Tariffs and evasion: examining the effectiveness of protectionist measures in the solar sector

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Preface

The energy transition is reshaping industries, markets, and government policies, while increasing market globalisation continues to transform production and trade across borders. I have been interested in the links between these developments for years, with special emphasis on the developments of China. The particular characteristics of China as a developing economy and its role as the world's largest producer and exporter of green technology raise interesting questions. From the early discussions of this thesis, I was eager to investigate questions related to trade in green technology and to contribute to wider discussions on globalisation, trade policy, and sustainable development.

I would like to thank my supervisor, dr.ir. Koos Gardebroek for supervising this thesis. It would not have been possible without his eye for detail and extensive knowledge of econometric models. Lastly, I would like to thank my family for their support during this process, and all my friends for the many hours we spent in the library.

Abstract

This thesis investigates whether the 2013-2018 EU trade-defence tariffs on solar panels from China resulted in trade diversion or tariff circumvention through Southeast Asian hub countries during and after the tariff period. Drawing on theories of protectionism and strategic trade policy, this study combines a qualitative analysis of EU trade-defence measures with an empirical analysis of bilateral trade flows between China, selected Asian hub countries, and the EU. A difference-in-differences analysis assesses the impact of the tariff's imposition on hub-to-EU exports and China-to-hub exports during and after the tariff period.

The results provide clear evidence of trade diversion, since exports from intermediary hub countries to the EU increased alongside shifts in Chinese exports to those hubs. Little evidence is found of the reversal of these patterns after the Minimum Import Price was dismantled in 2018, indicating persistence rather than temporary circumvention. This persistence is consistent with sunk investments in regional production networks, supply-chain rigidities, and firms' incentives to diversify regulatory and reputational risk. While deliberate tariff evasion is difficult to spot in aggregate trade data, the findings reveal that EU trade-defence policy did reshape trade flows without significantly reducing Chinese input in the EU solar panel market.

The research shows the limitations of tariff protection in a globally integrated market and highlights the need of incorporating supply chain dynamics when constructing trade-defence policies.

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1. Introduction

The European Union has set bold and transformative climate goals, aiming to reduce net greenhouse-gas emissions by at least 55% by 2030 and to achieve climate neutrality by 2050. It also aims to raise renewables to at least 42.5 per cent of gross final energy consumption by this decade (European Commission, 2025a). In 2022, the European Commission set ambitious targets concerning solar energy usage, aiming to generate over 320 Gigawatt (GW) of solar photovoltaic energy by 2025 (more than doubling compared to 2020) and almost 600 GW by 2030 (European Commission, 2022). Recently, European Union institutions created the Net-Zero Industry Act, in which they plan to ensure that 40% of the solar panels deployed in Europe are also made on the continent (McWilliams et al., 2024).

Yet the very technologies Brussels hopes to scale rapidly are at the centre of its most contentious trade actions. In December 2013, the Commission imposed definitive anti-dumping duties of up to 47.1% on solar panels made in China, arguing that state support enables Chinese firms to sell below "fair" value (European Commission, 2012). The main issue with these solar modules is that they are produced at low costs and heavily subsidised (Feng & Wang, 2023). This could lead to the crowding out of European manufacturers if no protective policies are implemented (Adams et al., 2006). Once its competitors exit the market, the firm that has been dumping will be a monopolist and can reap high profits (Ha Lau, 2007). Guarding the market, however, means missing out on affordable and widely available green technologies (Oxford Analytica, 2024; Chen, 2015).

It should be noted that excessive dependency on these Chinese goods would be detrimental to the solar market in Europe (European Commission, 2024). This is further illustrated by the substantial price drop in 2023, with solar panel prices declining from approximately €0.20 per watt in 2022 to under €0.12 per watt in 2023 (European Commission, 2024). For many European companies, this price is not sustainable and thus they are at risk of market exit. In the long term, this may lead to overdependence on Chinese panels and increased costs for consumers in Europe.

The Chinese Communist Party's (CCP) geopolitical leverage is expanded through initiatives such as the Belt and Road Initiative (Zuokui, 2018). In the long term, this could lead to China leveraging its green tech dominance to push for a friendly disposition of European nations towards the Chinese geopolitical agenda (Zuokui, 2018). The debate, therefore, centres on three interconnected trade-offs.

The first concerns the economic dimension, which shows that low-cost Chinese solar modules enable rapid deployment, at the risk of crowding out European manufacturers. Second, there is the sustainability dimension that shows how protective tariffs may shield European manufacturers, but at the same time also potentially slow down Europe's energy transition. Last, there is the geopolitical dimension, which shows how purchasing Chinese products strengthens Beijing's leverage, while limiting the imports of these products could constrain short-term progress toward climate neutrality and economic growth.

However, anti-dumping measures do not necessarily eliminate Chinese competition. Evidence from similar policy implementations suggests that tariffs may lead to trade diversion, with Chinese firms rerouting exports through third countries (e.g., Southeast Asian) or shifting assembly abroad to circumvent EU duties (Shi et al., 2025; Iyoha et al., 2025). This raises questions about the effectiveness of tariff-based protection.

This study empirically investigates the relationship between EU tariffs and Chinese solar panels and the trade flows of these panels. There is a specific focus on the possibility of trade diversion happening to circumvent the tariffs. With this ambition, the following main research question is formulated:

To what extent have EU tariffs on Chinese solar panels led to trade diversion and reshaped trade flows in green technology?

Based on this main question, three specific sub-questions are formulated:

1. What are the economic, political, and ethical justifications for import protection, and how do these affect long-term competitiveness?
2. What trade-defence measures (e.g., anti-dumping and anti-subsidy) has the EU applied to Chinese solar modules, and how have their ad-valorem equivalent rates evolved?
3. Is there evidence that EU solar panel tariffs led to trade diversion or tariff circumvention through Southeast Asian countries?

This study is relevant as it shows how European Union tariffs on Chinese green technology could increase economic costs and lead to trade diversion(Munteanu, 2024). Firms and markets may begin adjusting well before the official implementation of tariffs. This anticipatory dimension, however, has received little systematic attention (Contractor, 2025). On top of that, there is currently limited research on the potential trade diversion that occurred during the 2013-2018 solar panel tariffs. This research examines whether the tariffs were circumvented, and if so, through which countries. This way it offers insights into both the effectiveness and unintended consequences of EU trade-defence policies.

Given that this research examines the role of China's lower production costs and subsidies, the concept of comparative advantage provides an intuitive theoretical framework (Viner, 2016; Findlay, 1991). The EU counters this by invoking the infant-industry argument, protecting its new green tech sectors from foreign competition (Melitz, 2005). This may help European producers mature, but at the risk of delaying the mass production of cheap green technologies. The Heckscher-Ohlin model will be applied to investigate how tariffs and anti-dumping policies change comparative advantages between China, the EU and hubs, affecting green tech goods trade flow (Leamer, 1995).

Research question (RQ) 1 entails an extensive literature review of theories of economic protectionism, such as comparative advantage, infant industry protection, and political economy arguments, based on academic literature and policy reports. For RQ2, the tariff history is reconstructed via the European Commission and World Trade Organisation (WTO official) trade statistics to record the anti-subsidy duties applied to Chinese green technologies. Finally, RQ3 is tested empirically by estimating the impact of EU solar panel tariffs on trade using a panel difference-in-differences (DiD) estimation. This method allows for variation across countries and over time to assess whether the tariffs are associated with potential trade diversion in the Asian hubs

Following the introduction, Chapter 2 presents definitions and a background on the EU's import protection regime, trade policy, and the literature on circumvention. Chapter 3 presents the empirical strategy and data. Chapter 4 uses econometric analysis to evaluate the market's economic impact of these tariffs. Lastly, Chapter 5 provides conclusions and implications for policymakers.

2. Literature Review

The debate on protectionism and trade policy is a key issue in global trade. While globalisation has increased cross-border trade, governments often use protectionist measures to protect domestic industries from unfair competition. This literature review looks at the reasons for import protection, based on articles discussing the protection of domestic industries, market stability, and strategic interests. It also explores how companies try to bypass tariffs, reducing the effectiveness of these trade policies and impacting global markets.

2.1 Free trade versus protectionism

A central theme in international trade in the 21st century has been breaking the barriers surrounding international trade. Globalisation has facilitated a significant expansion of cross-border trade. This is supported by the liberalisation of trade policies and the growth of multilateral and regional trade agreements. The creation of the WTO has furthered this process through promoting good regulatory practices, such as transparency in rulemaking and the use of international standards. Overall, this simplified importing and exporting from countries all over the world. This chapter analyses the economic and political justifications for import protection and their impact on long-term competitiveness.

There have been many studies on the gains countries can reach from free trade. Classical and modern trade theories highlight benefits such as efficiency gains from comparative advantage. This theory shows that countries should concentrate on producing products for which they have a comparative advantage (i.e., which have the least opportunity cost to produce) (Kemp & Wan, 1972). Countries can export these goods and import goods that are relatively more expensive to make domestically (Findlay, 1991). International trade is also justified by the added variety for consumers and efficiency gains made possible by international competition (Bergsten, 1996). Trade exposes local firms to international competition and encourages them to improve and adapt.

At the same time, these potential gains coexist with distributional challenges and strategic concerns. While free trade may increase aggregate welfare, certain industries, firms, and workers can experience significant losses due to import competition (Venables, 1985). As a result, governments frequently resort to trade policy instruments. This includes measures such as tariffs, subsidies, or anti-dumping duties to shield domestic producers (Goldberg & Pavcnik, 2016). They are implemented to protect employment and maintain industrial capacity (Tarr, 2000). It is important to note that they also reduce some of the efficiency gains that trade liberalisation provides. Tariffs limit competition and slow innovation, potentially leading to less worldwide economic growth.

The idea of the infant industry argument can be applied to the case of the European Union's (EU) solar panel industry (Myint, 1963). Compared with China, which dominated the global solar market thanks to lower production costs and massive scale, European manufacturers were at a significant disadvantage. The protection of up-and-coming European solar companies could, after a while, lead to them being as competitive as their Chinese competitors.

Another important perspective comes from the political economy of trade policy, particularly the role of interest group politics. Earlier, it was shown that the European Commission initiated an investigation after a complaint from EU Pro Sun. Under political economy models of trade policy, it is expected that highly concentrated, capital-intensive producers facing large, specific losses from import competition will organise effective lobbying efforts (Kerr & Gaisford, 2007). This lobby partnership represents over twenty European solar panel manufacturers seeking protection against Chinese dumping. On the other side were European consumers and solar project developers who had nothing to gain from imposing tariffs (Schmidt et al., 2016). In the EU solar case, downstream interests (installers and consumers) are more diffuse and less organised. This helps explain why, despite objections from member states with large downstream sectors, contingent protection was nonetheless implemented (Eckhardt, 2015).

When the European Commission first proposed the anti-dumping tariffs in 2013, most EU member states opposed them. Countries such as Germany, the United Kingdom (UK), and the Netherlands were particularly reluctant when it came to the protectionist measures. These governments argued that tariffs would raise the cost of solar energy and harm downstream industries (e.g., installers, project developers). The member states were afraid that it could lead to retaliation from China (Emmott & Bilby, 2013). The Chinese government had been threatening the EU for a while that it would do the same exact thing to European wine exports. Even with the critique from member states and the threats from China, the European Commission still went ahead and imposed the tariffs.

2.2 Ethical concerns

There is a compelling ethical reason to opt against Chinese solar panels. A large share of the world's polysilicon (the key input for solar cells) has been produced in China, with Xinjiang as a major hub. Not long ago, one out of every seven panels produced worldwide was manufactured by a single facility in Xinjiang (IEA, 2022). Murphy & Elimä (2021) document links between Xinjiang polysilicon and state-imposed forced-labour programs affecting Uyghurs and other minorities. Xinjiang polysilicon has had a cost advantage driven by very cheap coal-fired power and lowered production costs due to the exploitation of minorities (Mulvaney & Bazilian, 2023). The authors argue that climate progress is being pursued at the cost of basic human rights (Murphy & Elimä, 2021).

Recently, the United States of America (U.S.A.) and the EU have both moved to restrict goods linked to forced labour in Xinjiang. The U.S., for example, is enforcing the Uyghur Forced Labor Prevention Act (UFLPA). It is created for the prohibition on the importation of goods into the U.S. manufactured with forced labour (U.S. Customs and Border Protection, 2024). The same American government organisation provides data on the shipments into the U.S. that are interconnected with forced labour in Xinjiang. In the period 2022–2025, the attempted import value amounted to $3.71 billion (U.S. Customs and Border Protection, 2025). Overall, 61% of the shipments were denied at the border by customs because they did not comply with the rules (U.S. Customs and Border Protection, 2025). Solar shipments with insufficient traceability are banned from entering the market. A couple of years after the U.S., the EU also adopted a forced labour ban.

