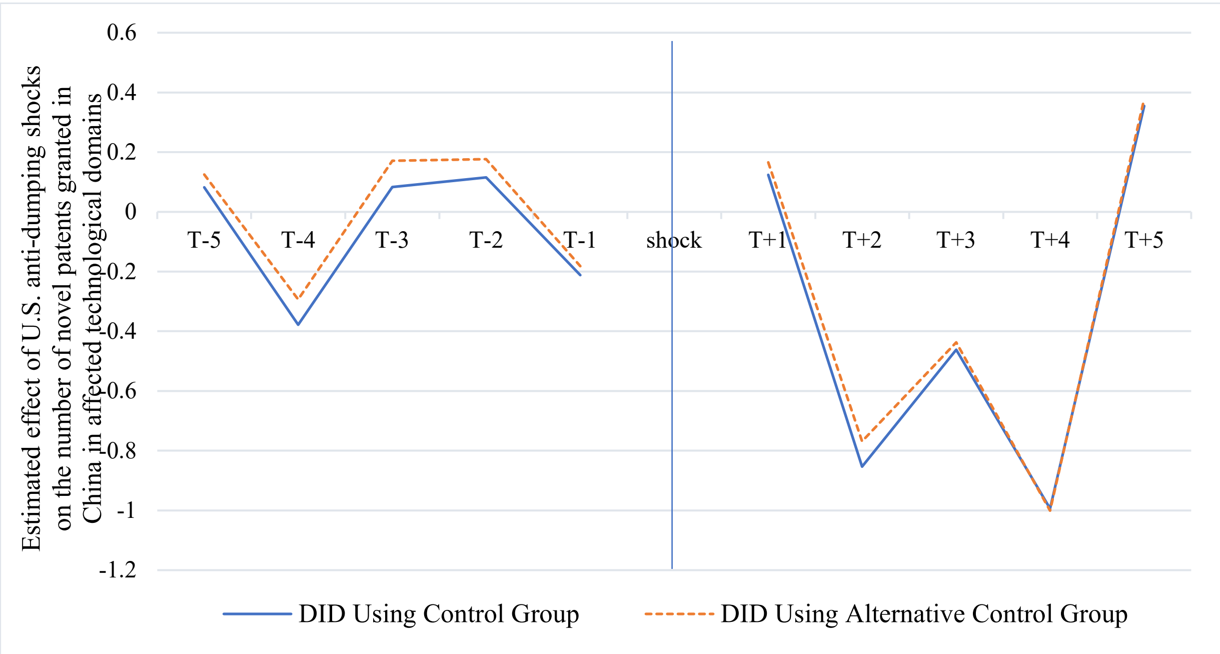


Figure 3. Estimated Temporal Impact of Anti-dumping Investigation on Number of Patents



Notes: The coefficients are estimated based on the model specifications in Model 3-1 and Model 3-2 of Table 3. The figure illustrates the estimated temporal impact of U.S. anti-dumping investigations on granted patent in China for each year preceding and following year of "shock" which is the investigation announcement year.

Figure 4. Estimated Temporal Impact of Anti-dumping Investigation on Number of Novel Patents



Notes: The coefficients are estimated based on the model specifications in Model 4-1 and Model 4-2 of Table 4. The figure illustrates the estimated temporal impact of US anti-dumping investigations on granted novel patent in China for each year preceding and following the year of "shock" which is the investigation announcement year.

Table 1. Comparison between Treatment Group and Control Group

Variables	N	Treatment Group Mean	Treatment Group S.D.	Control Group Mean	Control Group S.D.	Two-sample T-test P-value
Average patent application year	44	2011.4	0.730	2011.5	0.619	0.325
Average patent grant year	44	2014.0	0.639	2014.1	0.541	0.314
Average patent grant delay	44	2.607	0.258	2.590	0.210	0.737
Average number of inventors per patent	44	3.524	0.986	3.553	0.846	0.923
Average number of assignees per patent	44	1.158	0.087	1.160	0.072	0.881
Average number of claims per patent	44	5.871	1.106	5.644	0.559	0.229

Note: None of the variables above between the treatment group and control group are significantly different at the 5% level.

