Place-Based Policy and Entrepreneurial Resilience: Evidence from China's Development Zones

Abstract: Entrepreneurship is a pivotal driver of a country's economic development, and particularly in emerging economies like China, entrepreneurial firms' ability to adapt to and survive external shocks serves as a critical metric of entrepreneurial quality. Yet regional disparities in firm resilience persist, raising a key question: Do governments' place-based policies explain why enterprises in some regions weather shocks while others falter? Development zones, a flagship type of place-based policy in China, are widely studied for their growth-promoting effects, but their role in enhancing firm resilience remains underexplored. This paper fills this gap by examining how development zones shape firm resilience to external trade shocks, and by using the 2011 U.S.-EU anti-dumping and countervailing duties imposed on Chinese photovoltaic enterprises as a quasi-natural experiment. Drawing on firm-level industrial registration data, customs trade data, and precise geographic boundary data of development zones, we find that firms in development zones exhibit significantly higher resilience; this effect stems from stronger linkages to the zones' industrial base, which enable faster export market diversification. Our findings highlight development zones as a potent instrument of place-based policy for boosting entrepreneurial resilience and stabilizing local entrepreneurial ecosystems.

1 Introduction

In recent years, the global economic landscape has undergone profound changes, marked by rising trade protectionism, escalating geopolitical conflicts, and vulnerabilities in supply chains, all of which have subjected businesses to unprecedented external shocks. According to Global Trade Alert, nearly 27,000 instances of government intervention disrupting international trade have been recorded over the past five years. Against this backdrop, corporate resilience has become a focal point of research. There are substantial variations in how firms respond to global trade shocks, some companies swiftly adjust their market strategies

and expand into new export markets, effectively mitigating the negative impacts of trade policies; others suffer severe setbacks, even facing bankruptcy or market exit.

Among the various factors influencing firm resilience, industrial clusters are particularly significant. Studies have shown that industrial clusters enhance firm resilience through mechanisms such as supply chain synergies, knowledge spillovers, and network externalities (Delgado and Porter, 2021). Both during the Great Recession (Hundt and Grün, 2022) and the COVID-19 pandemic (Dai et al., 2021), industrial clusters demonstrate stronger resilience. Development zones, as government-led clusters, attract firms to specific geographic areas through policy incentives, fostering economic growth. As historically significant drivers of economic activity, can development zone policies also play a positive role in enhancing firms' resilience and strengthening their ability to withstand external shocks? Addressing this question not only deepens our understanding of development zone policies and their mechanisms but also provides valuable insights for navigating economic uncertainties in the current macroeconomic environment.

this paper uses the 2011 AD-CVD duties imposed by the European Union and the United States on China's photovoltaic (PV) industry as a quasi-natural experiment to evaluate the export performance of firms exposed to this trade shock. It further examines how development zones influence firms' adaptive capacity in the face of external shocks. The results indicate that AD-CVD duties significantly reduced exports from Chinese PV firms, with a notable decline in export values. However, this effect is primarily observed among firms outside development zones, while firms within development zones experienced no significant impact. This finding is robust across several tests, suggesting that development zones help mitigate the negative consequences of trade shocks. Mechanism analysis reveals that firms within development zones hedge against trade shocks by diversifying into new export markets. Moreover, the greater the alignment between a firm and the industrial base of its development zone, the more pronounced its diversification strategy.

These findings contribute to the theoretical literature on the role of development zones and offer empirical support for studies on industrial clusters. The study also holds practical significance, as the PV industry's response to the shock reflects challenges faced by China's strategic emerging industries. By using the PV industry as a case study, this paper provides insights into how development zones can enhance firm resilience, offering valuable lessons for other emerging industries in China facing

an unstable international environment, and providing empirical evidence to inform relevant government policies.

This study contributes to the empirical literature on industrial clusters and economic resilience, particularly in the context of government-led industrial clusters. Existing studies primarily focus on the role of industrial clusters in enhancing firm resilience during economic downturns. For example, Delgado and Porter (2021) investigate regional industrial clusters in the U.S. and their impact on employment resilience during the 2008 financial crisis. They find that strong clusters, characterized by high firm density, supply chain linkages, and knowledge spillovers, significantly enhance regional employment resilience, especially for firms in supply chains benefiting from inter-industry synergies. Kitsos et al. (2023) analyze European industrial clusters and reveal that the impact of industrial clusters on firm resilience exhibits non-linear characteristics. By examining the relationship between local industry embeddedness (the share of local economic activities) and regional resilience to recessions, they demonstrate that moderate embeddedness enhances resilience by reducing transaction costs, while over-embeddedness can trigger lock-in effects, hindering adaptive adjustments. Hundt and Grün (2022) further differentiate between resistance and resilience, analyzing the performance of the German economy during and after the 2008 recession. They find that manufacturing-heavy and export-oriented regions exhibited stronger resilience, while regions with a higher share of public-sector employment demonstrated greater shock resistance but slower recovery.

Beyond economic recessions, public health emergencies, such as the COVID-19 pandemic, present additional challenges to firm resilience. Dai et al. (2021) examine the survival performance of Chinese firms during the COVID-19 outbreak and find that regions or industries with higher clustering are less affected by the shock, evidenced by smaller decreases in new firm entries and a higher likelihood of firms resuming production. Mechanistic analyses suggest that clusters enhance firm productivity through resource sharing, supply chain proximity, and entrepreneurial networks facilitating online sales transformation. While most studies focus on market-driven industrial clusters, this study examines government-led clusters, specifically development zones. By doing so, it fills a gap in the literature and deepens our understanding of how these clusters enhance firm resilience.

This study is also closely related to the literature on firm heterogeneity in response to trade shocks. Since the turn of the 21st century, international trade has

shifted from accelerated liberalization to an anti-globalization trend, revealing significant heterogeneity in firm responses to trade volatility. Researchers have extensively explored the impact of trade shocks on firms and the variability in their coping strategies. They have identified factors such as productivity, firm size, network position, and factor endowment as key determinants of firms' responses to trade shocks.

First, productivity is a central factor in explaining differences in firms' responses to trade policies. Melitz (2003) develops a dynamic industry model showing that only high-productivity firms can enter export markets and adapt to trade shocks, thereby expanding their market share, while low-productivity firms may be forced to exit. Bloom et al. (2016) find that European firms faced with competitive pressures from China responded by improving product quality and productivity, with high-productivity firms demonstrating greater adaptability. Handley and Limão (2017) further suggest that high-productivity firms are more proactive in expanding into new export markets when trade policy uncertainty is reduced. However, in some cases, low-productivity firms may also benefit from trade liberalization. For instance, Lileeva and Trefler (2010) show that U.S. tariff reductions under the Canada-U.S. Free Trade Agreement led some low-productivity Canadian firms to begin exporting, increase labor productivity, and adopt new technologies, whereas high-productivity firms did not exhibit similar changes.

Firm size also plays a crucial role in shaping responses to trade shocks. Following China's permanent Most Favored Nation status with the United States, the number of U.S. manufacturing firms declined, with small firms being particularly hard-hit by mergers and acquisitions. In contrast, large multinational firms were better able to withstand trade shocks by offshoring production (Griffin, 2023). The capital-labor ratio also influences resilience in the face of specific trade shocks. Autor et al. (2013) find that U.S. manufacturing jobs declined and wages fell due to Chinese import competition, but firms with higher automation levels were more resilient. Additionally, a firm's position in the global production network affects its exposure to trade wars. Huang et al. (2023) find that U.S. firms more dependent on imports and exports with China experienced a larger decline in stock prices during the U.S.-China trade war. In summary, firms' responses to trade shocks exhibit significant heterogeneity, shaped by factors such as productivity, size, capital-labor ratios, and global network positioning.

This paper extends the literature on trade shocks and firms' coping strategies by

introducing the location of firms within development zones as an additional explanatory factor. The analysis shows that firms' ability to withstand trade shocks is significantly stronger when they are well-aligned with the industrial structure of the development zone. This finding highlights that, besides internal factors such as productivity and size, the external environment, particularly the development zone where a firm operates, plays a crucial role in shaping its response to external shocks. Moreover, the results suggest that enhancing the cluster effect, along with strengthening firms' internal capabilities, can be an effective strategy for navigating the increasingly complex and volatile trade environment.