Martinez (2023) shows that following the UFLPA's mid-2022 start, Xinjiang's share of Chinese polysilicon output dropped from about 57% to roughly 27% in 2023. This shift is explained as production moved to provinces such as Ningxia and Inner Mongolia. Instead of improving labour conditions for the Uyghurs, manufacturers would rather move their entire production to a new province (Martinez, 2023). This raises the suspicion that the same exploitation will occur in the new province until they are caught again.

Trade-defence measures, even when ethically motivated, do not automatically translate into ethical outcomes. While forced-labour bans can disrupt specific supply chains and increase transparency, they may also incentivise relocation rather than reform.

2.3 EU trade-defence measures

This paragraph examines the trade-defence measures that the EU implemented on Chinese solar modules. It focuses on the case of anti-dumping and anti-subsidy duties. The analysis of these duties and their effects provide insight into the evolving solar panel market and the shift to renewable energy within Europe. The following sub-section explains the two trade-defence measures that the EU employed.

Anti-dumping measures are imposed when a foreign company exports a product at a price lower than its normal value. This practice allows Chinese manufacturers to gain market share by offering solar panels at artificially low prices. This then undermines European manufacturers who cannot compete at these prices. The importing country can impose anti-dumping (AD) duties to address the price differences. These duties are meant to bring the price of the imported goods in line with fair market value by raising the price of the dumped product (Jabbour et al., 2019). Since the price of Chinese solar panels was significantly lower, the duty needed to be substantial.

Anti-subsidy measures, also known as countervailing duties (CVD), are used when a foreign government provides subsidies to its domestic producers. This gives them an unfair competitive advantage in the importing country's market, in this case, the EU. If investigations find that subsidies are in fact distorting the market, then the importing country imposes countervailing duties (CVD) to neutralise the effects of the subsidies (European Commission, 2025b). The duty increases the price of the subsidised goods to a fair market level (European Commission, 2025b).

Anti-subsidy measures are when a foreign government gives financial support in the form of subsidies to its domestic producers. This creates a disparity in the market of the importing country (in this case, the EU). If through investigation the EU notices that they are distorting the market, then countervailing duties are implemented (CVD) to neutralise these impacts (European Commission, 2025b). The duty enhances the price of the subsidised product to a reasonable market price (European Commission, 2025b).

Having outlined the mechanisms of anti-dumping and anti-subsidy measures, the following paragraphs describe how the European Union applied these policies to protect its solar panel market from unfair competition. After investigations opened in 2012, the Commission imposed provisional anti-dumping duties in June 2013 on solar panels coming from China (European Commission, 2012). This measure initially set rates on solar panel imports from China at up to 47% of the original price. In December 2013, definitive anti-dumping and countervailing duties were adopted to avoid price undertaking (Commission Regulation (EU) No 513/2013, 2013).

The EU determined a fair price for Chinese solar panels by aggregating the production costs and considering a reasonable profit (European Commission, 2025). They then compared this fair price to the actual price of import and found a gap of about 88%. The second step was to calculate how much prices should be raised to stop harm to EU producers. These would be the cost sides plus a normal profit. The duties were then set by the EU on the lesser value of these two figures, that is, the ad valorem rate of 47.6% with an 11.8% rate for the first two months to phase in (European Commission, 2025). These measures continued to be active for the following years, but they were gradually reduced in 2017 because of the lower global solar prices. The definitive duties (both AD and CVD) were extended following an expiry and were reimposed on 1 March 2017. Finally, in September 2018, the EU terminated all solar panel duties (both AD and CVD). The reasoning behind this, as they describe, was a policy shift and a reduced threat from China (Blenkinsop, 2018).

Similar measures have been implemented by the U.S. and Australia, providing additional insight into the role anti-dumping duties play in the solar markets. These cases demonstrate the limitations of tariffs when Chinese producers open factories in third countries to avoid them. The U.S. has imposed a number of tariffs on solar products and panels. In May 2012, the U.S. already imposed anti-dumping tariffs (31%) and countervailing duties on Chinese solar cells and panels (Hughes & Meckling, 2017). In 2014, these duties were extended but they did not apply to Chinese firms manufacturing panels outside of China. This illustrates the weakness of tariffs as they are easily circumvented. There is a grey area of when a product would be defined as a Chinese product in this scenario. Even though the product is largely produced in China, companies might establish a factory in some other jurisdiction and export the panels under a different name. The anti-dumping and anti-subsidy duties would be rendered useless if the products in question were not recognized as originating from China (Iyoha et al., 2025).

A case study from Australia shows anti-circumvention measures applied in practice. New policy allowed for the investigation of circumvention without reopening a full AD investigation (Zhou, 2016). This makes it easier to adjust duties without having to conduct a full and lengthy investigation each time a circumvention case arises (Zhou, 2016). For Europe, the same issue arises; China was able to dump many products in Europe via different channels before it could be restricted.

2.4 Tariff circumvention

As mentioned in the chapters above, tariffs are an essential instrument of international trade. The imposition of tariffs, however, leads to the evasion of such barriers by businesses and traders. This evasion of tariffs is referred to as tariff circumvention. It occurs when goods are intentionally routed through intermediary countries or modified in ways that allow them to avoid or minimise the impact of tariffs (Wen et al., 2025). The outcome is that it undermines the intended protective function of tariff policies (Choi, 2023).

Tariff circumvention has become a significant concern for governments and trade bodies around the world. The biggest concerns are the substantial revenue losses, disruption of fair competition, and the way it reduces the effectiveness of trade agreements (Forganni & Reed, 2019). It is also important to note that it can strain international relations. Countries could perceive the circumvention practices as violating trade rules or bypassing the intentions of trade policies (Deng et al., 2025).

Puccio and Erbahar (2016) present the level of EU trade-defence activity from 1995 to 2013 for four series: AD investigations and actions, and anti-circumvention (AC) investigations and actions (Puccio & Erbahar, 2016). AD activity spikes around 1999–2000, then declines steadily to single digits by 2012–2013. As expected, measures always trail investigations, and not all the investigations are converted to policy. AC actions stay low but tick up after 2010, and by the end they all converge at low levels.

Recently, the European Commission announced measures to stop the circumvention of tariffs on imports of graphite electrode systems. This shows that circumvention arises in all shapes and sizes since it does not necessarily happen through rerouting. The AD measures on graphite electrode systems were circumvented by exporting artificial graphite from China to the EU, which was then processed into graphite electrode systems within the EU to avoid the duties (European Commission, 2025c). In response, the European Commission extended the duties to now also include artificial graphite that is used to produce the graphite electrode systems (European Commission, 2025c). In this case, the circumvention happened through the act of masking the product under a different item.

Another manner of circumvention occurs with the help of a practice named transshipment. Countries, like China, reroute their commodities through third countries to evade the tariffs (Nagurney & Samadi, 2025). Peter Navarro, former trade advisor to President Trump of the

U.S., highlighted that roughly one-third of the goods Vietnam exports to the United States, about $5 of every $15, are originally made in China. The main issue lies in the fact that it there receives a 'Made in Vietnam' label before being sent to the U.S. to circumvent tariffs (Lopez, 2025). The same news article by Lopez (2025) states that Vietnam does not earn a lot of money from this scheme because only a few workers are required for this action. Beijing's regional presence and political power could be a big reason for participating in the transshipment (Lopez, 2025).

Thirdly, there is also a more rigorous way of circumventing the tariffs, and that is by moving (part of) the production to a different country, where there are no tariffs placed. This can be seen as a last-ditch effort, since this bears higher costs than other circumvention methods (Dong & Kouvelis, 2020). However, companies may choose this strategy when the financial impact of the tariffs becomes too burdensome to absorb, or when alternative methods of circumvention are not viable (Dong & Kouvelis, 2020).

Table 1 Overseas production sites of the largest Chinese solar panel manufacturers.

Manufacturer	**Production Sites (outside of China)**
LONGi Green Energy	Vietnam and Malaysia
Trina Solar	Vietnam, Thailand, USA
JA Solar	Malaysia and Vietnam
JinkoSolar	Malaysia, Vietnam, USA
Suntech Power	Germany, Japan, USA
China Sunergy (CSUN)	Turkey
SolaX Power	Australia, United States

As can be seen in Table 1, Chinese solar panel manufacturers have expanded their production sites rapidly in recent years. By establishing production facilities in countries like Vietnam, Malaysia, and the U.S., Chinese manufacturers can circumvent these tariffs (Dong & Kouvelis, 2020). In particular, Vietnam and Malaysia are utilised for evasion, and therefore, it will be interesting to visualise this with the help of the data.

A study by Shi et al. (2025) on trade circumvention in China's AD measures against the U.S. has looked at how long it takes for circumvention to start. The study finds that circumvention did not occur immediately after China imposed AD duties against U.S. products. They found that evasive behaviour typically emerges around 17 months after policy implementation (Shi et al., 2025). This delay shows the adjustment period exporters need to establish new trade routes and build reliable distribution channels through third countries (Shi et al., 2025). When analysing the effectiveness of tariffs, it is thus important to not only look at the short term but also at a longer period. In the immediate aftermath of a ruling, AD measures may appear successful because the imports have dropped sharply. The delayed circumvention effect, as described above, reveals that this initial impact might be overstated. Once new trade routes have been established, the protective function of tariffs is completely eroded.

3. Empirical strategy

3.1 Method

The empirical strategy for this study is based on Liu and Shi (2018), who examine trade rerouting in response to AD measures. Their model predicts that exports from China to a third country and imports from that third country to the EU should both increase in response to anti-dumping measures taken against China (Liu & Shi, 2018). These third countries, such as Vietnam, Thailand, and Malaysia, act as intermediaries to bypass the tariff barriers.

First, a simple specification was estimated to document the bivariate association between exports from China to the hub and exports from the hub to the EU destination. This baseline lacks depth and serves only to establish the direction and approximate magnitude of the relationship. This regression is performed twice, once for the potential hubs and another time for the non-hubs.

$$lnY_{cht} = \lambda_h + \beta_X lnX_{ht} + \beta_P P_t + \varepsilon_{cht} \quad (1)$$

The coefficient β_X measures the percentage change in imports from hub (or non-hub for the second regression) h to EU country c in year t (lnY_{cht}) in response to a percentage change in exports from China to that hub h in year t (lnX_{ht}). A positive and significant β_X supports the rerouting hypothesis, as it implies that an increase in Chinese exports via the hub is directly associated with an increase in hub exports to the EU. λ_h is a country fixed effect capturing all time-invariant differences across (non)hubs. Moreover, P_t is a dummy variable with a value of 1 after 2018, and β_P measures the average change in imports from all hubs to all EU countries after 2018. It is included to capture the common time trend after the policy change.

A simple difference-in-differences specification was estimated by augmenting the baseline model with an indicator for the post-2018 period (P_t) and an interaction between this indicator and a hub country dummy (T_h), which equals 1 for potential hub countries and 0 otherwise. This model isolates whether Chinese exports to potential hubs decline, increase, or remain unchanged after the policy shift. A negative and significant interaction effect indicates that Chinese exports to hub countries declined relative to non-hub countries after 2018, which is in line with the idea of rerouting.

$$lnX_{ht} = \lambda_h + \beta_{TP} T_h P_t + \beta_P P_t + \varepsilon_{ht} \quad (2)$$

In addition to this, another regression is performed to analyse direct Chinese trade to Europe. If the removal of the Minimum Import Price (MIP) had immediately restored direct access to the European market, it is expected that a structural increase in China's direct exports to EU member states would be observed after 2018.

$$lnQ_{ct}= \lambda_c + \beta_P P_t + \varepsilon_{ct} \quad (3)$$

In this model, lnQ_{ct} is the natural logarithm of Chinese solar panel exports to EU member state c in year t. A positive and statistically significant estimate would indicate that Chinese exporters re-entered the European market immediately after the removal of the minimum import price, consistent with the policy having previously constrained direct bilateral trade. λ_c denotes the destination fixed effect, with destinations defined at the EU-country level.

The DiD framework given by equation (2) is extended, based on the ideas of Liu and Shi (2018), to allow the relationship between China's exports to potential hubs (X) and EU imports from those hubs (Y) to vary across countries and over time. The specification must capture the average percentage association between X and Y, including how this association differs between suspected hubs and non-hubs. Besides this, it is interesting to analyse how the relation changes after the removal of the tariffs and see whether treated hubs display a distinct post-2018 co-movement pattern that is consistent with trade rerouting. In all specifications, standard errors were clustered at the country level to allow for heteroskedasticity and serial correlation within importing countries over time. This leads to the following empirical model:

$$lnY_{cht} = \beta_X lnX_{ht} + \beta_{XT} lnX_{ht}T_h + \beta_{XP} lnX_{ht}P_t + \beta_{TP}T_hP_t + \beta_{XTP} lnX_{ht}T_hP_t + \beta_Z Z_{ht} + \lambda_h + \lambda_t + \varepsilon_{cht} \quad (4)$$

In this case, European imports from third countries are expected to lead to higher demand in third countries, which then increases imports from China. This is conditioned for in the equation by including $\ln X_{ht}$. Z_{ht} is a time-varying gravity equation variable, namely log(GDP), and λ_h and λ_t are the hub country and year effects. Time fixed effects absorb all common time shocks, including global Photovoltaics price movements; thus, no separate price index is included to avoid collinearity. Hub country fixed effects absorb time-invariant traits of hub h, such as long-standing industrial capacity and stable differences in governance. ε_{cht} is the error term, which contains non-included variables affecting EU imports from third countries.