Table 2. Summary Statistics and Correlations

Variable	Obs.	Mean	S.D.	[1]	[2]	[3]	[4]	[5]	[6]
[1] *Post-anti-dumping*	2728	0.297	0.457	1.000					
[2] *Number of patents*	2728	358.996	1133.490	0.227	1.000				
[3] *Number of novel patents*	2728	0.651	1.323	0.015	0.172	1.000			
[4] *Average number of inventors per patent*	2728	2.980	1.683	0.084	0.126	0.171	1.000		
[5] *Average number of assignees per patent*	2728	1.050	0.440	0.066	0.097	0.172	0.704	1.000	
[6] *Average number of claims per patent*	2728	4.262	2.656	0.207	0.256	0.148	0.399	0.510	1.000
[7] *Accumulated patents*	2728	1764.368	6899.940	0.202	0.892	0.124	0.105	0.077	0.221

Table 3. Effects of Anti-dumping on Number of Patents

Models	3-1	3-2	3-3
DV	*Number of patents*		
Sample and Model	With control group-FE Poisson	With alternative control group-FE Poisson	Treatment group only-FE Poisson
Post-anti-dumping	0.355***	0.367***	0.356***
	(0.0965)	(0.0914)	(0.0904)
Average number of inventors per patent	-0.00410	-0.000407	0.0128
	(0.0511)	(0.0498)	(0.0526)
Average number of assignees per patent	0.252	0.432**	0.218
	(0.208)	(0.213)	(0.316)
Average number of claims per patent	0.0396	0.0278	0.0275
	(0.0298)	(0.0294)	(0.0412)
Accumulated patents	-0.0000191***	-0.0000193***	-0.0000194***
	(0.00000125)	(0.00000116)	(0.00000112)
IPC fixed effects	YES	YES	YES
Year fixed effects	YES	YES	YES
Observations	2640	2640	1320
Log likelihood	-31449.5	-29126.7	-18105.6

Robust standard errors in brackets. All tests are two-tailed. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

All control variables except IPC fixed effects and year fixed effects are lagged by one year.

Table 4. Effects of Anti-dumping on Number of Novel Patents

Models	4-1	4-2	4-3
DV	*Number of novel patents*		
Sample and Model	With control group-FE Poisson	With alternative control group-FE Poisson	Treatment group only-FE Poisson
Post-anti-dumping	-0.281**	-0.243*	0.00446
	(0.143)	(0.133)	(0.147)
Average number of inventors per patent	-0.0220	-0.0271	-0.0404
	(0.0435)	(0.0433)	(0.0653)
Average number of assignees per patent	0.0893	0.357***	0.161
	(0.155)	(0.137)	(0.227)
Average number of claims per patent	0.00215	-0.00517	0.0330
	(0.0142)	(0.0175)	(0.0225)
Accumulated patents	-0.0000119	-0.0000109	-0.00000588
	(0.0000108)	(0.00000967)	(0.00000643)
IPC fixed effects	YES	YES	YES
Year fixed effects	YES	YES	YES
Observations	2640	2640	1320
Log likelihood	-2190.6	-2127.9	-1035.6

Robust standard errors in brackets. All tests are two-tailed. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

All control variables except IPC fixed effects and year fixed effects are lagged by one year.

Table 5. Effects of Anti-dumping on Number of Patents Before and After the Launch of the National Innovation Campaign in China in 2006

Models	5-1	5-2	5-3	5-4
DV	*Number of patents*			
Sample and Model	Before 2006		During and After 2006	
	With control group - FE Poisson	Treatment group only-FE Poisson	With control group - FE Poisson	Treatment group only-FE Poisson
Post-anti-dumping	-0.279*	-0.340**	0.199***	0.144***
	(0.163)	(0.166)	(0.0444)	(0.0500)
Average number of inventors per patent	-0.0916***	-0.140***	0.118*	0.169***
	(0.0206)	(0.0287)	(0.0636)	(0.0593)
Average number of assignees per patent	0.148	0.206	-0.216	-0.730
	(0.120)	(0.200)	(0.309)	(0.484)
Average number of claims per patent	0.0227**	0.0256**	0.00332	-0.0450
	(0.00891)	(0.0119)	(0.0358)	(0.0488)
Accumulated patents	0.000171***	0.000183***	-0.0000210***	-0.0000221***
	(0.0000235)	(0.0000258)	(0.00000133)	(0.000000980)
IPC fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES
Observations	1760	880	880	440
Log likelihood	-6461.5	-4006.5	-16062.5	-7292.9

Robust standard errors in brackets. All tests are two-tailed. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

All control variables except IPC fixed effects and year fixed effects are lagged by one year.