2 Policy Background

2.1 Current Status of China's Photovoltaic Industry

Since 2004, China's solar photovoltaic (PV) industry has experienced rapid expansion, driven by strong government support and surging demand from European and American markets. According to statistics from the China Photovoltaic Industry Association, in 2001, China's photovoltaic cell production was merely 3 MW, accounting for less than 1% of global output. However, by 2009, production had surged to 4,000 MW, surpassing Germany and Japan for the first time and making China the world's leading PV manufacturer. Between 2006 and 2015, China's cumulative installed PV capacity increased by a factor of 534, rising from 80,000 kW to 43.48 million kW. Over the same period, its share of global PV capacity expanded from 1.2% to 18.9% (United Research Group of China Center for Energy and Development at the National School of Development et al., 2018).

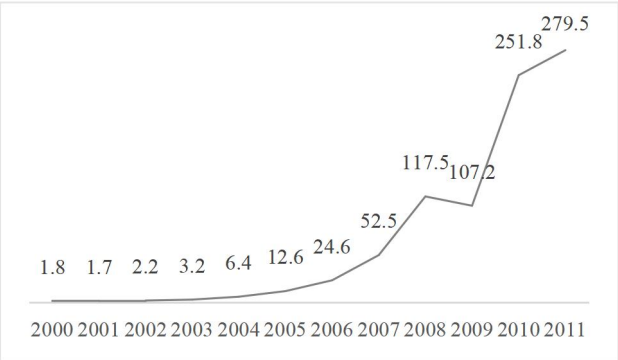


Figure 4.1 Trends in China's PV product exports (2000-2011) (billions of dollars)

Data source: Adapted from Xiang and Lai (2013), compiled using statistical data from the UN Comtrade database.

However, the rapid expansion of production capacity stood in stark contrast to the

underdeveloped domestic market. Despite the industry's massive production capacity, domestic demand remained in its infancy before 2010, with the sector heavily reliant on exports. In 2010, China's total photovoltaic cell output reached 8,500 MW, yet newly installed domestic PV capacity was only 500 MW, representing less than 6% of total production. The remaining 94% was exported, with Europe and the United States being the primary destinations, accounting for over 90% of total exports.

From a technological perspective, China's PV industry in the early 2010s was largely concentrated in midstream manufacturing, where its competitive advantage relied primarily on low-cost domestic labor. Most firms had not yet developed independent technological capabilities, and high-end manufacturing remained dependent on foreign suppliers. For instance, critical production equipment such as wafer cutting machines and coating systems was largely imported, reflecting the industry's limited autonomy in core technologies. Overall, while China's PV industry expanded rapidly, it remained in a "large but not strong" stage of development, characterized by "technology and market dependence on external sources".

2.2 The Timeline of the Anti-Dumping and Countervailing Duties

At the beginning of the 21st century, the global PV industry entered a phase of rapid expansion, particularly in Europe, where policy incentives played a crucial role in driving growth. By 2010, leveraging cost advantages in manufacturing and strong government support, Chinese PV firms had made significant inroads into European and American markets, becoming the world's largest producer of PV modules with a global market share of 50%. The rapid rise of Chinese manufacturers intensified competition, placing significant pressure on domestic PV producers in both Europe and the United States.

In October 2010, the German PV company SolarEdge and other industry players filed a complaint with the German government, alleging that Chinese PV firms were engaging in price dumping in the German market and calling for an anti-dumping investigation. The following year, in October 2011, the U.S. subsidiary of German PV giant SolarWorld, in collaboration with six U.S. PV manufacturers, formed the U.S. Solar Manufacturing Federation and submitted a petition to the U.S. Department of Commerce and the International Trade Commission. The petition accused Chinese PV firms of selling products below market prices while benefiting from unfair government subsidies, demanding that AD-CVD duties investigations be launched. As

the primary advocate of this investigation, SolarWorld was among the largest PV manufacturers in Europe at the time. Headquartered in Germany, the company specialized in high-efficiency PV cells and modules and held a significant market presence in both Europe and the U.S., directly competing with Chinese firms. However, as Chinese PV manufacturers expanded, SolarWorld lost its price competitiveness in an increasingly crowded market. In November 2011, the U.S. Department of Commerce officially initiated an investigation, and in December, the ITC issued a preliminary determination, concluding that Chinese solar cell exports had caused material injury to the U.S. domestic industry. Between March and May 2012, the U.S. Department of Commerce announced its preliminary findings, imposing countervailing duties of 2.9% – 4.73% and anti-dumping duties ranging from 31% to 250% on Chinese PV imports. On October 10, 2012, the Department issued a final ruling, confirming the existence of dumping and subsidy practices and setting countervailing duty rates at 14.78% – 15.97% and anti-dumping duties between 18.32% and 249.96% (Xiang and Lai, 2013).

Following the U.S. trade investigation, SolarWorld replicated the same strategy in Europe. In July 2012, the company led an initiative with the European Union of Photovoltaic Manufacturers (EU ProSun), filing an anti-dumping complaint with the European Commission against Chinese PV imports. In September 2012, the Commission formally launched an anti-dumping investigation, marking the largest trade dispute ever initiated by the EU against China. In addition to claims of dumping, EU ProSun alleged that Chinese PV firms benefited from unfair government subsidies and called for punitive tariffs on imports. In November 2012, the European Commission expanded the investigation to include countervailing (anti-subsidy) measures. In March 2013, the EU imposed import registration requirements on all Chinese PV products, and in June 2013, it announced provisional anti-dumping duties averaging 47.6%. Faced with escalating trade tensions, China and the EU reached a "price commitment" agreement in December 2013. Under the agreement, Chinese PV firms committed to maintaining a minimum export price and limiting export volumes to the EU, while the EU agreed to suspend further increases in anti-dumping duties and additional trade sanctions. This arrangement helped ease trade frictions between the two parties to some extent.

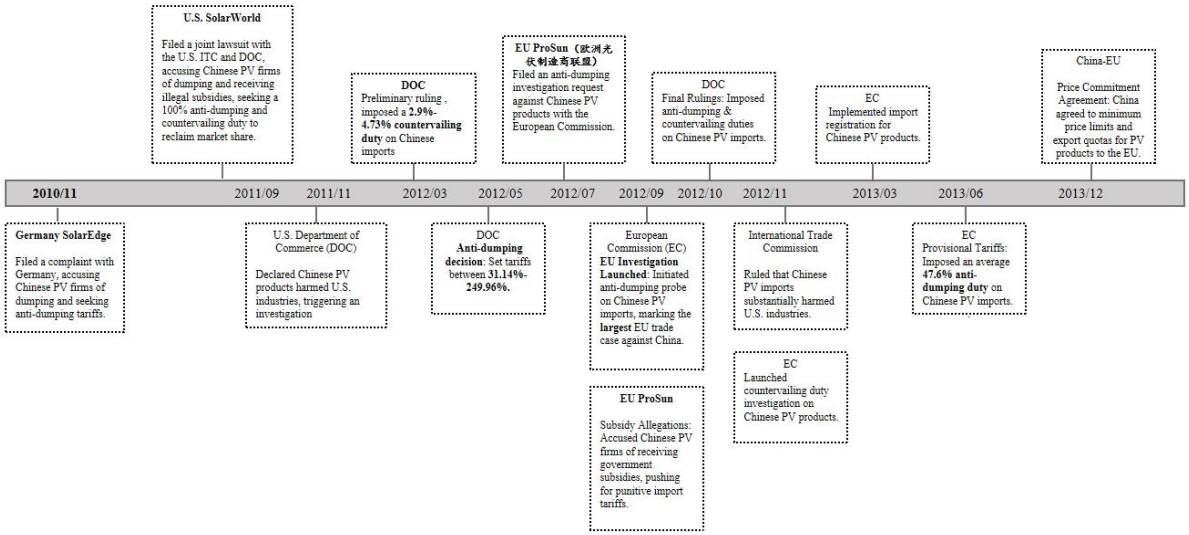


Figure 4.2 Policy timeline

Data source: Compiled and visualized by the author based on publicly available data.