Liu and Shi (2018) provide further support for the evasion hypothesis in several characteristics of trade rerouting. They show that geographical distance to China has an effect for third countries to whether they act as hubs. Based on this idea, using neighbouring countries lowers rerouting costs (Liu & Shi, 2018). Moreover, their article uses research by Rauch and Trindade (2002) that states that businesses and social networks that are proxied by Chinese populations have a considerable impact on international trade by matching buyers and sellers. Chinese manufacturers are more likely to use countries with a higher share of Chinese residents, reflecting diaspora networks that lower search and transaction costs (Rauch & Trindade, 2002; Guo, 2022). These two ideas are incorporated in this thesis's model by including interactions that capture both geographical proximity and diaspora-related trade linkages.

In addition to capturing how China's exports to a hub (X_{ht}) and the treatment status of the country (T_h) interact with the post-2018 period (P_t), the model now includes an interaction with a diaspora measure D_h. This allows the key ($lnX_{ht}T_hP_t$) effect to be stronger or weaker in countries with a larger Chinese community. This is in line with the idea that existing Chinese networks may facilitate trade rerouting. The coefficient β_{XTPD} captures whether trade rerouting is stronger in countries with a larger Chinese diaspora.

Following this idea, the extended Chinese diaspora difference in difference regression is as follows:

$$lnY_{cht} = \beta_X lnX_{ht} + \beta_{XT} lnX_{ht}T_h + \beta_{XP} lnX_{ht}P_t + \beta_{TP}T_hP_t + \beta_{XTP} lnX_{ht}T_hP_t + \beta_{XTPD} lnX_{ht}T_hP_tD_h + \beta_Z Z_{ht} + \lambda_h + \lambda_t + \varepsilon_{cht} \quad (5)$$

To test whether trade rerouting is stronger in countries that are physically connected to China, the model is further extended with an indicator L_h for land-connected countries. This comes from the idea that trade over land is easier and more expandable, which could mean more circumvention. It interacts with the key rerouting term ($lnX_{ht}T_hP_t$), allowing the rerouting effect to differ between land-connected and non-land-connected hubs. In the model, β_{XTPL} captures how the rerouting effect differs for land-connected countries ($L_h = 1$).

The leads to the extended land connectedness DiD model:

$$lnY_{ct} = \beta_X lnX_{ht} + \beta_{XT} lnX_{ht}T_h + \beta_{XP} lnX_{ht}P_t + \beta_{TP}T_hP_t + \beta_{XTP} lnX_{ht}T_hP_t + \beta_{XTPL} lnX_{ht}T_hP_tL_h + \beta_Z Z_{ht} + \lambda_h + \lambda_t + \varepsilon_{cht} \quad (6)$$

Lastly, a key requirement for the validity of the DiD framework is the parallel trends assumption. This core idea is that the treated and control groups would have followed similar outcome trajectories over time if there had been no policy change. In the context of this thesis, this implies that expected hub countries and non-hub countries would have displayed comparable trends in Chinese imports if the tariff on solar panels had not occurred. Establishing parallel trends is necessary so that any difference observed after the end of the MIP in 2018 is interpreted as a structural change rather than one caused by pre-existing differences in the trend. The behaviour of Chinese exports to hub and non-hub countries is examined over the period 2013–2024. The period 2013-2018 is, in this case, actually the treatment period, and therefore it is essential to establish parallel trends post 2018.

A first task is to graphically inspect the group-year averages of Chinese exports for hubs and non-hubs. If the slopes of the two lines evolve similarly during the post-tariffs window, there is visual support for parallel trends. The issue with this method is that with smaller sample sizes and fewer years, the lines converge together, making it more difficult to spot real differences. Therefore, a formal regression-based trend test is also performed. This is done by estimating a fixed-effects model in which the log of Chinese exports to third countries is regressed on a linear time trend interacted with the treatment status. A statistically insignificant interaction term indicates that the treated and control groups share a similar underlying trend slope after 2018.

$$lnX_{ht} = \lambda_h + \beta_t t + \beta_{tT} t T_h + \varepsilon_{ht} \quad (7)$$

In this model, a trend (*t*) is included to capture the general evolution of Chinese exports over time and to test whether this underlying trajectory differs between hub and non-hub countries after 2018. For this test, only data from after the removal of the tariffs is included as only this timeframe needs to be checked for post-treatment trend heterogeneity. Fixed effects ensure that the coefficients reflect pure changes over time, not differences in country size or baseline export levels. The coefficient on the trend variable reflects the average annual change for the control group (non-hubs), while the interaction term between the trend and the treatment indicator shows whether hubs follow a systematically different slope. An insignificant interaction term is required as this means that there are parallel trends in the model.

3.2 Data

Sources

This study relies on data obtained from the United Nations Comtrade Database, which provides official import and export statistics reported by national customs authorities (United Nations, 2025). It is widely recognised as a comprehensive source of international trade data and is therefore suitable for analysing long-term trends in global solar product flows. The data spans from 2013 to 2024 and shows trade value in U.S. dollars. This set shows who trades with whom for each product, covering all country pairs. This way, it is possible to spot potential circumvention through the rise of exports to third countries. Product code HS 8541 is used, which contains PV cells whether or not assembled in modules or made up into panels.

Similar research by Liu and Shi (2018) used trade value data. This is often done as value series have fewer missing observations and fewer zero/implausible entries than quantities. When looking at the Comtrade data, yearly value series are available for all countries, whereas quantity data is often missing.

Countries

The set of countries used in this analysis includes all countries that were part of the EU in the period 2010-2012. Besides China, also included are countries such as Vietnam, Malaysia, and Thailand that have been flagged in previous studies and trade reports as potentially playing roles in circumventing tariffs through transshipment or processing trade. The analysis tries to identify patterns of indirect routing that may indicate circumvention efforts. Countries such as Japan, South Korea, and the Philippines are used as controls, as they are expected not to be involved in Chinese circumvention of tariffs. These countries maintain regular trade relations with both China and the EU but have not been identified in documents as locations used for the transshipment of solar products.

In total 35 countries are included, covering a total of 3240 observations. This dataset contains trade flows from China to potential (non-)hub countries, as well as the subsequent exports from these hubs to Europe. The sample which spans from 2013-2024 as mentioned earlier, is comprised of EU destinations, which were subject to the anti-dumping measures on Chinese products. Each observation represents a trade flow from China to a specific hub and from that hub to a specific destination in a given year.

Descriptive statistics

Table 2 reports yearly Dutch imports of PV modules from China, Vietnam, Thailand and Malaysia. In this example, exports to the Netherlands are shown because it is one of the largest importers of solar panels and acts as a hub for other European countries. The table shows the actual value of imports in million U.S. dollars (USD) over 2013–2021.

Table 2 Dutch imports of product code HS 8541 by origin in million USD.

Years	China	Vietnam	Thailand	Malaysia
2013	1698.85	0.10	0.75	109.54
2014	1104.73	18.92	0.94	82.72
2015	958.78	123.25	0.12	87.30
2016	604.94	588.69	91.44	81.86
2017	958.78	741.27	190.07	74.55
2018	285.98	606.28	179.44	119.98
2019	2272.73	114.35	35.25	36.42
2020	3001.73	49.88	32.24	22.88
2021	6063.83	43.15	14.98	46.18

Source: UN Comtrade

After the imposition of the tariffs in 2013, imports from Vietnam, Thailand, and Malaysia all increased drastically. The sharp reversal after 2018 suggests that much of the earlier shift reflected circumvention or temporary relocation rather than a lasting restructuring of production. Exports from Vietnam, Malaysia, and Thailand are significantly higher than before the European tariffs, showing that not all the production has returned to China. Production costs remain relatively low in all the listed countries, and an important reason for keeping factories open may be the continued presence of U.S. tariffs on Chinese solar panels. Solar panels destined for the American market are therefore still manufactured in third countries, and these factories likely continue to supply the European market even after the abolition of EU tariffs. It is therefore important to acknowledge that the results may not display a clear decrease in exports, given that production in these intermediary countries has continued at stable levels.

In a simplistic way, this already shows that tariff circumvention did in fact happen between 2013 and 2018. A rigorous empirical assessment must be performed to disentangle circumvention-driven rerouting from other potential drivers of trade growth.

Table 3 shows summary statistics for the two hub-related solar panel trade flows. It is reported in millions of USD and split into the pre-2018 and post-2018 periods. For each hub country, the table reports the mean, standard deviation, minimum, maximum, and number of observations. It is included to provide a first impression of the trade flows pre and post abolishment of the tariffs. A value of 0.00.. reflects very small but non-zero trade flows, since all values are expressed in millions.

Table 3 Summary statistics of hub-related solar panel trade flows, pre- and post- 2018 in millions (USD).

Hub	Period	Trade	Mean	Std.	Min	Max	N
Hong Kong	Pre	Hub→EU	20.29	61.26	0.04	446.35	150
Hong Kong	Pre	China→Hub	9135.97	1193.53	7960.54	11036.07	150
Hong Kong	Post	Hub→EU	26.05	78.52	0.04	548.64	150
Hong Kong	Post	China→Hub	8981.07	623.66	8223.48	10120.04	150
India	Pre	Hub→EU	3.95	11.61	0	76.86	137
India	Pre	China→Hub	2016.53	1084.04	722.17	3677.77	150
India	Post	Hub→EU	0.70	1.30	0.00..	8.32	130
India	Post	China→Hub	3239.53	1025.05	1692.59	4370.08	150
Japan	Pre	Hub→EU	28.19	69.31	0.00..	387.55	150
Japan	Pre	China→Hub	4400.40	229.28	4108.20	4731.92	150
Japan	Post	Hub→EU	34.66	88.04	0.00	497.28	148
Japan	Post	China→Hub	3893.92	567.86	3185.03	4685.90	150
Korea	Pre	Hub→EU	14.26	42.88	0.00..	361.60	149
Korea	Pre	China→Hub	2714.09	408.06	2121.63	3341.71	150
Korea	Post	Hub→EU	9.48	30.68	0	245.39	148
Korea	Post	China→Hub	1318.72	196.65	999.20	1570.50	150
Malaysia	Pre	Hub→EU	59.17	201.61	0.00..	1377.62	135
Malaysia	Pre	China→Hub	2915.73	159.65	2777.18	3195.42	150
Malaysia	Post	Hub→EU	52.69	194.57	0.00..	1092.06	149
Malaysia	Post	China→Hub	3513.85	689.95	2799.16	4848.86	150
Philippines	Pre	Hub→EU	12.51	39.40	0.00..	357.77	131
Philippines	Pre	China→Hub	943.19	56.43	824.17	997.77	150
Philippines	Post	Hub→EU	8.97	27.60	0.00	161.28	136
Philippines	Post	China→Hub	1047.51	154.40	919.55	1280.22	150
Singapore	Pre	Hub→EU	32.89	115.72	0	630.78	150
Singapore	Pre	China→Hub	1300.78	312.60	712.34	1631.92	150
Singapore	Post	Hub→EU	50.10	164.85	0.00..	918.99	148
Singapore	Post	China→Hub	1495.50	484.46	884.60	2393.90	150
Thailand	Pre	Hub→EU	6.50	25.84	0	190.08	139
Thailand	Pre	China→Hub	733.51	159.95	479.57	952.85	150
Thailand	Post	Hub→EU	3.90	7.18	0	36.51	143
Thailand	Post	China→Hub	932.74	101.88	757.36	1052.02	150
Vietnam	Pre	Hub→EU	28.02	114.08	0	741.28	97
Vietnam	Pre	China→Hub	132.40	115.86	8.02	355.79	150

Vietnam	Post	Hub→EU	10.53	27.53	0.00..	186.02	88
Vietnam	Post	China→Hub	547.95	223.28	268.58	967.44	150

Note: Pre refers to the period before the abolition of the tariffs; Post refers to the period after the tariffs were removed. A value of 0.00.. reflects very small but non-zero trade flows, since all values are expressed in millions.

The table shows strong heterogeneity in trade flows across hubs and over time. Average trade volumes change differently across hubs in the post period, with some experiencing increases and others declines. The large standard deviations indicate substantial volatility, suggesting that the effects of tariff abolition vary by hub and trade direction, supporting the use of a DiD framework. For completeness, the full set of hub-to-EU and China-to-hub trade flow graphs (previewed in millions, USD) is provided in the Appendix. Especially in Thailand, Vietnam, and Malaysia, some suspicious circumvention movements can be seen during and after the abolishment of the tariffs.