Table 6. Effects of Anti-dumping on Number of Novel Patents Before and After the Launch of the National Innovation Campaign in China in 2006

Models	6-1	6-2	6-3	6-4
DV	*Number of novel patents*			
Sample and Model	Before 2006		During and After 2006	
	With control group - FE Poisson	Treatment group only-FE Poisson	With control group - FE Poisson	Treatment group only-FE Poisson
Post-anti-dumping	-0.225	0.0428	-0.312	-0.284
	(0.206)	(0.219)	(0.250)	(0.237)
Average number of inventors per patent	-0.0313	-0.0000373	-0.0984	-0.127
	(0.0485)	(0.0820)	(0.107)	(0.146)
Average number of assignees per patent	-0.196	-0.356	-0.667	-1.253
	(0.242)	(0.310)	(0.433)	(0.935)
Average number of claims per patent	0.0217	0.0367	-0.0522	-0.0903
	(0.0235)	(0.0306)	(0.0409)	(0.0670)
Accumulated patents	-0.0000408	-0.0000147	-0.0000168	-0.00000750
	(0.0000678)	(0.0000710)	(0.0000104)	(0.00000672)
IPC fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES
Observations	1760	880	880	440
Log likelihood	-876.2	-449.5	-1079.3	-478.8

Robust standard errors in brackets. All tests are two-tailed. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
All control variables except IPC fixed effects and year fixed effects are lagged by one year.

Table 7. Effects of Anti-dumping on Number of Patents (Instrumental Variable Approach)

Models	7-1	7-2	7-3	7-4	7-5
	1st Stage	2nd Stage		2nd Stage	
DV	*Post-anti-dumping*	*Number of patents*		*Number of novel patents*	
Post-anti-dumping		381.3**	-4,096.07	-1.630**	-7.619
		(176.6)	(11,536.34)	(0.780)	(15.626)
U.S. Presidential Turnover Year	-0.0824***				
	(0.0168)				
Average number of inventors per patent	0.0314**	5.449	113.962	0.0518	0.224
	(0.0131)	(12.83)	(362.868)	(0.0435)	(0.491)
Average number of assignees per patent	-0.169**	-240.4	-929.202	-0.439*	-1.422
	(0.0683)	(146.5)	(1,942.94)	(0.240)	(2.632)
Average number of claims per patent	0.0789***	37.34	333.204	0.206***	0.606
	(0.00980)	(41.03)	(909.415)	(0.0729)	(1.232)
Accumulated patents	0.0000111***	0.133***	0.171	0.0000301***	0.0001
	(0.00000380)	(0.0223)	(0.128)	(0.0000111)	(0.0002)
Constant	0.312***	85.28	114.025	0.870***	-0.989
	(0.0580)	(91.96)	-3,233.14	(0.290)	(4.379)
IPC fixed effect	YES	YES	YES	YES	YES
Year fixed effect	NO	NO	YES	NO	YES
Observations	1320	1320	1,320	1320	1320
R^2	0.276	0.663	0.792	0.069	0.266

Robust standard errors in brackets. All tests are two-tailed. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
All control variables except IPC fixed effects and year fixed effects are lagged by one year.

Table 8. Robustness Check: Using the Year of *Affirming* Preliminary Dumping Decisions as the "Shock" Year

Models	8-1	8-2	8-3	8-4
DV	*Number of Patents*		*Number of Novel Patents*	
Sample and Model	With control group-FE Poisson	Treatment group only-FE Poisson	With control group-FE Poisson	Treatment group only-FE Poisson
Post-anti-dumping	0.333***	0.336***	-0.337**	-0.0541
	(0.101)	(0.0931)	(0.141)	(0.150)
Average number of inventors per patent	-0.00991	0.00153	-0.0223	-0.0412
	(0.0521)	(0.0544)	(0.0434)	(0.0652)
Average number of assignees per patent	0.235	0.151	0.0855	0.158
	(0.218)	(0.326)	(0.155)	(0.228)
Average number of claims per patent	0.0400	0.0273	0.00251	0.0335
	(0.0295)	(0.0399)	(0.0143)	(0.0225)
Accumulated patents	-0.0000190***	-0.0000194***	-0.0000117	-0.00000572
	(0.00000131)	(0.00000113)	(0.0000109)	(0.00000635)
IPC fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES
Observations	2640	1320	2640	1320
Log likelihood	-31598.9	-18192.2	-2189.3	-1035.5

Robust standard errors in brackets. All tests are two-tailed. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
All control variables except IPC fixed effects and year fixed effects are lagged by one year.

Table 9. Robustness Check: Using only Anti-dumping Cases that Named All Firms

Models	9-1	9-2	9-3	9-4
DV	*Number of patents*		*Number of novel patents*	
Sample and Model	With control group-FE Poisson	Treatment group only-FE Poisson	With control group-FE Poisson	Treatment group only-FE Poisson
Post-anti-dumping	0.103*	0.140**	-0.340*	0.117
	(0.0545)	(0.0644)	(0.185)	(0.206)
Average number of inventors per patent	-0.0894***	-0.0225	0.0592	0.131
	(0.0336)	(0.0416)	(0.0583)	(0.0806)
Average number of assignees per patent	-0.0231	0.343	-0.144	-0.244
	(0.148)	(0.211)	(0.224)	(0.326)
Average number of claims per patent	0.0362**	-0.0392	-0.0168	-0.0209
	(0.0170)	(0.0246)	(0.0306)	(0.0541)
Accumulated patents	-0.0000262***	-0.0000368***	-0.0000890***	-0.0000568**
	(0.00000383)	(0.00000299)	(0.0000215)	(0.0000225)
IPC fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES
Observations	1440	720	1440	720
Log likelihood	-14993.4	-6470.3	-1272.8	-602.9

Robust standard errors in brackets. All tests are two-tailed. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
All control variables except IPC fixed effects and year fixed effects are lagged by one year.