2.3 Market Response to the AD-CVD Investigation

The launch of AD-CVD duties investigations by the United States and the European Union against China's PV industry led to a rapid deterioration in market expectations. In 2012, which was a U.S. presidential election year, political candidates seeking voter support were inclined to adopt a hardline stance on China and to use trade sanctions to protect domestic industries. This political climate further exacerbated market concerns. Moreover, historical rulings by the U.S. International Trade Commission suggested that an initial determination of "material injury" and subsequent termination of the investigation was exceedingly rare, reinforcing market pessimism about the likely outcome. From the perspective of strategic incentives, SolarWorld, the largest PV module manufacturer in the European Union, successfully lobbied for the U.S. investigation into Chinese firms. Given its competitive interests, it was highly likely that the company would seek to replicate a similar strategy in the EU. The combination of these factors further eroded market confidence, prompting some European and American importers to scale back purchases of Chinese PV products due to concerns over impending tariff increases. This, in turn, led to a decline in overseas orders for Chinese PV firms and negatively impacted their brand reputation.

The deteriorating market sentiment was reflected in a sharp contraction of China's PV exports. In 2012, the total export value of China's PV products declined by 37.44% compared to 2011, while exports of solar cells and modules fell by more than

40%. Both industry leaders and smaller supporting enterprises experienced severe disruptions. LDK Solar, one of the sector's leading firms, reported a $588 million loss in 2011, with total liabilities reaching $6 billion and a debt-to-equity ratio of 87.7%. Similarly, Wuxi Suntech, burdened by excessive debt, was unable to meet its financial obligations and ultimately filed for bankruptcy and reorganization in 2013. The impact was particularly pronounced for small and medium-sized enterprises that relied heavily on a single overseas market. According to 2011 data from the Zhejiang PV SME Alliance, of the 374 PV SMEs in Zhejiang Province, at least 50% were operating at reduced capacity, while in upstream processes such as crystal pulling and wafer slicing, the proportion of firms ceasing operations reached 70% – 80%. Many enterprises were forced to exit the market, either through bankruptcy or by transitioning to other industries.

3 Database

This paper continues to utilize the national business registration database and the geographic boundary data of development zones, both of which have been detailed in the previous section and will not be reiterated here. The focus of this paper is to introduce additional data sources and processing methods, primarily covering the identification of PV firms and the import and export data of firms, with the latter serving as the dependent variable in the analysis of trade policy impacts.

3.1 Identification of Photovoltaic Firms

The photovoltaic industry chain can be divided into three main segments: upstream, midstream, and downstream. The upstream segment primarily involves the production and supply of raw materials, with the core focus on the manufacture of polysilicon and monocrystalline silicon, which are produced by purifying and processing silica. These materials are essential for the production of solar cells. The next stage is the cutting of silicon wafers, which directly impacts the performance of solar cells. The midstream segment includes the production of photovoltaic cells and the assembly of photovoltaic modules. Cells are components that convert light into electricity, made by processing silicon wafers, while photovoltaic modules consist of multiple cells combined into a complete power generation unit through packaging technology. The modules generally include components such as glass, EVA film, backplane, and frame. The downstream segment primarily focuses on the

development, construction, and operation of photovoltaic power plants. EPC (Engineering, Procurement, and Construction) companies oversee the entire process, from design to delivery of the completed plant, while ensuring ongoing management and maintenance for the long-term stable operation and return on investment of the photovoltaic system. All links in the industry chain are interconnected, jointly advancing the development of the photovoltaic sector.

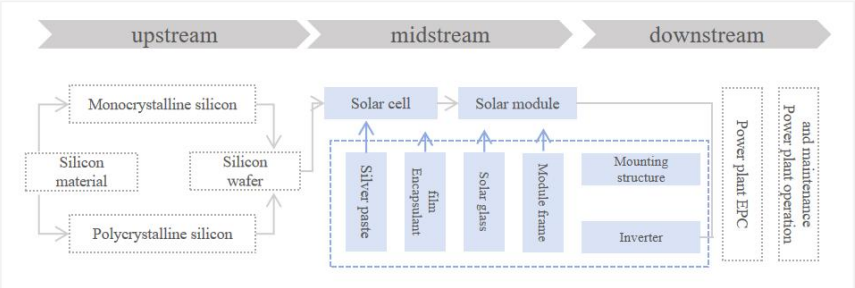


Figure 4.3 Photovoltaic industry chain

Data source: Compiled and visualized by the author based on information from the China Photovoltaic Industry Association and other public sources.

Accurately identifying PV firms is a critical step in assessing the impact of trade policies. However, PV enterprises are not assigned a distinct industry classification code in national standard systems. To address this limitation, this study employs a text-matching approach based on firms' business scope descriptions in the national industrial and commercial registration data. Specifically, we first construct a keyword list reflecting key segments of the PV industry chain, covering core activities across the upstream (e.g., silicon materials, silicon wafers), midstream (e.g., batteries, modules), and downstream (e.g., power plants, EPC, operation and maintenance) sectors. We then match the text of firms' business scope descriptions with this keyword list to determine their engagement in PV-related activities. Firms whose business scope contains at least one PV-related keyword are classified as PV firms; otherwise, they are excluded.

This method offers two key advantages. First, compared to industry classification codes such as ISIC, keyword matching reduces classification errors by capturing firms that are engaged in PV-related activities but are not explicitly categorized under a specific PV industry code. Second, this approach not only identifies PV firms but also precisely locates their position within the industry chain, particularly midstream enterprises. Given that midstream firms are the primary targets of trade policy measures, while upstream and downstream firms are more likely to be affected

indirectly through spillover effects, this classification method enables the construction of a more accurate treatment group for empirical analysis, thereby improving the precision of policy impact assessments.

3.2 China Customs Trade Database

The export data used in this study is sourced from China's General Administration of Customs and comprises monthly trade data at the 8-digit Harmonized System (HS8) code product level. It includes key variables such as enterprise code, product HS code, import source country, export destination country, trade volume, trade value, unit of measurement, and trade mode. To facilitate empirical analysis, we aggregate the data to the firm-year level, constructing key indicators such as annual trade volume and the number of new market entries, which serve as measures of firms' export behavior.

In defining the sample timeframe, this study focuses on 2000–2013, excluding data from 2014 onward. This decision is based on two primary considerations. First, China's PV industry underwent a systemic transformation after 2014. National industrial policy increasingly shifted toward stimulating domestic demand, with policies such as Feed-in Tariff (FIT) subsidies being widely implemented. This transition marked a strategic reorientation from a supply-side-driven model to a demand-side-driven model. Second, in 2017, China's PV industry was subjected to a second round of AD-CVD investigations, leading to renewed trade frictions and a significantly altered policy environment compared to 2011–2013. Given these factors, we limit the sample timeframe to 2013 and earlier to isolate the impact of the 2011–2013 AD-CVD duties and minimize confounding effects from subsequent policy shifts and trade disputes. This approach ensures greater precision in identifying the causal effects of the policy intervention.

4 Identification Strategy and Baseline Results

4.1 Identification Strategy

To accurately assess the impact of the European and American AD-CVD duties on China's PV industry, we employ a DID model for empirical analysis. A key requirement of this approach is the selection of an appropriate control group to ensure comparability with the treatment group (the PV industry). However, industry-specific export trends are influenced by multiple factors, including the industry life cycle,

macroeconomic conditions, policies, and technological advancements, leading to significant heterogeneity. Directly selecting other industries as a control group may violate the parallel trend assumption, thereby compromising the validity of policy effect identification.

To address this issue, we construct a quantitative measure of export trends based on China Customs data. Specifically, we calculate the total annual export value of each three-digit industry from 2000 to 2010 (prior to the policy shock). We then estimate an industry-specific time-trend coefficient (β-value) by regressing the logarithm of export values on annual time trends. This β-value captures each industry's pre-policy export growth trajectory, where a larger β-value indicates a stronger upward trend in exports, a smaller β-value suggests a more moderate growth trajectory, a negative β-value reflects a declining export trend. By quantifying export trends before the policy shock, this method provides an objective basis for selecting a suitable control group.