4. Results

4.1 Regression results

This section presents the empirical findings on whether trade patterns consistent with post-2018 circumvention can be observed in the data. The first task is to establish hub countries based on the results and from there on the model extends into a version based on Liu and Shi (2018). Across all tables, coefficients are interpreted in log points and can be translated into approximate percentage changes. The results are reported with standard errors in parentheses, and significance levels are indicated using conventional thresholds.

Table 4 reports the results of Equation (1), examining how import volumes of solar panels in expected (non)hub countries are affected by Chinese export flows and whether these relationships structurally changed after 2018. For hubs, the coefficient lnX_{ht} is positive (0.747), and statistically significant. At first glance, this appears to suggest a strong elasticity, a 1% increase in Chinese exports to the hubs corresponds to roughly a 0.74% increase in the hub's exports to the EU. It is important to remember that this model is only a baseline and is used only as a rough indication of the effect and magnitude. P_t is not significant, so there is no evidence that exports from expected hubs changed after 2018.

Table 4 Fixed effects regression for simple hub/non-hub export to the EU.

	Equation 1 LnY_{cht} **(Non-hub)**	**Equation 1** LnY_{cht} **(Hub)**
lnX_{ht} (China to hub/non-hub)	0.001 (0.291)	0.747** (0.192)
P_t (2018 dummy)	-0.349 (0.274)	0.137 (0.203)
Fixed effects	Significant	Insignificant
Observations	1129	1340
R-squared	0.156	0.123

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Standard errors in parentheses.

For non-hubs, the coefficient β_X is positive (0.001) but not statistically significant, showing no real relationship between upstream Chinese exports and downstream non-hub to EU exports. The post dummy (P_t) is negative (-0.349) but not statistically significant, suggesting that the data do not show a clear change in exports to European countries after 2018 for non-hub countries.

Besides, the observed correlation likely reflects parallel trends rather than a causal or supply-chain mechanism. For solar panels, this means that hub countries increase their imports from China and their exports to the EU at the same time, but these flows are not mechanically linked through value-added processing or transit. Both moments could very well be driven by global demand growth or domestic installation cycles. In both models, the R-squares are low, which is expected given the number of predictors that are included.

From the regression of equation 2 in Table 5 below, it can be seen that the coefficient for the post dummy is not significant, showing no real change in trade after the tariffs are removed. There is, however, a significantly positive effect for the treatment (T_h) variable. On average, countries classified as hubs import more from China than non-hubs, in log terms, over the sample period.

Table 5 Fixed effects regression for the dependent variable China to hub trade.

	Equation 2 $\ln X_{ht}$
P_t (2018 dummy)	0.278 (0.466)
T_h (Treatment dummy)	1.948*** (0.208)
T_hP_t *(diff in diff interaction)*	0.524 (0.417)
Fixed effects	Significant
Observations	2700
R-squared	0.850

Note: * p < 0.1, ** p < 0.05, *** p < 0.01

Standard errors in parentheses.

The interaction term suggests that, after 2018, hub countries imported 52.4% more from China than non-hubs, but this difference is not statistically significant. Under the circumvention hypothesis, the removal of EU trade measures in 2018 should have reduced the incentive for Chinese producers to route panels through intermediary countries, leading to a negative DiD effect. This rerouting idea is however not visible in the performed regression of Equation 2

Table 6 OLS regression with several post dummies (P_t) for direct trade ($lnQt$) from China to the EU.

		Equation 3 $\boldsymbol{lnQ_{ct}}$	
P_t (2018 dummy)	0.219 (0.346)		
P_t (2019 dummy)		0.201 (0.356)	
P_t (2020 dummy)			0.220 (0.378)
Fixed Effects EU countries	Significant	Significant	Significant
Observations	300	300	300
R-squared	0.922	0.922	0.922

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Standard errors in parentheses.

In Table 6 results for the equation for direct solar panel trade from China to European member states are presented. It examines whether the removal of tariffs affected the volume of trade. From the circumvention idea, it is expected that exports should increase since there is no need to evade the tariffs. By looking at the non-significant dummy parameter, it becomes clear that there is no evidence that direct Chinese exports to the EU changed after 2018. From this regression, you could conclude that the end of the MIP did not immediately lead to a shift from indirect (hub-based) exports to direct exports. This pattern can be explained by the rigidity of established supply chains. Long-term contracts make sudden change impossible and thus there is no structural break visible. Moreover, extensive Chinese investments in Southeast Asian production and the abrupt removal of the MIP make a rapid shift unlikely, leading to slower rather than faster change. In all three regressions, the fixed effects are statistically significant, indicating the presence of substantial unobserved heterogeneity across destinations.

Based on the idea that supply chain shifts may take time to materialise rather than occurring immediately, two additional separate regressions are estimated using dummy variables for 2019 and 2020. For both specifications, the estimated effects are not statistically significant, suggesting no noticeable shift in the outcome in 2019 or 2020 relative to the baseline period. An explanation for this could be that 2019 also might have been too soon for the shift to occur, and that in 2020 trade halted due to COVID-19. Another interpretation is that manufacturers may have had little incentive to relocate production back to China. Production costs remain competitive in the hub countries, while these locations face fewer reputational and compliance concerns, such as scrutiny over links to Uyghur forced labour, and often encounter fewer trade restrictions.

Although the existing literature consistently identifies countries such as Vietnam, Malaysia, and Thailand as circumvention hubs, the empirical tests so far do not provide clear evidence of circumvention between 2013 and 2018. Because the dataset contains only a limited number of observations in 2013, prior to the policy change, and because the statistical comparisons rely mainly on post-2018 variation, the analysis has difficulties capturing the circumvention patterns that the literature describes for the earlier tariff regime.

Even though the earlier tests do not give a clear indication of circumvention, the final model continues to consider the expected hub countries as treatment units. This decision is grounded in the extensive literature and news articles documenting that these countries functioned as circumvention hubs prior for this or other products. And it is important to note that the absence of a post-2018 decline in Chinese exports to these countries does not contradict their earlier status as circumvention hubs.

Table 7 presents the first full difference-in-differences model (Equation 4), which analyses the potential causal relationship between Chinese exports to hub countries and subsequent exports to European countries.

Table 7 Difference in difference specification for hub to EU and China to hub trade.

	Equation 4 $\boldsymbol{LnY_{cht}}$
lnX_{ht} (China to Hub)	0.524*** (0.190)
P_t (2018 dummy)	-0.036 (0.381)
T_h *(Treatment dummy)*	0.269 (0.483)
Z *(lnGDP)*	-1.350** (0.679)
T_hP_t *(DiD interaction term)*	0.612** (0.241)
Fixed effects	Significant
Observations	2469
R-squared	0.136

Note: * p < 0.1, ** p < 0.05, *** p < 0.01

Standard errors in parentheses.

In Table 7 the coefficient for lnX_{ht} is positive and significant. This indicates that, on average and holding other controls constant, a 1% increase in Chinese exports to hub and non-hub countries is associated with approximately a 0.52% increase in the country's exports to the EU. The post-policy effect (P_t) is not significant, suggesting that there was no real change in exports to the EU after the tariffs were removed.

The insignificant coefficient for T_h implies that there is no statistical evidence of a baseline difference in trade to the EU between hubs and non-hubs. This could, however, very well be due to the hub fixed effects that are included in the model. To assess whether baseline trade differences exist between hubs and non-hubs, country fixed effects were extracted and compared across groups. Non-hub countries exhibit a positive mean fixed effect of 1.159, whereas hub countries display a negative mean fixed effect of –0.976. The resulting difference between the two groups is 2.134, which is also significant. Non-hub countries are associated with structurally higher levels of trade to the EU than hub countries.

This result indicates that baseline trade levels differ systematically between hubs and non-hubs, but these differences are fully absorbed by the country fixed effects. The insignificance of the coefficient T_h in the main regression does not imply the absence of baseline differences; rather, it reflects that such differences are captured by the fixed effects and therefore cannot be identified separately in the regression.

Back to the difference in difference regression in Table 7, where it is visible that the coefficient on log(GDP) is negative and statistically significant. This suggests that, conditional on the other regressors and fixed effects in the model, higher-GDP countries are associated with lower hub to EU export values in this specification. This sign is not what standard gravity intuition would predict and may reflect collinearity with other controls. Therefore, the GDP coefficient is best treated as a control effect rather than a central parameter of interest.

The DiD coefficient T_hP_t is insignificant, implying that there is no statistically reliable evidence that hub countries experienced a different post-2018 change in trade than non-hub countries. Therefore, the results do not support a robust hub-specific shift consistent with circumvention in this baseline specification. In that case, it is expected that trade from hubs to the EU decreased after 2018, since no more rerouting was required. A joint significance test of the fixed effects is conducted, indicating that they are significant.

Next, the same DiD model is performed with Chinese diaspora and land connectedness included as an interaction (Table 9). This is done to find out whether a higher percentage of Chinese citizens within a country and being connected by land make the country more susceptible to participate in possible circumvention.

Table 8 DiD specification for hub to EU and China to hub trade interacted with Chinese diaspora and a dummy for whether a country is connected to China via land.

	Equation 5 LnY_{cht} *Diaspora interaction*	**Equation 6** LnY_{cht} *Land Connectedness interaction*
lnX_{ht} *(China to Hub)*	0.520** (0.214)	0.571*** (0.192)
P_t *(2018 dummy)*	0.457 (0.560)	0.131 (0.382)
T_h *(Treatment dummy)*	0.175 (0.493)	0.716* (0.392)
Z *(lnGDP)*	-1.072 (0.806)	-1.077 (0.709)
T_hP_t *(DiD interaction term)*	-0.113 (0.658)	-0.153 (0.425)
D_h *(Diaspora hubs)*	-0.0005 (0.009)	
P_tD_h *(post diaspora interaction)*	-0.374 (0. 381)	
$ln\ X_{ht}T_hP_tD_h$ *(Extended interaction term)*	0.338 (0.371)	
L_h *(Land connectedness hubs)*		-0.509 (0.374)
P_tL_h *(Post land dummy)*		-0.755* (0.424)
$ln\ X_{ht}T_hP_tL_h$ *(Extended interaction term)*		1.456** (0.602)
Fixed effects	Significant	Significant

Observations	2469	2469
R-squared	0.136	0.138

Note: * p < 0.1, ** p < 0.05, *** p < 0.01
Standard errors in parentheses.

In the diaspora model, holding all other controls constant, hub countries imported 11.3% less from China after 2018 than non-hub countries did, relative to the pre-2018 period, for countries with a zero share of Chinese diaspora. However, this estimate is not statistically significant. The first column of Table 9 shows there is no statistically significant effect of Chinese diaspora on solar panel exports from hub countries to the EU.

Table 9 also reports Equation (6), which includes the interaction with land connectedness. From these results, it is visible that there is a strong interaction effect for whether or not a country is connected to China via land. The inclusion of the term is to see whether the effect of China on hub trade is stronger in the post period, for treated countries, and more so when they are connected via land to China. The significant interaction shows that being land-connected increases the post-2018 DiD effect by 1.456 log points, compared to otherwise similar countries that are not land-connected. To avoid confounding structural heterogeneity with post-policy timing, an alternative specification excludes the post-2018 interaction. The resulting estimates, which are shown in Table A1 in the appendix, are comparable in magnitude and significance (1.834***), further reinforcing the interpretation that land connectedness is associated with a stronger trade response among treated countries. Liu and Shi (2018) discuss that costs are a large driver of the incentive to evade anti-dumping duties. In this case, for Chinese manufacturers, it is likely cheaper to circumvent tariffs through Vietnam or Thailand compared to Malaysia.

4.2 Testing the parallel trends assumption

Next, a parallel trends test is performed, as the validity of the difference-in-differences approach depends on the assumption that treated and control groups follow similar trends in the absence of the policy change. Figure 1 displays the average log of Chinese exports to hub and non-hub countries over the period 2018–2024. From this, it is visible that both groups follow broadly similar patterns starting from 2018. Even though they differ in levels, the movements are much alike. Both hubs and non-hubs experience an increase between 2018 and 2021, followed by a peak around 2021–2022 and a subsequent decline toward 2024.