Table 10. Robustness Check: Effects of Anti-dumping on Alternative Dependent Variable (Number of Patents minus Number of Novel Patents)

Models	10-1	10-2	10-3
DV	*Number of patents* minus *Number of novel patents*		
	With control group - FE Poisson	With alternative control group - FE Poisson	Treatment group only - FE Poisson
Post-anti-dumping	0.355***	0.367***	0.357***
	(0.0957)	(0.0908)	(0.0903)
Average number of inventors per patent	-0.00366	-0.0000690	0.0141
	(0.0512)	(0.0499)	(0.0530)
Average number of assignees per patent	0.268	0.445**	0.235
	(0.207)	(0.213)	(0.316)
Average number of claims per patent	0.0397	0.0278	0.0272
	(0.0298)	(0.0293)	(0.0411)
Accumulated patents	-0.0000192***	-0.0000195***	-0.0000196***
	(0.00000124)	(0.00000115)	(0.00000112)
IPC fixed effects	YES	YES	YES
Year fixed effects	YES	YES	YES
Observations	2640	2640	1320
Log likelihood	-31239.9	-28904.8	-17977.8

Robust standard errors in brackets. All tests are two-tailed. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

All control variables except IPC fixed effects and year fixed effects are lagged by one year.

Appendix

Table A1. Effects of Anti-dumping on Number of Patents and Number of Novel Patents (All Control Variables except IPC fixed effects and year fixed effects Lagged by 2 Year)

Models	A1-1	A1-2	A1-3	A1-4
DV	*Number of Patents*		*Number of Novel patents*	
Sample and Model	With control group-FE Poisson	Treatment group only-FE Poisson	With control group-FE Poisson	Treatment group only -FE Poisson
Post-anti-dumping	0.287***	0.300***	-0.377**	-0.183
	(0.0911)	(0.0907)	(0.149)	(0.146)
Average number of inventors per patent	0.0154	0.00592	-0.00133	-0.00927
	(0.0406)	(0.0466)	(0.0307)	(0.0456)
Average number of assignees per patent	0.0988	0.225	0.111	0.438**
	(0.172)	(0.226)	(0.129)	(0.196)
Average number of claims per patent	0.0143	-0.00679	0.0487***	0.0481
	(0.0185)	(0.0230)	(0.0143)	(0.0392)
Accumulated patents	-0.0000212***	-0.0000212***	-0.0000139	-0.00000605
	(0.00000101)	(0.00000107)	(0.0000125)	(0.00000654)
IPC fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES
Observations	2552	1276	2552	1276
Log likelihood	-30074.2	-16968.6	-2128.7	-996.1

Robust standard errors in brackets. All tests are two-tailed. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A2. Effects of Anti-dumping on Number of Patents and Number of Novel Patents (All Control Variables except IPC fixed effects and year fixed effects Lagged by 3 Year)

Models	A2-1	A2-2	A2-3	A2-4
DV	*Number of Patents*		*Number of Novel patents*	
Sample and Model	With control group-FE Poisson	Treatment group only-FE Poisson	With control group-FE Poisson	Treatment group only-FE Poisson
Post-anti-dumping	0.232***	0.253***	-0.212	0.0290
	(0.0751)	(0.0798)	(0.158)	(0.159)
Average number of inventors per patent	-0.0117	-0.00246	-0.0208	-0.0742
	(0.0366)	(0.0412)	(0.0314)	(0.0459)
Average number of assignees per patent	0.0470	0.167	0.390***	0.861***
	(0.116)	(0.158)	(0.129)	(0.199)
Average number of claims per patent	-0.00571	-0.0170	-0.00529	-0.000369
	(0.0136)	(0.0156)	(0.0164)	(0.0462)
Accumulated patents	-0.0000240***	-0.0000241***	-0.0000165	-0.00000703
	(0.00000103)	(0.00000115)	(0.0000155)	(0.00000781)
IPC fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES
Observations	2464	1232	2464	1232
Log likelihood	-29073.4	-16248.2	-2064.2	-958.8

Robust standard errors in brackets. All tests are two-tailed. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$