Once the β-values are obtained, we select industries for the control group using the following criteria: (1) Direction Consistency. Industries with β-values of opposite signs to the PV industry are excluded to ensure that the control industries exhibit a similar export growth direction as the PV industry. (2) Proximity to PV Industry. The absolute difference between each industry's β-value and that of the PV industry is computed. Figure 4.4 presents the distribution of these differences. The industries with the smallest absolute differences are identified as potential control group candidates. The underlying assumption is that, in the absence of the AD-CVD duties, the PV industry's export trajectory would resemble that of the selected control industries. To determine the appropriate threshold for selecting control industries, we initially define a benchmark threshold at the top 25%, meaning that we retain the 25% of industries with the closest β-values to the PV industry. To verify the robustness of the results, we conduct sensitivity analyses by applying a stricter threshold (top 10%) and re-estimating the model to ensure that the findings are not driven by the selection of the control group.

This data-driven control group selection approach ensures that the treatment and control groups exhibit similar pre-policy export trends, thereby enhancing the validity of the DID model. By adopting this methodology, we can more accurately estimate the direct impact of

the AD-CVD duties on China's PV industry exports while minimizing potential

confounding effects. We then apply the DID model to analyze panel data on enterprise exports from 2005 to 2013 to evaluate the effects of the European and U.S. AD-CVD duties on the export performance of Chinese PV firms. The econometric model is specified as follows:

$$Y_{i(m)t}=\beta_0 + \beta_1 \cdot Treat_{i(m)} \cdot after_t + \beta_2 \cdot Treat_{i(m)} + \beta_3 \cdot after_t + \delta_i + \theta_t + \varepsilon_{it}$$

$Y_{i(m)t}$ is the logarithm of the export volume for firm i in industry mm at year t, which is the dependent variable of interest.$Treat_{i(m)}$ is a dummy variable indicating whether firm i belongs to the PV industry (1 if yes, 0 otherwise). $after_t$ is a dummy variable indicating whether the observation occurs in the post-policy period (i.e., 2011 and subsequent years, coded as 1; otherwise, 0). δ_i and θ_t are firm-level and year-level fixed effects, respectively, which control for unobservable heterogeneity at the firm and time levels.

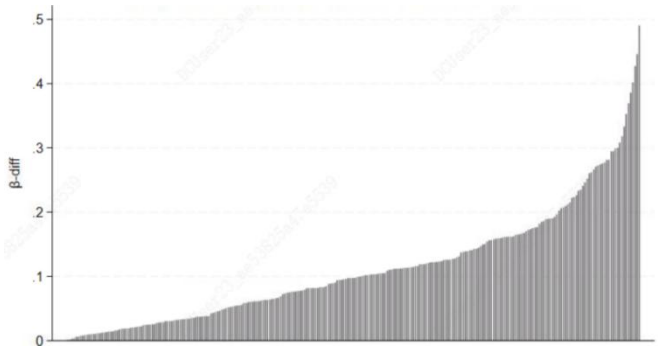


Figure 4.4 Degree of export trend deviation from the PV industry across sectors (absolute value of difference)

Data source: Calculated by the author based on the China Customs Trade Database.

4.2 Descriptive Statistics

The following figure visualizes the export dynamics of the PV industry and the control group of industries. To facilitate comparison, we aggregate export values at the two-digit industry level, with time on the horizontal axis and log export values on the vertical axis. Specifically, we identify seven two-digit industries whose export trends closely align with those of the PV industry and plot the logarithmic total export values for each group over the 2005–2013 period. Figure 4.5 illustrates that prior to 2010, the export growth trends of the PV industry and the control group were largely parallel, indicating that the selected control group is highly comparable to the PV industry in terms of export dynamics. However, after 2010, following the policy shock, the PV industry's export trend exhibited a distinct inflection point, shifting

from a growth trajectory to a decline. Notably, no such trend reversal occurred in any of the control group industries. Overall, these results highlight the divergence between the PV industry and the control group following the policy shock, providing empirical evidence of its impact on the PV sector.

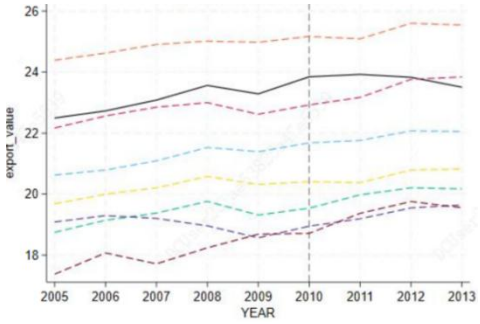


Figure 4.5 Comparison of export value trends between PV firms and control group (2005–2013)

Data source: Compiled by the author based on China Customs Trade Database.

4.3 Baseline Results

Table 4.1 presents the results of the baseline regression. Column 1 follows the standard model specification, where the treatment group consists of midstream firms in the PV industry, which are the primary targets of the AD-CVD duties. The control group comprises the top 25% of industries whose export trends most closely resemble those of the PV industry before the policy shock. The regression results indicate that, after controlling for firm and time fixed effects, the estimated coefficient is -0.236, suggesting that, on average, the export value of midstream PV firms declined by 23.6% relative to the control group, which was not directly affected by the policy.

In Columns 2 and 3, we conduct robustness tests by adjusting the selection criteria for the control group and treatment group, respectively. In Column 2, we refine the control group selection by narrowing the threshold to the top 10%, select the top 10% of industries with export trends most similar to the PV industry before the policy shock. Under this more stringent control group selection, the regression coefficient is -0.187, and it remains significant at the 1% level, confirming that the main findings remain robust. In Column 3, we expand the treatment group to include other non-midstream PV firms. The estimated coefficient is -0.098, which is significant at the 5% level, and its absolute value is smaller than that in Column 1. This result aligns with theoretical expectations, as upstream and downstream PV firms were not the direct targets of the policy and, therefore, should experience a weaker impact. Expanding the treatment group to include these firms dilutes the overall

policy effect, leading to a reduction in the absolute magnitude of the coefficient. Overall, despite adjustments to the selection of the treatment and control groups, the core findings remain consistent. The results provide strong empirical evidence that the European and American AD-CVD duties had a significant negative impact on the export performance of China's PV industry.

Table 4.1 Impact of the policy on firm export value

VARIABLES	ln(export value)		
	(1)	(2)	(3)
treat·after	-0.236***		
	(0.055)		
treat2·after		-0.187***	
		(0.056)	
treat3·after			-0.098**
			(0.043)
constant	12.671***	12.671***	12.674***
	(0.005)	(0.006)	(0.001)
Observations	222,477	98,128	228,136
R2	0.770	0.771	0.770
Firm FE	YES	YES	YES
Year FE	YES	YES	YES

Robust standard errors in parentheses, **p<0.01,**p<0.05,*p<0.1,cluster at city-year level

4.4 Subsample Regression

The impact of industrial clusters on enterprise resilience remains an open question in the literature. Some studies argue that clusters enhance firms' ability to withstand external shocks such as economic downturns and public health crises by facilitating faster recovery, stabilizing production, and sustaining growth. However, others suggest that clusters may amplify the transmission of negative shocks among firms, thereby increasing their overall vulnerability. Development zones, as a form of government-led industrial cluster, concentrate a large number of firms within a specific geographic area, centralizing their production and business activities. To examine whether development zones enhance firm resilience, this study conducts regression analyses based on firm location, comparing the differential responses of firms inside and outside development zones to the AD-CVD trade shock and assessing

the impact of development zones on firm resilience.

Before conducting subsample regression, we first examine the descriptive statistics of export characteristics for PV firms inside and outside development zones to assess the comparability of the two groups. If substantial differences exist in their export performance, the split-sample regression strategy may introduce estimation bias. In particular, large differences in export scale could directly influence firms' resilience to export shocks. For example, larger firms may benefit from economies of scale or have more established long-term contracts that partially absorb market volatility. If such factors drive firms' responses rather than their location within a development zone, the estimated effects may not reflect the true impact of development zones.