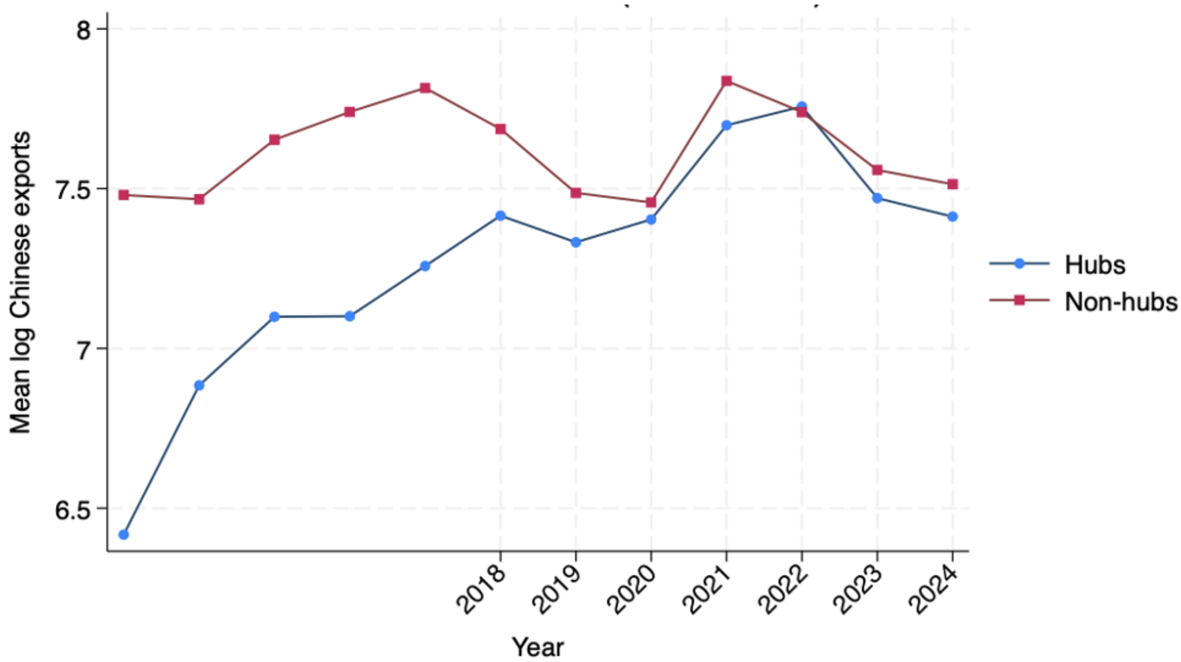

Figure 1 Visualisation of China to hub trade for hubs and non-hubs for Parallel trends inspection.

From a visual parallel trend's perspective, this similarity in the direction and timing of changes supports the plausibility of the parallel trend's assumption for the post-2018 window. Still, the graph alone cannot confirm parallel trends conclusively. Given the relatively small number of years and visible level differences, a formal regression-based trend test remains necessary to verify whether the slopes of the two groups are statistically comparable. Results for this are presented in Table 10.

Table 9 Parallel trends regression

	Equation 7 lnX_{ht}
t *(Trend)*	-0.003 (0.042)
tT_h *(Treatment trend interaction*	0.025 (0.056)
Fixed effects	Significant
Observations	1512

*Note: * p < 0.1, ** p < 0.05, *** p < 0.01*
Standard errors in parentheses.

The formal parallel trends test provides no evidence of differential post-treatment trends, as neither the overall time trend nor its interaction with treatment status is statistically significant. This means that hub and non-hub countries do not exhibit systematically different slopes in Chinese imports over the 2018–2024 period, validating the DiD approach. In this model singular treatment effect is omitted as FE absorbs all time-invariant differences between hubs and non-hubs.

4.3 Discussion of the results

In short, the empirical findings provide limited evidence of post-2018 reversed trade circumvention of EU solar panel trade measures through hub countries. From the visual inspection of parallel trends, it appears that hub countries are becoming further integrated into Chinese solar panel supply chains compared to non-hub countries. The results, however, do not indicate that these relationships changed in a way that would be consistent with a reversal of circumvention behaviour following the removal of the MIP in 2018.

The absence of a post-2018 reversal in hub-related trade flows may reflect the persistence of established supply chains rather than the continued need for tariff circumvention. By 2018, Chinese producers will have had enough sunk investment in production and logistics infrastructure in Southeast Asia that dismantling the operation will have represented a non-trivial cost. The cost advantages of hub-based production likely have continued to appear attractive even after the MIP's removal. Firms may also have been disinclined to re-establish production in China because of concerns over compliance and reputational issues (e.g., exploitation of Uyghurs), as well as a wish to diversify their exposure to risks related to regulatory issues. All these factors suggest that the removal of the MIP did not remove the incentives that gave rise to the trade pattern in the first place, leading to persistence rather than reversal. Identifying circumvention would have been more straightforward during the period in which the tariffs were introduced. However, data constraints necessitate a focus on the post-abolition period.

Another explanation for the absence of circumvention evidence is the rigidity of supply chains, which constrains rapid rerouting. Therefore, more tests were performed to spot longer-term changes. As mentioned earlier, 2019 might have also been too soon for the shift to occur and that it in 2020 trade halted due to Covid-19. In the results no noticeable shift was discovered in the outcome in 2019 or 2020 relative to the baseline period. This further supports the idea that production, for some part at least, remained in the hub countries instead of returning to China.

While it is difficult to spot active circumvention, there have definitely been changes in trade flows. In particular, exports from certain intermediary hubs to the EU have increased alongside shifts in Chinese exports to these hubs, suggesting patterns consistent with trade diversion. The difficult part is that these hubs facilitate little to no solar production themselves and that it is mostly rerouting or Chinese production companies in the country. The analysis is complicated by the fact that most of the hubs have little domestic production capacity for solar panels, meaning that increased trade patterns are more likely to reflect re-routing or Chinese production firms operating in those countries rather than actual production.

These findings stand in contrast to those of Liu and Shi (2018), which did reveal clear circumvention practices. Their key result is that U.S. AD measures against China led to a stronger positive correlation between Chinese exports to third countries and U.S. imports from those same third countries. The correlation is significantly stronger for products subject to AD duties than for comparable products not facing duties, which serves as their control group. This pattern is interpreted as direct evidence of trade rerouting, rather than standard trade diversion or trade deflection. The key difference is that they had access to detailed pre-tariff data before the 2002 implementation, allowing them to clearly identify the effects of tariff introduction, whereas this study only observes trade patterns during and after the tariff period.

5. Conclusions and Implications

5.1 Conclusions

This study contributes to the broader free trade versus protectionism debate by examining the effectiveness and unintended consequences of EU trade-defence measures in the solar panel industry. This thesis examines the degree to which EU tariffs on Chinese solar panels led to trade diversion and reshaped trade flows of green technology. The literature review revealed that while protectionist measures are employed for economic, geopolitical and ethical purposes, they often do not consider losses in efficiency, and they also incentivise firms the to adjust their behaviour in ways that weaken policy effectiveness

The empirical findings of the study align with the theoretical tension. While the EU tariffs had the objective to safeguard the European producers against unfair competition, empirical evidence shows a clear case of trade diversion through intermediary trading hubs during the tariff period.

Existing evidence suggests that export growth in hub countries has been driven disproportionately by foreign-owned firms, raising questions about whether observed trade increases reflect genuine domestic industrial upgrading. Thus, it is necessary to distinguish between actual increasing domestic production and foreign direct investment (FDI) driving the export-related activity. Trade data may be inflating reports of domestic industrial production while downplaying the role of foreign ownership in the observed trade patterns.

At the same time, consistent with prior literature on tariff circumvention, this study finds that identifying active and deliberate circumvention is considerably more challenging. Unlike firm-level studies that can directly trace rerouting strategies, the aggregate trade data used here primarily capture shifts in trade flows rather than intentional evasion mechanisms. This suggests that, rather than straightforward tariff evasion, firms have engaged in broader supply-chain reorganisation and geographic reallocation of production, which is in line with political economy and strategic trade perspectives discussed in the literature.

The findings raise questions about the consistency of Western trade policy. The United States and the European Union have long been free-market supporters with a minimal role for government intervention. They have advocated for liberalisation, competition, and minimal state involvement in trade. But this commitment to free-market trade is selectively being reinterpreted as the economic success of China in the global marketplace becomes too evident to ignore. The growing use of trade-defence instruments highlights a tension, and arguably a degree of hypocrisy, as distorting the market outcome is now normalised as being a necessary intervention to ensure a level playing field. Intervention seems acceptable only when free-market outcomes no longer favour Western producers.

Beyond these trade dynamics, the findings also raise broader questions about the goals of the EU's trade-protection strategy. A key goal of the tariffs, in addition to protecting solar manufacturers in Europe, was to send a clear message of political resolve to Beijing. The trade-defence measures acted as a deterrent that demonstrated to China that the EU was willing to use trade-defence instruments and other forms of deterrent measures if needed to push back against perceived trade unfairness and assert its own regulatory dominance. However, based on everything discussed in this thesis, the 'strong' defence appears to have been largely symbolic. If the primary objective had been to fully protect European manufacturers, it is unclear why comparable tariffs were not imposed on countries such as Vietnam and Thailand, which have almost certainly played a role in tariff circumvention.

To understand this inconsistency, it is necessary to consider the broader strategic context of EU policy. While the European solar panel manufacturers do need protection, an even greater priority for the EU may be the achievement of its ambitious climate objectives. Imposing broad tariffs on all major supplying countries could have raised costs and slowed solar deployment, ultimately undermining the pace of the energy transition.

Interestingly, the 2013-2018 tariffs can be interpreted in a few different ways. On the one hand, the matter may be viewed as evidence of the fact that the EU had been outsmarted by the Chinese producers, who were still able to supply the EU market through alternative means despite the tariffs. From this perspective, the tariffs were ineffective at disrupting trade, and this allowed Chinese firms to remain one step ahead of regulatory enforcement.

Alternatively, the policy might be interpreted as a strategic success for the EU. The tariffs projected power while leaving enough solar panels on the market to support their own energy transition. The need of Chinese manufacturers to adapt to the new regulatory constraints may have also caused them to slow down their expansion. This potentially created a situation in which the struggling European firms were able to catch up. The tariffs might have struck a perfect balance between symbolic protection, strategic signalling, and climate policy objectives.

Overall, the findings provide evidence for one of the main findings of the literature review: that while trade-defence instruments can provide a short-term solution to domestic industries, their remedy in the medium- to long-term is limited by firms' ability to adjust, and by the re-routing of trades. This finding reflected the potential for such protectionist responses to create large unintended consequences, ultimately questioning their suitability for achieving both economic an ethical policy objectives. Additionally, from a policy viewpoint, the results suggest that trade-defence measures in a globally integrated market might require additional tools such as supply-chain disclosure. Tariffs by themselves appear insufficient to prevent trade reallocation if firms can reorganise their production and shipping plans quickly.

5.2 Critical reflection

When it comes to the limitations of this study, the main constraints come from data availability. Two key issues negatively affect the results, with the first one being that global data on solar panel trade is limited. Large-scale adoption of solar panels only accelerated over the past fifteen years, driven by government incentives and declining production costs. As a result, the UN trade dataset used in this study is only available from 2013 onward, which means losing valuable pre-tariff data.

Second, the analysis relies on HS code 8541, which includes solar panels but also other semiconductor devices. The use of a combined product code may lead to aggregation bias as the trade flow changes may be partially driven by the trade flows of other products attenuating the estimated effect for solar panels. While aggregation could result in some bias, it is unlikely to have a major effect since the EU tariffs that were applied in 2018 were applied to solar panels alone, preventing the non-solar-related movement of the remaining products in this HS code from "masking" changes in trade flows entirely.

5.3 Future studies

Future studies could use firm or ownership data to examine whether the increased hub exports are the outcome of increased production by local producers or foreign (e.g., Chinese) firms operating abroad. By tracking the establishment and scale of new production plants, production scale-up, and FDI in the hub countries, it should become clear whether the surge in exports is those which are supported by real increases in production instead of short-term rerouting.

In short, while definitive circumvention is difficult to prove, the 2013–2018 tariffs have led to clear and persistent shifts in trade patterns. The results indicate that EU solar panel tariffs did not eliminate Chinese involvement in the European market, but instead reshaped trade routes through intermediary hubs, consistent with trade diversion rather than full market disengagement. These adjustments suggest that firms responded strategically to the trade-defence measures by reorganising supply chains, thereby limiting the effectiveness of the tariffs.

The solar tariffs case illustrates the tension between strategic trade policy and climate objectives, ultimately highlighting the difficulties that the EU has in reconciling industrial protection, ethical concerns, and the urgent need for affordable renewable energy.