To address this concern, we calculate key export-related statistics for firms inside and outside development zones and present them visually (Figure 4.6). In the figure, blue segments represent firms outside development zones, while red segments correspond to firms inside development zones. The vertical axis illustrates the distribution of export characteristics, where the top of the segment represents the 90th percentile, the bottom represents the 10th percentile, and the midpoint denotes the median. The four key dimensions, from left to right, include logarithm of the firm's average export value, average number of product-country combinations exported, average number of export destinations, and average unit price of exported products (plotted on the secondary axis, referenced to the right scale). The results in Figure 4.6 indicate that firms inside and outside development zones exhibit highly similar distributions across all measured dimensions. This pattern suggests that there is no systematic difference in export behavior between the two groups, effectively mitigating concerns regarding sample non-comparability. Consequently, the split-sample regression strategy remains a valid approach for isolating the effect of development zones on firm resilience.

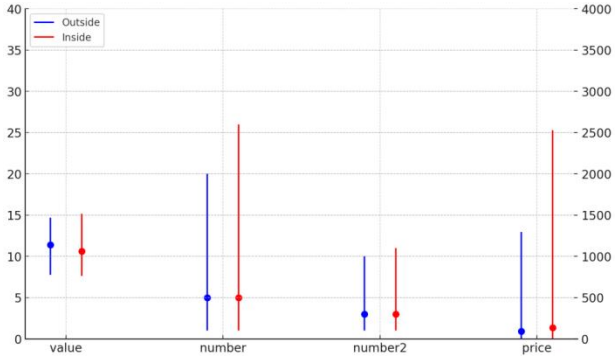


Figure 4.6 Comparison of PV firms inside and outside development zones

Data source: Compiled by the author based on China Customs Trade Database.

Table 4.2 presents the results of the sub-sample regressions. Column 1 examines the impact of the European and American AD-CVD duties on the export value of firms outside development zones. The results indicate that following the policy's implementation, the export value of these firms declined significantly, with a regression coefficient of -0.264, statistically significant at the 1% level. The absolute value of this coefficient is larger than the full-sample regression result, suggesting that the policy had a stronger negative impact on firms outside development zones. Column 2 shifts the focus to firms inside development zones and evaluates the policy's effect on their export performance. The regression coefficient is -0.014 and statistically insignificant, with an absolute value only 1/20th of that for firms outside development zones. This suggests that the export value of firms within development zones was not significantly affected by the policy. In Columns 3 and 4, we further refine the control group by retaining only the top 10% of industries whose export trends most closely match those of the PV industry, and then re-estimate the sub-sample regressions. The results remain consistent, reinforcing the robustness of our findings.

From an export value perspective, the results reveal a significant divergence in the impact of the AD-CVD duties on firms inside and outside development zones. While the policy had a substantial negative effect on firms outside the zones, it did not significantly affect those within the zones. This finding suggests that development zones may have played a role in enhancing firm resilience and mitigating the negative effects of external shocks. However, these results provide only preliminary evidence. Further analysis is required to assess the robustness of this conclusion and to investigate the underlying mechanisms through which development zones may contribute to firm resilience.

Table 4.2 Impact of the policy on firm export value (inside vs outside)

	ln(export value)			
VARIABLES	outside	inside	outside	inside
treat·after	-0.264***	-0.014		
	(0.06)	(0.14)		
treat2·after			-0.203***	-0.086
			(0.06)	(0.14)
constant	12.631***	13.033***	12.622***	13.140***
	(0.01)	(0.01)	(0.01)	(0.02)
Equality Test p-value	0.07		0.07	
Observations	199,845	22,632	88,867	9,261
R2	0.765	0.793	0.765	0.8
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Robust standard errors in parentheses, **p<0.01,**p<0.05,*p<0.1,cluster at city-year level

5 Robustness Tests

5.1 Parallel Trend Test

To ensure the validity of the DID model, we conduct a parallel trend test to verify whether the pre-policy trends of the treatment and control groups are consistent. The regression setup follows the baseline model, except that we replace the interaction term with a set of interaction terms between year indicators and the policy shock status, using the year prior to the policy implementation as the benchmark. The key coefficient of interest, β, captures the dynamic effects of the PV AD-CVD duties on firms' export value.

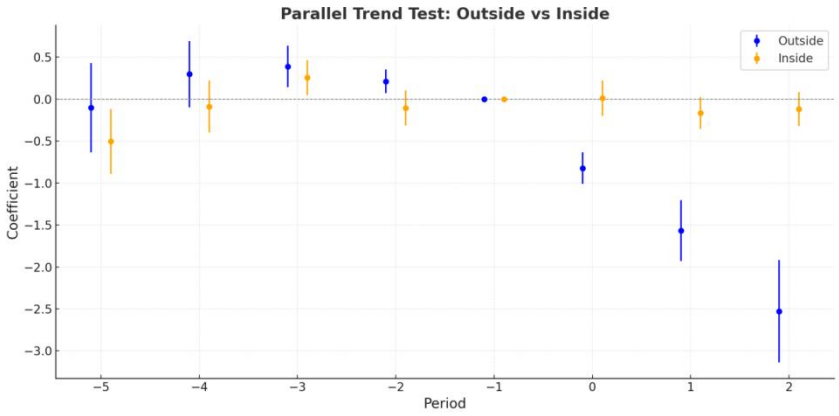


Figure 4.7 Parallel Trend Test

Figure 4.7 illustrates the year-by-year impact of the policy shock on firms' export value. We conduct separate parallel trend tests for firms inside and outside development zones. Blue lines represent the estimated coefficients for firms outside development zones. Yellow lines represent the estimated coefficients for firms inside development zones. As shown in Figure 4.7, during the pre-policy period (-5 to 0), the estimated coefficients for both groups fluctuate around zero, indicating that prior to the implementation of the policy, the export trends of PV firms and the control group were largely parallel, satisfying the parallel trend assumption. However, after the policy shock (post-period 0), the dynamic effects for firms inside and outside development zones begin to diverge significantly, with this difference widening over time. For firms inside the development zone, the interaction term remains statistically insignificant, indicating that these firms were not significantly affected by the policy shock, while for firms outside the development zone, the interaction term turns negative immediately after the policy shock, with the absolute value of the coefficient increasing over time, suggesting a worsening negative impact. This pattern aligns with the progression of the policy shock, from the initial 2011 complaint filing, to the government's arbitration announcement, and eventually to the expansion of the investigation into the European market, reinforcing the finding that the policy's negative effects intensified over time.

The results of the parallel trend test not only confirm the validity of the DID model's key assumption, but also visualize the differential impact of the policy shock on firms inside and outside development zones. These findings further support the conclusion that development zones may enhance firm resilience and help mitigate the adverse effects of external trade shocks.

5.2 Alternative Specifications

In the baseline model, we selecte industries with pre-policy export trends similar to those of the PV industry as the control group. However, systematic differences between industries may still exist, which cannot be fully eliminated by controlling for industry fixed effects, potentially biasing the coefficient estimates of the core explanatory variables. Additionally, even if the export trends of the control industries and the PV industry are aligned before the policy implementation, post-policy technological advancements or demand-side shifts can lead to divergence, further complicating identification.

To enhance robustness and validate the reliability of the results, we refine the econometric model by restricting both the treatment and control groups to firms within the PV industry. Specifically, we define PV midstream firms as the treatment group and non-midstream PV firms as the control group. This design is based on the fact that the 2011 European and American AD-CVD duties primarily targeted midstream enterprises in the Chinese PV industry, particularly cell and module manufacturers. In contrast, upstream raw material suppliers (e.g., silicon and wafer manufacturers) and downstream installation firms (e.g., power plant construction and EPC service providers) were not direct policy targets. We take the PV midstream enterprises as the treatment group, which is labeled as zhong=1, and the non-midstream enterprises as the control group, which is labeled as zhong=0:

$$Y_{it}=\beta_0 + \beta_1 \cdot zhong_i \cdot after_t + \beta_2 \cdot zhong_i + \beta_3 \cdot after_t + \delta_i + \theta_t + \varepsilon_{it}$$

Table 4.3 presents the sub-sample regression results: For firms outside development zones, the interaction term coefficient is -0.271 and statistically significant at the 1% level, suggesting that the policy led to a substantial decline in their export performance. In contrast, for firms within development zones, the interaction term coefficient is 0.039 and statistically insignificant, implying that the policy had no measurable effect on their exports. After adjusting the identification strategy, the core regression results remain consistent, reinforcing the robustness of the baseline findings. These results indicate that the negative impact of the AD-CVD duties was primarily concentrated on firms outside development zones, while firms within the zones remained largely unaffected.

Table 4.3 Impact of the policy on firm export value (midstream vs non-midstream)

	ln(export value)

VARIABLES	outside	inside
zhong*after	-0.271***	0.039
	（0.072）	（0.194）
constant	12.753***	13.055***
	（0.017）	（0.052）
Observations	16,314	1,655
R2	0.783	0.776
Firm FE	YES	YES
Year FE	YES	YES

Robust standard errors in parentheses, **p<0.01,**p<0.05,*p<0.1,cluster at industry-year level

By restricting the sample to firms within the PV industry, this study effectively addresses concerns related to cross-industry comparability. However, a potential issue arises regarding whether using non-midstream PV firms as the control group violates the parallel trends assumption in the DID model, which requires that the control group remains unaffected by the policy. This concern is primarily driven by the possibility of spillover effects from midstream firms to upstream and downstream firms, which could manifest in two distinct ways. The first is a negative homogeneous effect, in which a decline in midstream firms' exports leads to a reduction in orders for upstream raw material suppliers and downstream installation firms, subsequently causing a negative shock to upstream firms. If this effect is significant, it would imply that the control group (non-midstream firms) is also affected by the policy, potentially leading to an underestimation of the policy's true impact. The second is the reverse effect, whereby midstream firms may increase their exports of upstream products by adjusting their supply chain strategies after suffering a trade shock. This argument is largely based on the third-country tax avoidance mechanism, where firms that originally exported PV components directly to Europe and the United States might reroute exports by first shipping raw materials to a third country, assembling components there, and then re-exporting to their final destinations to circumvent the AD-CVD duties. While this strategy is not uncommon in international trade, its feasibility in China's PV industry is highly questionable. In particular, the industry structure analyzed in this study adopts a broad classification, where the midstream sector encompasses the complete manufacturing process of modules and batteries, including equipment components and finished products. Under this framework,

upstream production is highly concentrated in raw materials and manufacturing equipment, both of which are technology-intensive fields. At the time of the policy shock, China's PV industry remained heavily dependent on imports from Europe and the United States for these key inputs. Given this reliance, it is highly unlikely that Chinese firms would engage in large-scale rerouting by exporting imported raw materials and manufacturing equipment to third countries for reassembly before selling them to Western markets.

Thus, in the specific context of China's PV industry, the reverse effect is unlikely to materialize and does not pose a substantive challenge to the study's main conclusions. Accordingly, the choice of non-midstream PV firms as the control group is methodologically sound and does not compromise the identification of policy effects.

5.3 Competitive Hypothesis

A key question is whether the greater resilience of firms in development zones arises from their interaction with the zone itself or merely reflects a screening effect, whereby development zones attract inherently more resilient firms. If the latter holds, the observed heterogeneity would not indicate that development zones enhance firm resilience but rather that firms with greater resilience are simply redistributed across regions.

To examine whether the screening mechanism is the primary driver of the observed effects, we test this competing hypothesis. If firm resilience is predominantly determined by selection into the zone, then firms that would have entered development zones should exhibit greater resilience regardless of their actual location. To assess this, we employ Propensity Score Matching (PSM) to estimate each firm's probability of locating in a development zone and match each firm within a zone to the most similar firm outside the zone. This matching procedure enhances comparability between firms inside and outside development zones and helps mitigate potential bias arising from the "picking winners" effect.

Using the matched sample, we re-estimate the baseline regression, and the results are presented in Table 4.4. The findings remain robust, after the AD-CVD trade shock, the export value of firms outside development zones declines significantly, whereas firms within development zones also experience a decline, but the coefficient is statistically insignificant, indicating that they are less affected by the shock. This

result further reinforces the conclusion that development zones contribute to firm resilience beyond mere selection effects. The underlying mechanisms driving this resilience will be further analyzed in the mechanisms analysis section.

Table 4.4 Impact of the policy on firm export value (after matching)

	ln(export value)			
VARIABLES	outside	inside	outside	inside
treat·after	-0.291**	-0.106		
	(0.135)	(0.151)		
treat2·after			-0.239*	-0.180
			(0.137)	(0.155)
constant	12.911***	13.095***	12.891***	13.198***
	(0.011)	(0.012)	(0.016)	(0.017)
Observations	20,677	21,199	8,888	8,594
R2	0.771	0.791	0.767	0.800
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Robust standard errors in parentheses, **p<0.01,**p<0.05,*p<0.1,cluster at city-year level

6 Mechanisms

The baseline regression results confirm that the EU and US AD-CVD duties have a significant negative impact on corporate exports. However, the sub-sample analysis reveals an important pattern. Firms outside development zones experience a more pronounced negative shock, whereas firms within development zones demonstrate greater resilience to trade disruptions. This observation raises critical questions: Why are firms in development zones better equipped to withstand international trade shocks? Do development zones enhance firm resilience, and if so, through what mechanisms?

Answering these questions is essential for a deeper understanding of corporate export behavior in the context of international trade and for shedding light on how development zones contribute to firm resilience. While existing literature has extensively examined the impact of development zones on local employment, total factor productivity (TFP), and corporate innovation, relatively few studies have

investigated their role in mitigating external shocks and reducing firm-level losses. Given the intensifying trade tensions between China and the United States, as well as the broader macroeconomic forces shaping global value chains, understanding this issue has become increasingly relevant.

This section aims to identify the mechanisms through which development zones enhance firms' ability to navigate international trade disruptions. By examining the sources of resilience among firms within development zones, we seek to clarify the specific role that development zones play in fostering economic stability and shielding firms from adverse external shocks.

6.1 Survey Evidence

Before conducting a formal analysis of the mechanisms through which development zones help firms navigate export market shocks, this section examines entrepreneurs' subjective perceptions of the role development zones play in their export activities. To do so, we utilize survey data from the ESIEC, which collects entrepreneurs' evaluations of the support provided by their respective development zones. The ratings range from 1 (not helpful at all) to 5 (most helpful). We classify firms into exporting and non-exporting categories based on their export activities and compare the distribution of ratings for each group. Figure 4.8 illustrates that exporting firms tend to assign higher ratings to development zones, with a significantly larger share of them falling in the high-score range (4–5). In contrast, non-exporting firms' ratings are more concentrated at 3 and below, indicating a greater proportion of lower evaluations. This result suggests that entrepreneurs engaged in exporting are more likely to perceive development zones as providing substantial support for their business operations compared to their non-exporting counterparts. These subjective assessments offer complementary evidence to the empirical analysis, reinforcing the argument that development zones may play a critical role in facilitating firm exports.

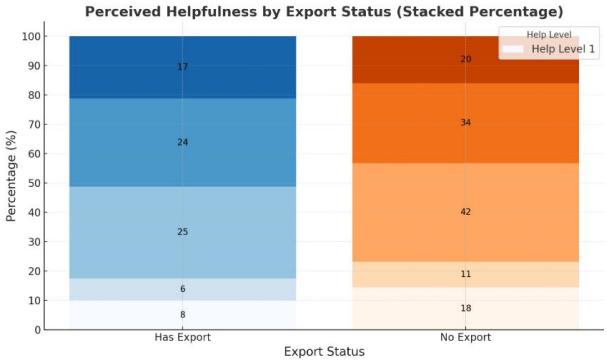


Figure 4.8 Perceived Helpfulness by Export Status

Data source: Compiled by the author based on ESIEC Data.