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Appendix

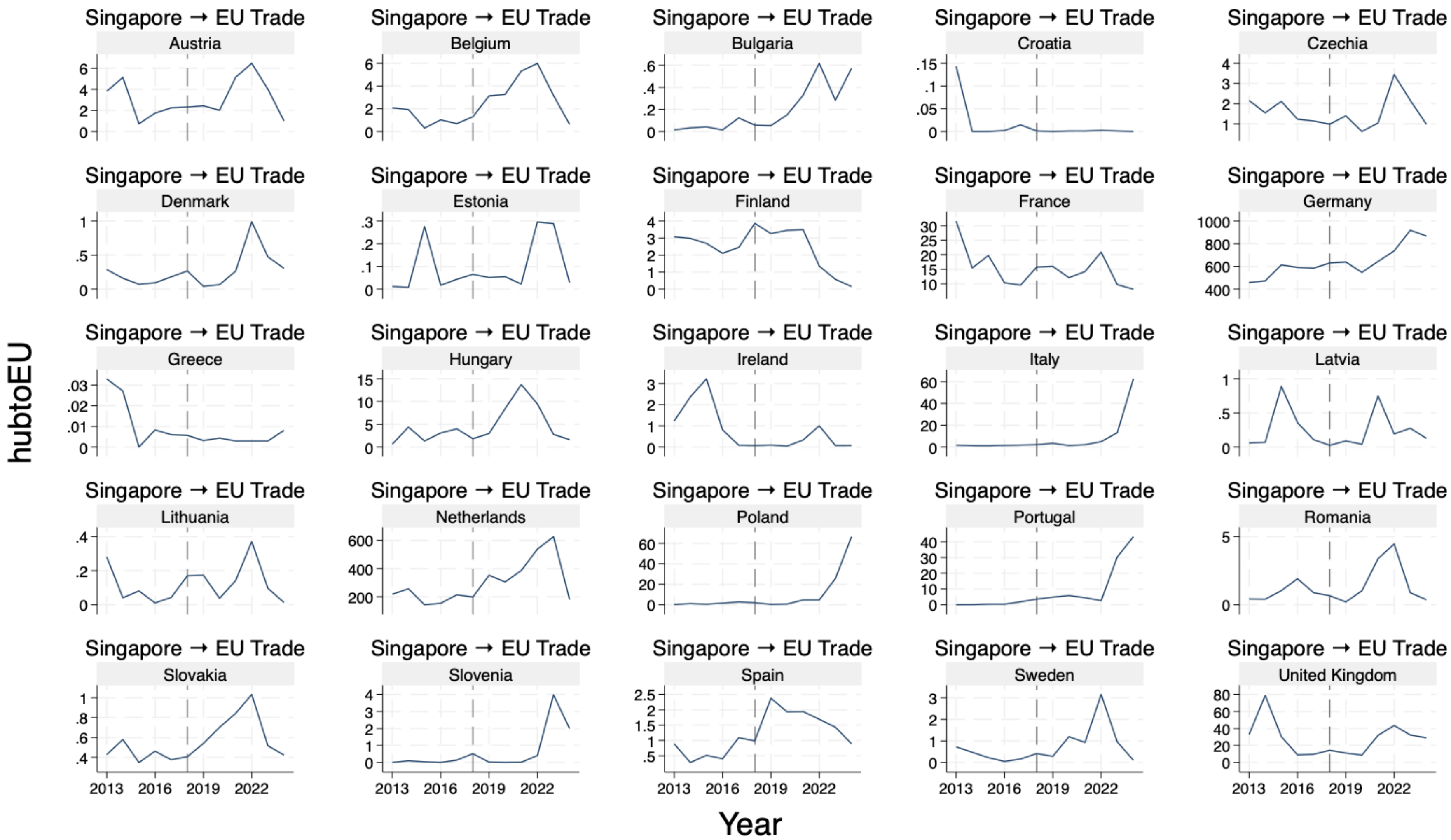

Figure A 1 Singapore to EU trade by destination.

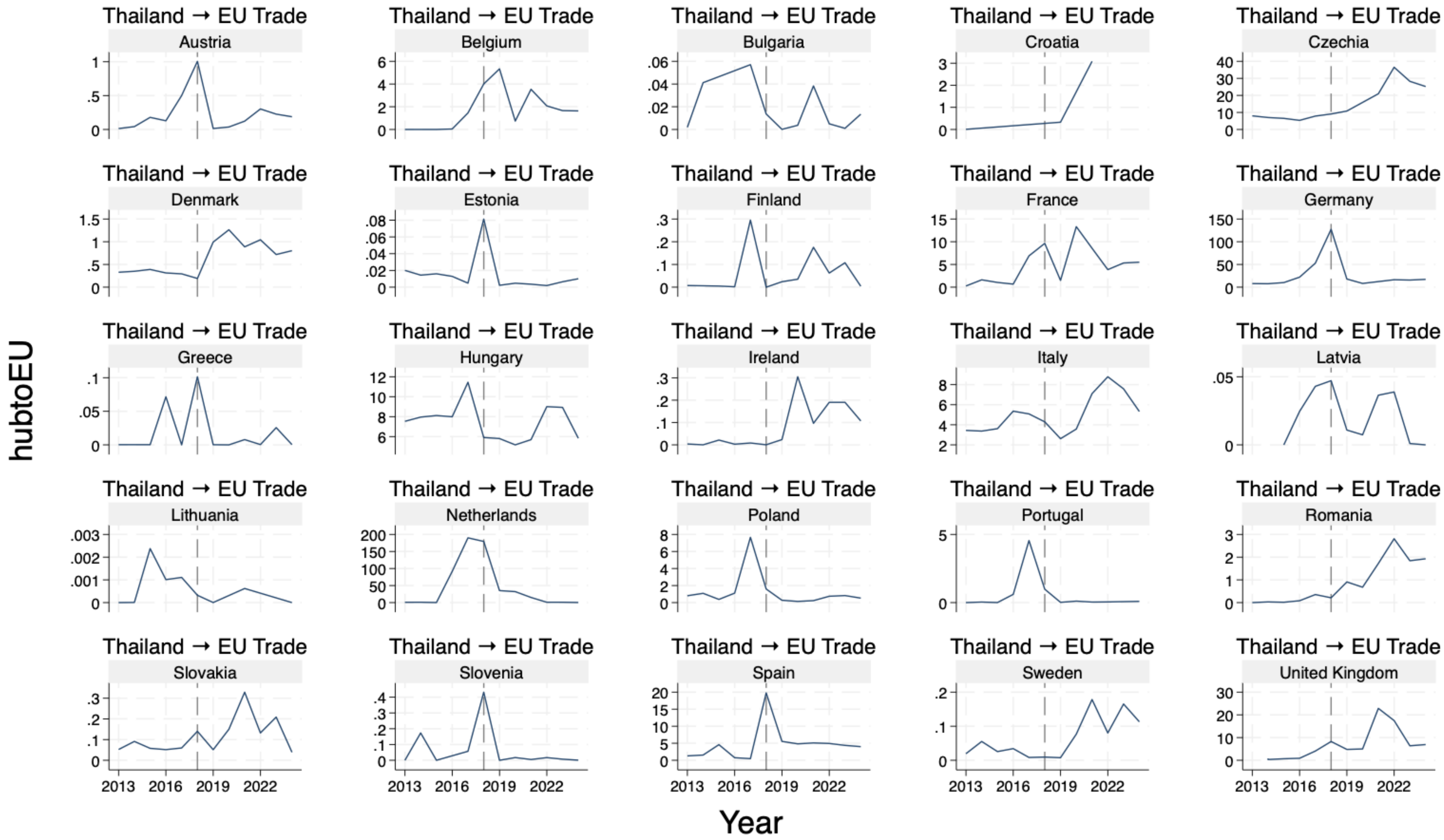

Figure A 2 Thailand to EU trade by destination.

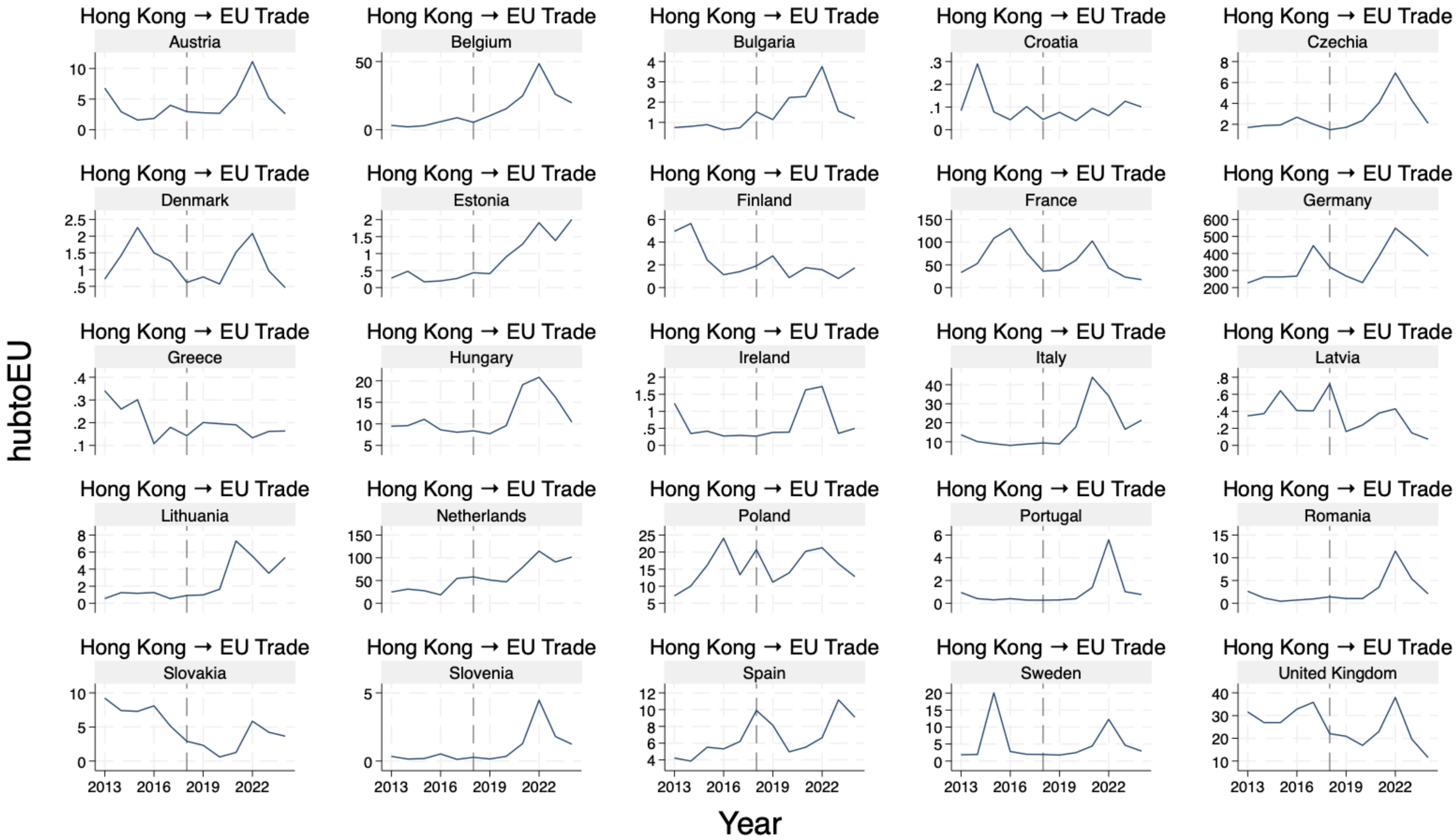

Figure A 3 Hong Kong to EU trade by destination.

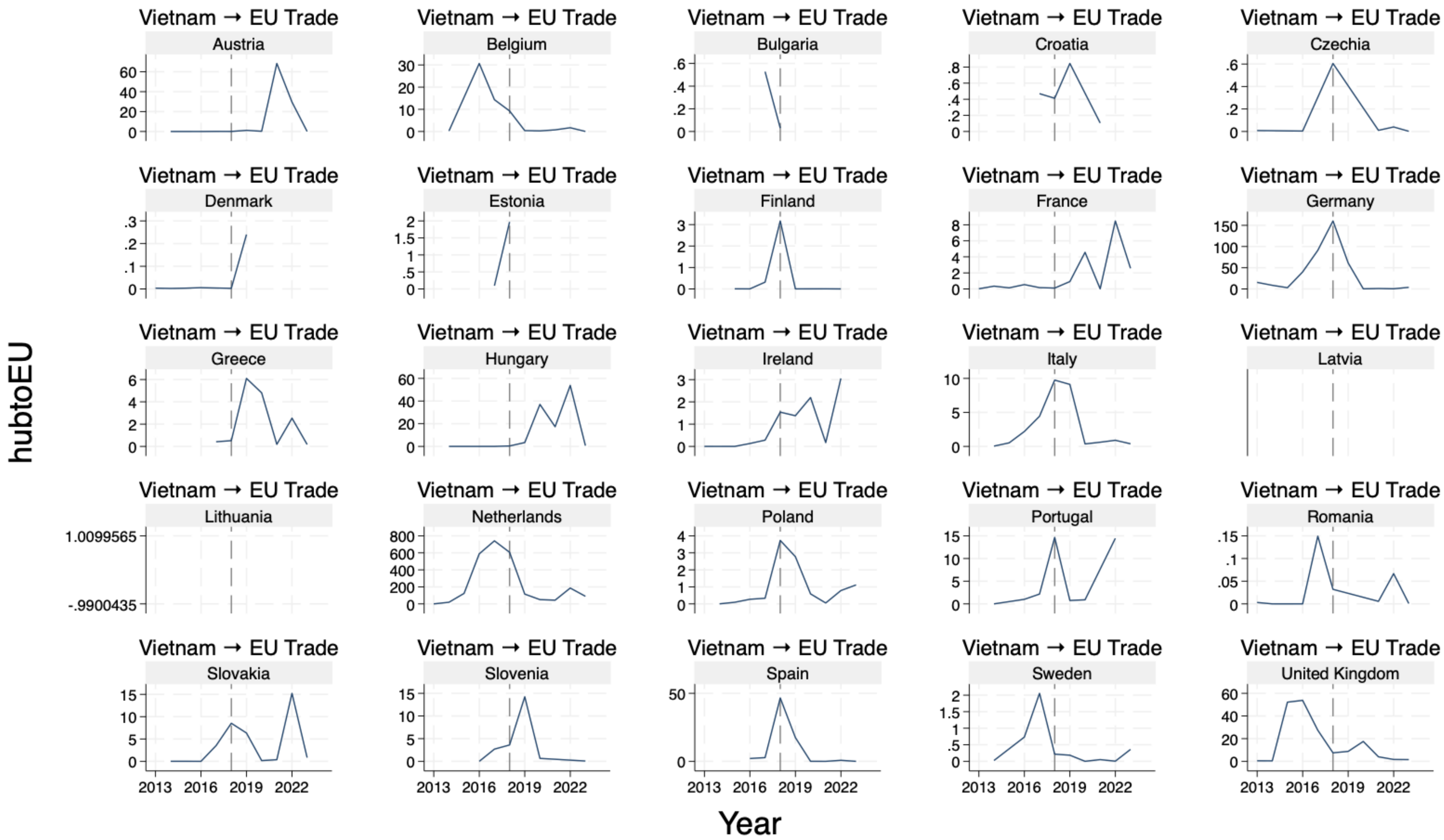

Figure A 4 Vietnam to EU trade by destination.