6.2 Direct Mechanism

Diversification is a key adjustment mechanism that enables firms to mitigate the impact of external shocks and market volatility. Product diversification not only facilitates economies of scale but also helps firms distribute demand risk more effectively, reducing uncertainty in the market (Chang and Wang, 2007). In response to global value chain disruptions, firms adopt multi-supplier strategies to reduce dependence on any single country, thereby lowering operational risks associated with supply chain vulnerabilities (Golgeci et al., 2023). Moreover, export market diversification broadens firms' international presence, accelerates the accumulation of market experience, and enhances their ability to adapt to external changes (Thomas, 2006). In the mechanism analysis section, we first investigate whether firms respond to the AD-CVD sanctions by adopting market diversification strategies to mitigate export shocks, providing further insights into their adjustment mechanisms in the face of external disruptions.

We begin by defining the number of new export markets firms enter each year. A "new market" is defined at the product-country level. For example, if a firm exports a product p to a new country c for the first time in year t, we count this "product-country combination" as one new market; otherwise, it is recorded as zero. Specifically, if a firm introduces a product that has been sold in other countries to a new export destination, it is considered a new market. Similarly, if a firm launches a new product in an existing export market, this is also classified as a new market. Based on this definition, we summarize the number of new markets at the firm-year level, denoted as N_{it}.

if firm i exports product p to country c for the first time in year t, otherwise.

$$I_{i,t}(p,c) = \begin{cases} 1, & if\ firm\ i\ exports\ product\ p\ to\ country\ c \\ 0, & otherwise \end{cases}$$

$$N_{it} = \sum_{p \in P_i} \sum_{c \in C_i} I_{i,t}(p,c)$$

To assess the impact of development zones on market diversification, we replace the dependent variable with the logarithm of the number of new export markets added by each firm annually and apply the benchmark regression model. Figure 4.9 presents the regression coefficient of the interaction term along with its 95% confidence interval. The results reveal significant differences in firms' market diversification strategies inside and outside development zones in response to the AD-CVD duties. Specifically, the first column shows that the interaction term coefficient for firms outside development zones is -0.018 and statistically insignificant, indicating that these firms did not significantly expand into new export markets following the policy shock. This result suggests that firms outside development zones did not adopt market diversification strategies to mitigate the negative effects of the policy. In contrast, the second column shows that the coefficient for firms within development zones is 0.139, which is statistically significant at the 5% level. This pattern suggests that firms in development zones actively expanded into new export markets, using market diversification as a risk mitigation strategy. To ensure the robustness of these findings, we restrict the control group to the top 10% of industries whose export trends most closely align with those of the photovoltaic industry and repeat the regression analysis. The results remain consistent, confirming that even under a more stringent comparison, firms within development zones demonstrate a greater capacity for market diversification. This finding further reinforces the reliability of our conclusions.

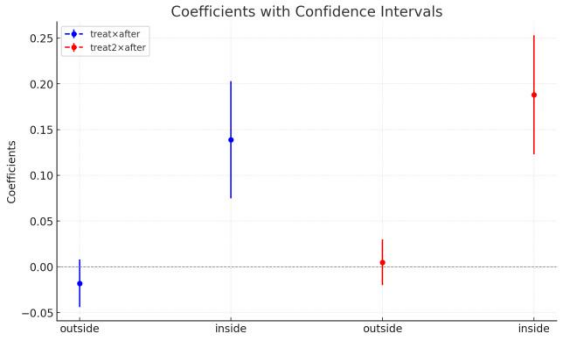


Figure 4.9 Differences in enterprise market exploration inside and outside development zones

6.3 Intrinsic Mechanism

In the preceding analysis, we observed that following the AD-CVD shock, firms within development zones responded by expanding the number of their export destinations, suggesting that market diversification serves as a key mechanism for mitigating external shocks. While our results indicate that firms in development zones alleviated the risk of export decline by entering new markets, the underlying drivers of this response warrant further investigation. Specifically, why were firms within the zones able to diversify more rapidly? What factors facilitated the effective implementation of this strategy? And why did firms outside the zones fail to adopt a similar approach? To address these questions, we further examine the role of development zones in firms' diversification strategies and the underlying mechanisms at play.

(1) Theoretical Hypothesis

Drawing on theoretical insights from the literature on industrial clusters and international trade, we identify two potential mechanisms through which development zones influence firms' export behaviors.

Mechanism 1: Industrial Base Channel. When firms' operations align closely with the industrial base of the development zone in which they are located, they are more likely to benefit from the advantages of industrial clustering. As Marshall (1890) highlighted, geographical concentration of firms employing workers with similar skills fosters positive externalities in labor markets, input markets, and information flows. For firms within development zones, these externalities manifest as improved access to specialized labor, lower search costs for inputs, and knowledge spillovers. These factors enhance firm productivity through multiple channels and strengthen supply chain integration. In export markets, high-productivity firms are more likely to enter a larger number of target markets (Melitz, 2003) and exhibit greater resilience to trade shocks (Bloom et al., 2016). Moreover, enhanced supply chain integration plays a crucial role in facilitating firms' rapid entry into new export markets (Gereffi and Lee, 2012). Based on this, we expect that firms will be more likely to adopt market diversification strategies to mitigate the adverse effects of policy shocks when their operations align more closely with the industrial base of the development zone in which they are located.

Mechanism 2: Export Information Channel. Information costs constitute a significant component of cross-border transaction costs (Helpman et al., 2008).

Compared to domestic markets, cross-border transactions are subject to greater information frictions due to differences in legal systems, property rights enforcement, regulatory environments, and languages (Anderson and Wincoop, 2004). Mechanisms that mitigate information asymmetry, such as migrant networks, have been shown to significantly enhance bilateral trade (Rauch and Trindade, 2002). The accessibility of market information directly affects firms' export performance. Firms with better access to market intelligence not only sustain longer export survival but also achieve a stronger competitive position in international markets. The geographic proximity within industrial clusters facilitates informal communication and collaboration among firms, thereby creating an environment conducive to information exchange, including knowledge about export markets (Audretsch and Feldman, 2004; Duranton and Puga, 2004). If firms within development zones can leverage access to effective information on foreign market opportunities, they are likely to experience lower information costs when entering new export destinations, thereby increasing the likelihood of successful export expansion (Reyes et al.,2014). Based on this, we expect that firms will be more inclined to pursue market diversification if development zones provide more effective export-related information and help reduce information costs.

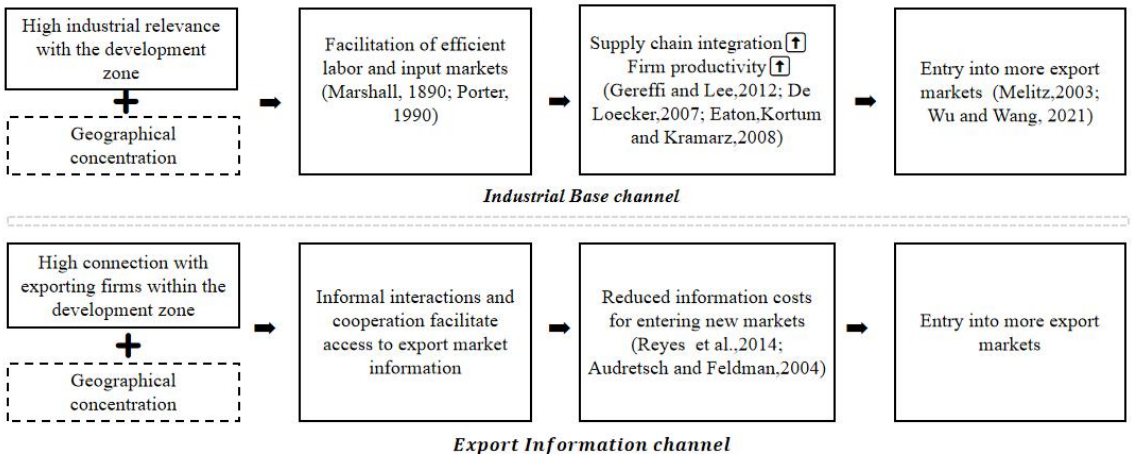


Figure 4.10 Mechanism analysis flowchart

(2) Index Construction

We estimate the linkage between firms and their respective development zones along two dimensions, industrial base relevance and export information relevance. As outlined in the theoretical framework, this linkage primarily manifests through the exchange and transmission of inputs, labor, and information. If a development zone hosts a large number of industries closely related to a given firm, facilitating spillover effects through channels such as labor supply and access to intermediate goods, the firm is more likely to benefit from industrial agglomeration effects.