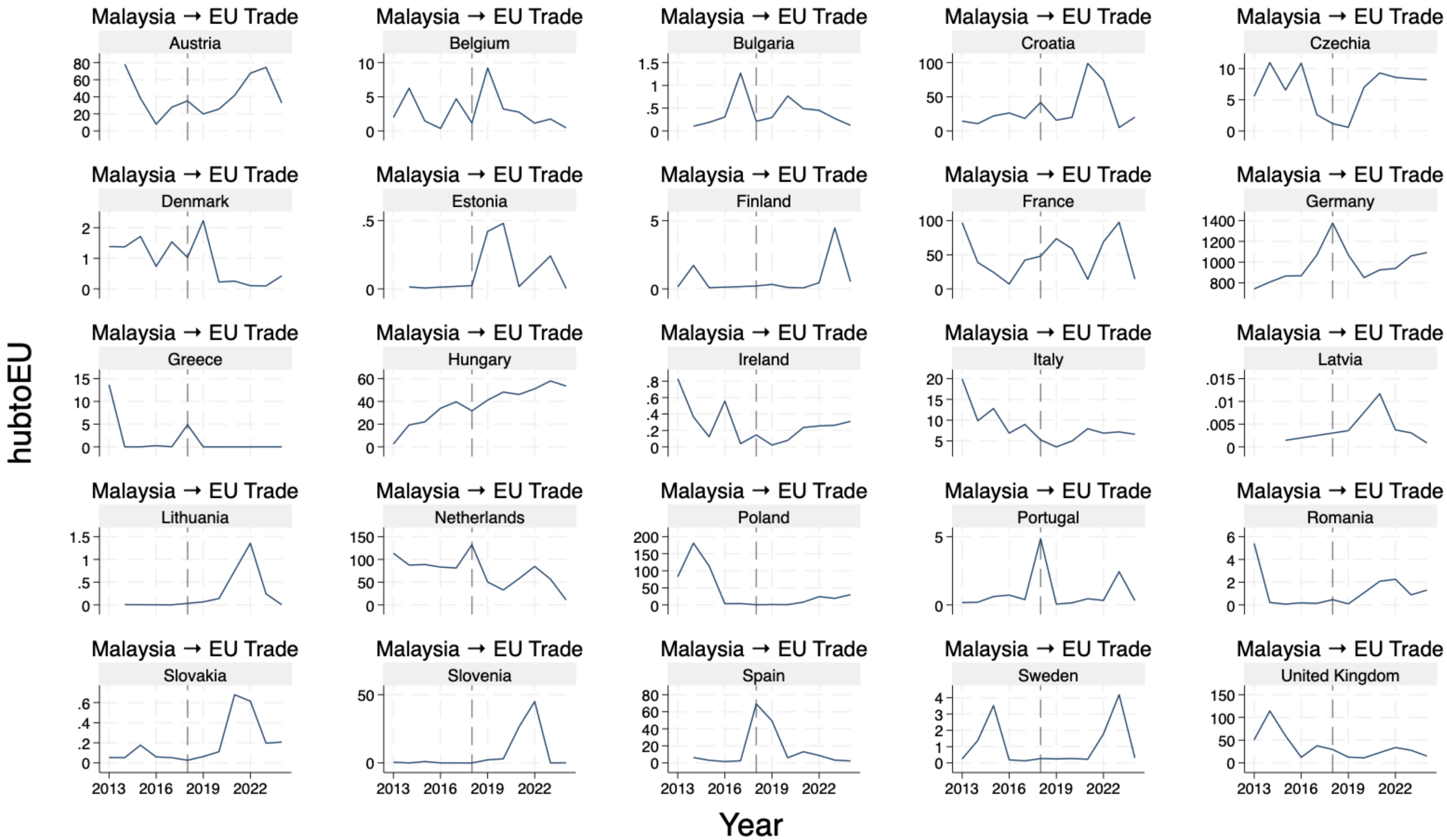

Figure A 5 Malaysia to EU trade by destination.

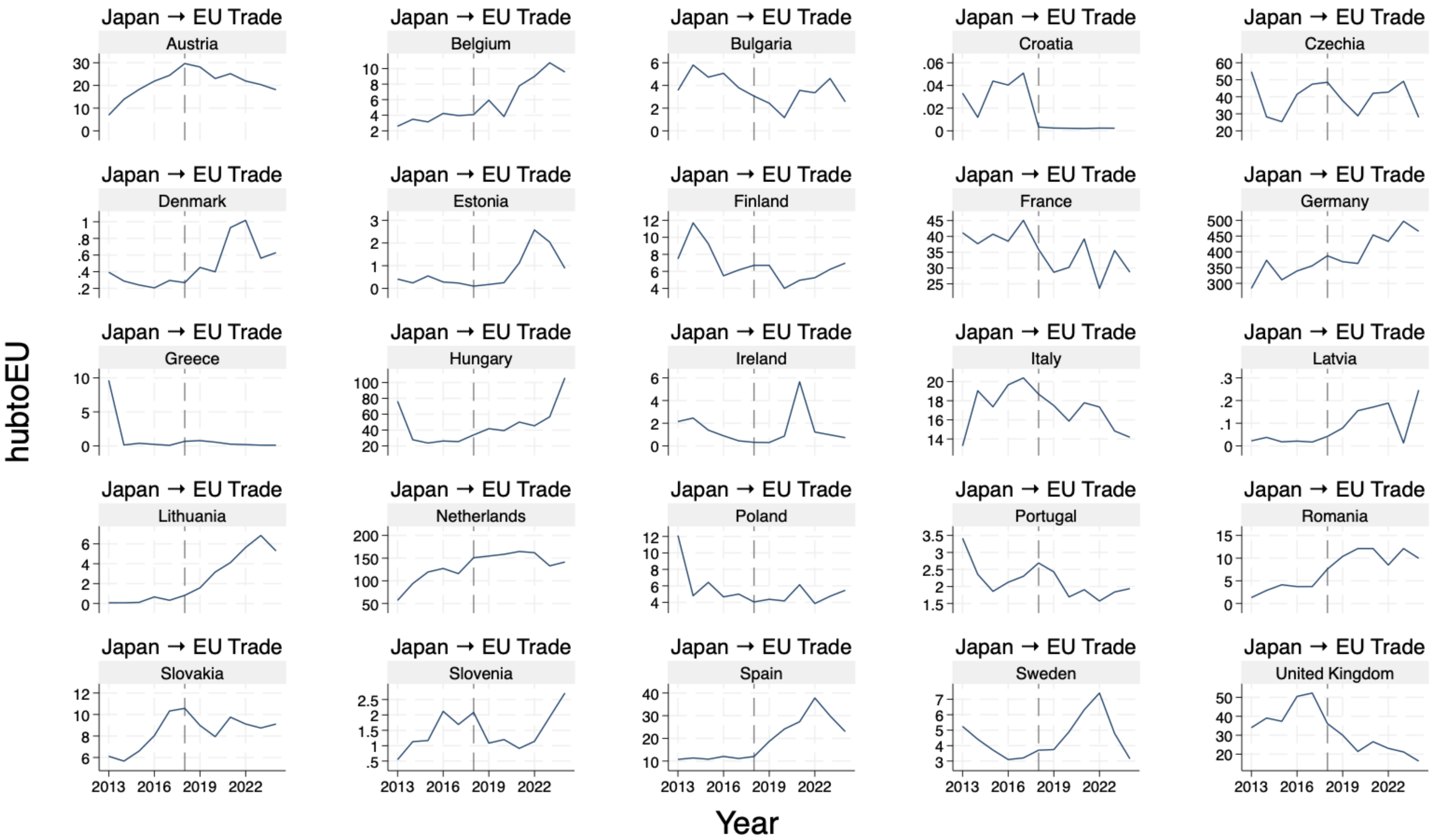

Figure A 6 Japan to EU trade by destination.

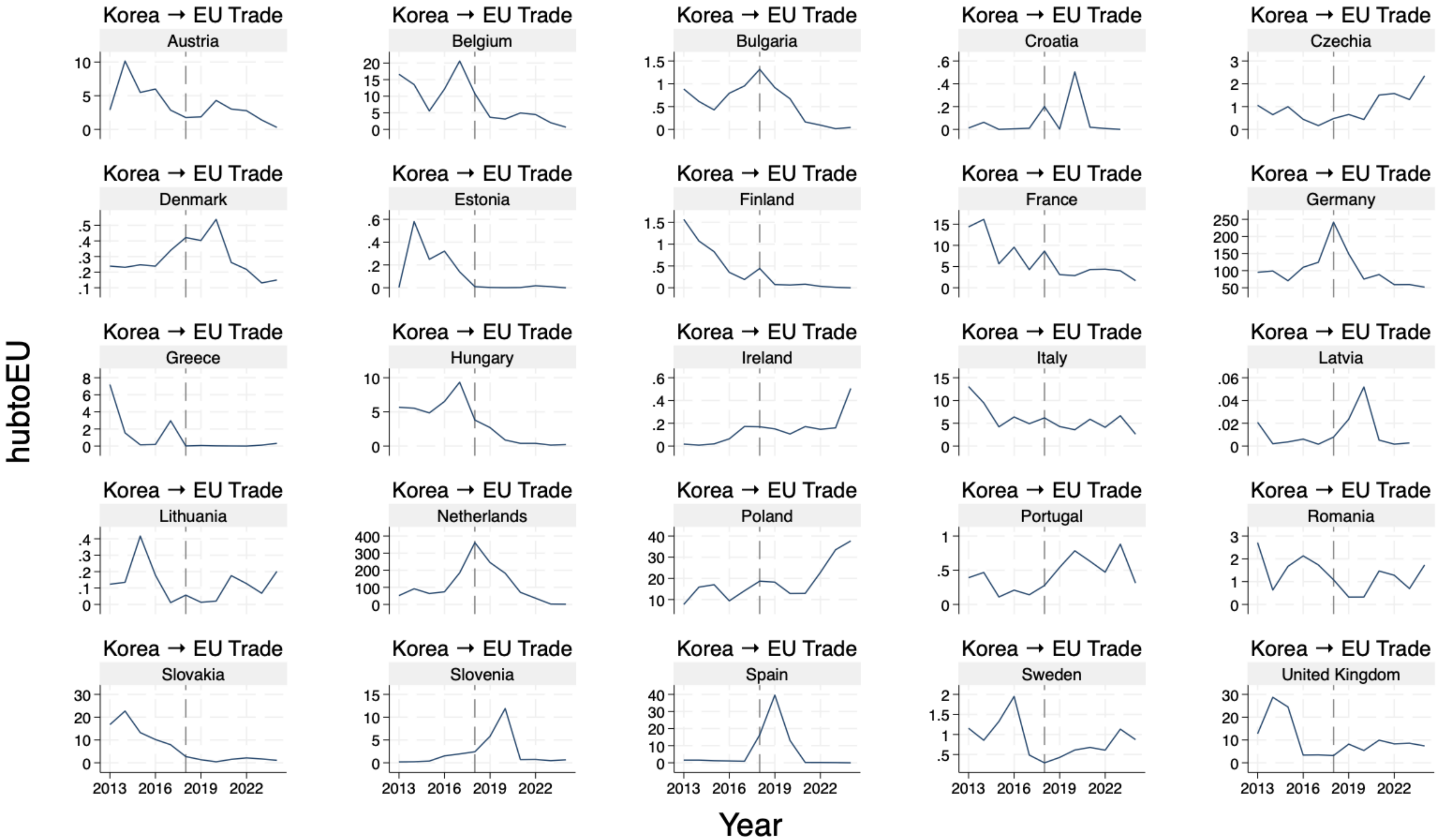

Figure A 7 Korea to EU trade by destination.

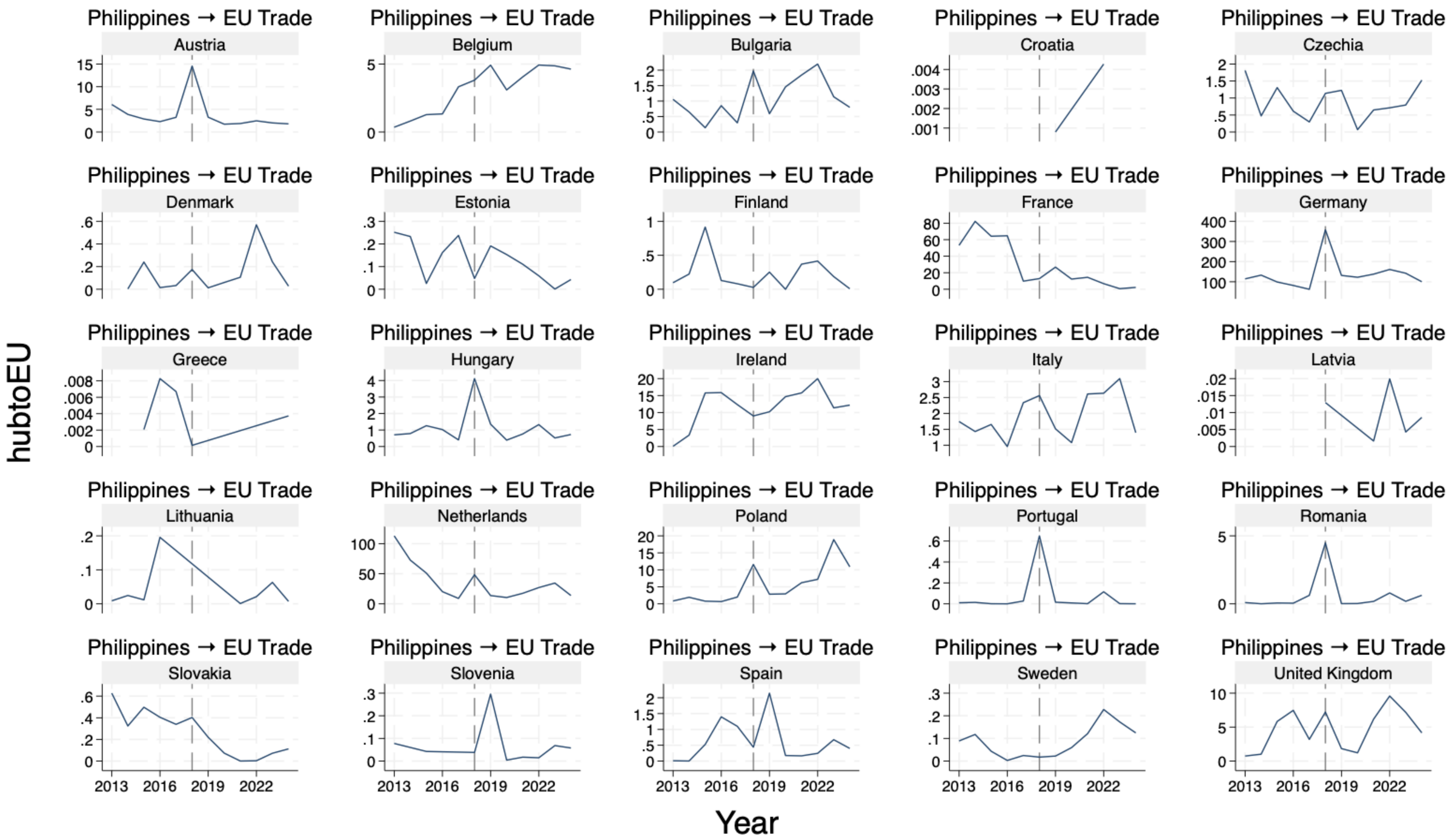

Figure A 8 Philippines to EU trade by destination.

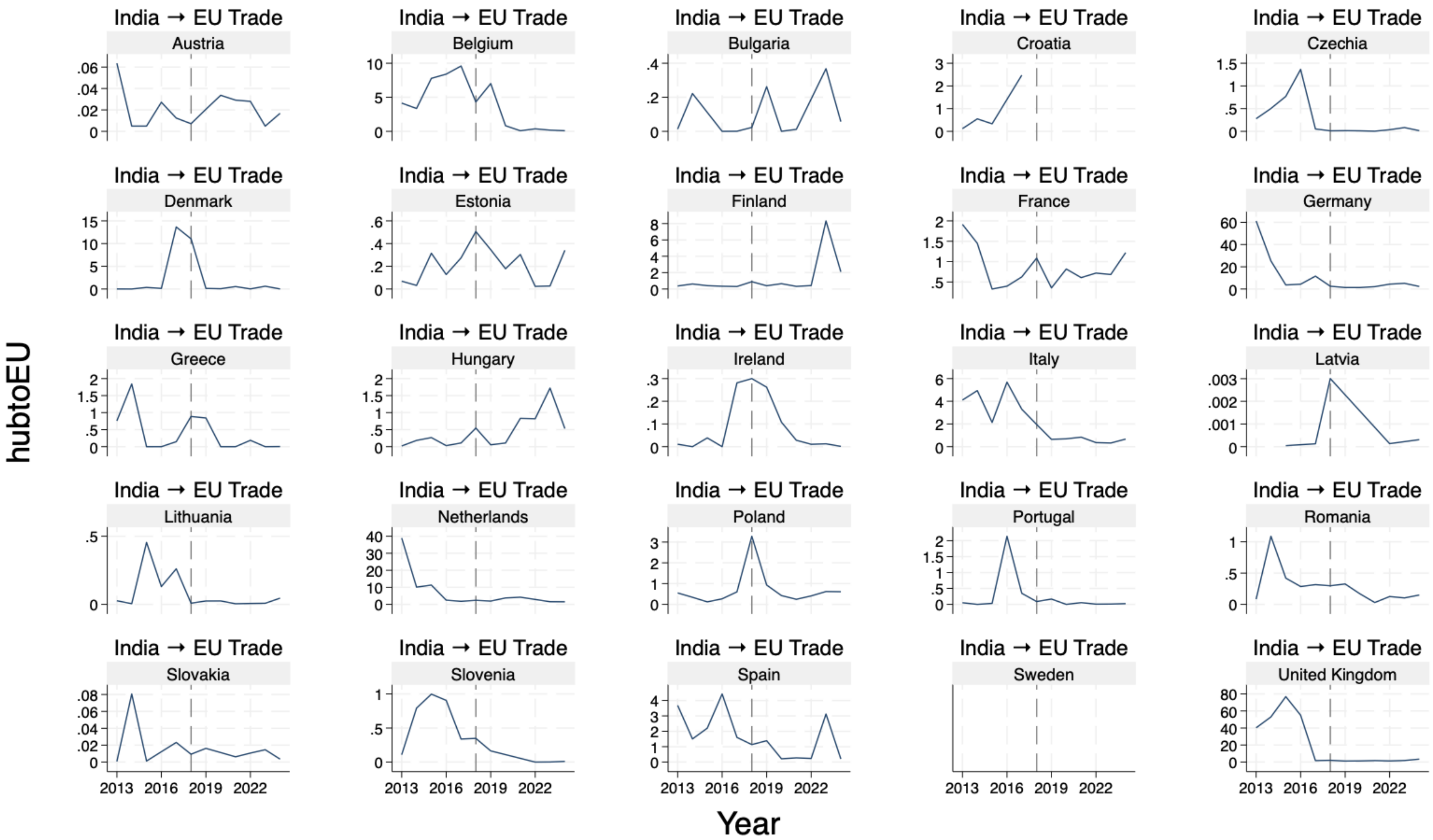

Figure A 9 India to EU trade by destination.

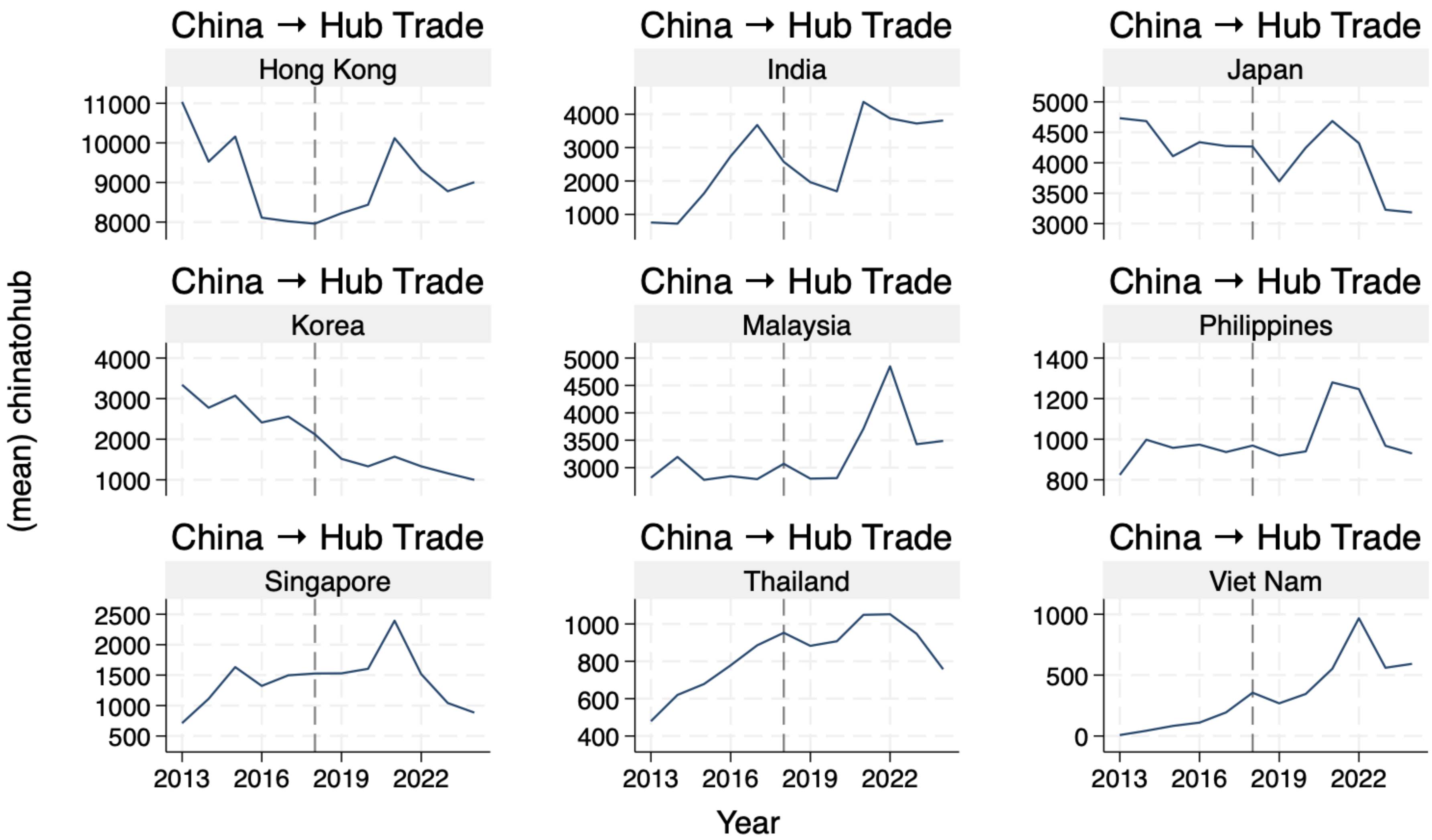

Figure A 10 China to hub trade by hub.

Table A 1 DiD specification for hub to EU and China to hub trade interacted with Chinese diaspora and a dummy for whether a country is connected to China via land but with post dummy removed.

	Equation 5 LnY_{cht} *Diaspora interaction without P_t*	**Equation 6** LnY_{cht} *Land Connectedness interaction without P_t*
lnX_{ht} *(China to Hub)*	0.665*** (0.088)	0.695*** (0.061)
T_h *(Treatment dummy)*	-4.334*** (0.647)	0.484* (0.261)
Z *(lnGDP)*	-0.788*** (0.152)	0.283*** (0.709)
D_h *(Diaspora hubs)*	-2.058*** (0.272)	
T_tD_h *(Treatment diaspora interaction)*	2.062*** (0. 272)	
L_h *(Land connectedness hubs)*		-2.270*** (0.209)
T_hL_h *(Treatment land interaction)*		1.834*** (0.293)
Observations	2469	2469
R-squared	0.083	0.105

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Standard errors in parentheses.