To quantify this association, we construct an indicator that captures two key aspects: (1) the industrial characteristics of the development zone and (2) the degree of association between the firm's industry and other industries in the zone. Our approach is inspired by Hidalgo et al. (2007), which argues that the spatial distribution of products is non-uniform and proposes an ex-post, non-parametric method to measure inter-product correlations. This methodology effectively captures multi-channel similarities in labor, inputs, and knowledge, making it suitable for our context.

First, we estimate industrial proximity, initially introduced by Hidalgo et al. (2007) in the context of global trade to measure product proximity. However, this approach has limitations in capturing linkages among non-traded industries, particularly within development zones where industries such as productive services play a crucial role. To address this, we adopt the improved methodology of Ruan and Zhang (2015), which measures proximity based on industry-level comparative advantages at the county level. The core assumption underlying this approach is that two industries are more likely to exhibit comparative advantages within the same region if they share similar dependencies on institutions, capital, infrastructure, and technology in the production process. Based on this, we employ a coexistence-based similarity measure, referred to as proximity.

To operationalize this measure, we first utilize national industrial and commercial enterprise registration data to compute the Location Quotient (LQ) for each county-industry pair, denoted as LQ_n, which reflects the comparative advantage of industry n in a given county. If LQ_n >1, the industry is considered to have a comparative advantage within that county. Building on this, we calculate industrial proximity by estimating the conditional probability that industry m has a comparative advantage given that industry n also has a comparative advantage, and vice versa. We define industrial $proximity_{mn}$ as the minimum of these two probabilities, ensuring a robust and symmetric measure of industry relatedness. To validate our results, we compute Location Quotients using both firm counts and total registered capital, employing different data sources to mitigate potential biases stemming from specific calculation methods or data choices. This approach effectively captures regional-level industrial comparative advantages, allowing us to assess the extent to which different industries tend to co-exist within the same region. If multiple counties consistently exhibit comparative advantages for a given industry pair, it suggests a high degree of

similarity in terms of production technology, labor demand, resource endowment, and reliance on public goods, indicating strong industry linkages.

Building on the estimated industry proximity, we further construct a measure of firm-development zone linkage, which assesses the degree of alignment between a firm's industry and the development zone's industrial structure or export-oriented sectors. This linkage reflects the potential support capacity of the development zone for the firm. Specifically, our indicator quantifies the average correlation between the firm's industry m and the existing industrial structure of development zone j. The calculation relies on industry proximity $proximity_{mn}$ and an industry weight $share_{nj}$, which measures the importance of industry n in the industrial structure of development zone j. To distinguish between the industrial base channel and the export information channel, we adjust the calculation method for $share_{nj}$. For the industrial base channel, $share_{nj}$ is defined as the share of industry n in the total industrial size of development zone j, measured using firm count or total registered capital. For the export information channel, $share_{nj}$ represents the share of firms in industry n that engaged in export activities within development zone j in a given year.

Compared to the industrial base channel, this metric introduces an additional export activity condition, since an industry, even if it is dominant within the zone, cannot provide export-related informational support to firms unless it actively participates in export activities. In summary, this indicator captures the degree of overlap between a firm's industry and the development zone's industrial base or export-oriented sectors. A higher value suggests that the firm is more likely to leverage local talent pools, supply chain resources, and market information, thereby enhancing productivity or reducing information costs. By constructing this measure, we provide a systematic approach to quantifying firm-development zone linkages, effectively portraying the extent of industrial and export market integration and objectively assessing the potential support that development zones offer firms across different dimensions.

$$Density_{ij(m)} = \frac{\sum_{n \neq m} Proximity_{mn} \times Share_{nj}}{\sum_{n \neq m} Proximity_{mn}}$$

(3) Regression Results

Building on the methodology used to construct the above indicators, we measure the degree of association between each firm and its development zone in two dimensions, industrial base relevance and export information relevance. We then classify firms into five groups based on their degree of association with the

development zone and conduct regression analyses within each group. The regression coefficients for the interaction terms are presented in figure 4.11.

The left panel illustrates the regression results for industrial base relevance and firms' market diversification strategies. The horizontal axis represents the degree of industrial base relevance to the development zone (density1), increasing from left to right, while the vertical axis shows the estimated coefficients of the interaction terms within each group. The figure reveals a clear positive correlation, indicating that as firms' industrial base relevance increases, they are more likely to explore new markets in response to policy shocks. This finding provides direct empirical evidence supporting the role of the industrial base channel in strengthening firms' resilience to external shocks.

The right panel presents the regression results for export information relevance and firms' market diversification strategies. The axes have the same meaning as in the left panel, with the horizontal axis representing export information relevance (density2), increasing from left to right. However, unlike the industrial base relevance, no significant correlation is observed between export information relevance and the estimated coefficients of the interaction terms. This pattern suggests that a stronger export information connection within development zones does not necessarily enhance firms' ability to enter new markets.

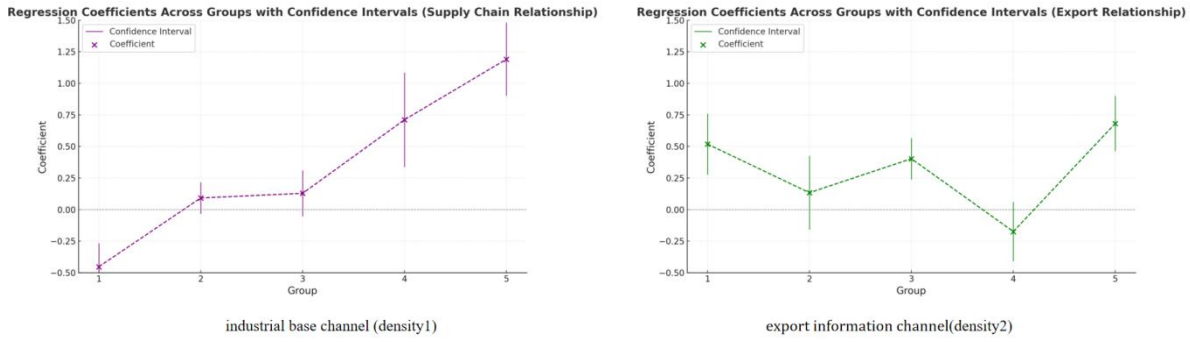


Figure 4.11 Regression coefficients by group at different density levels

Given that the direct interpretation of the triple interaction term may not be intuitive, our primary analysis relies on split-sample regressions. However, to ensure robustness, we also employ a triple difference (DDD) model, which incorporates the density dimension into the baseline specification to construct a three-way interaction term. The baseline regression equation is presented below. The key coefficient of interest is the interaction term β_1. A positive and significant β_1 indicates that stronger firm-development zone linkages enhance firms' resilience to shocks, while an insignificant or negative β_1 suggests that such linkages do not translate into greater

resilience.

$$Y_{it}=\beta_0+\beta_1\cdot density_{i(m)j}\cdot Treat_i\cdot after_t+\beta_2\cdot Treat_i\cdot after_{t_i}+\beta_3\cdot density_{i(m)j}\cdot after_t+\beta_4\cdot density_{i(m)j}\cdot Treat_i+\beta_5\cdot density_{i(m)j}+\beta_6\cdot after_t+\beta_7\cdot Treat_i+\delta_i+\theta_t+\varepsilon_{it}$$

The regression results are summarized in Table 4.5. Column (1) examines industrial base relevance, showing a significantly positive coefficient for the triple interaction term 0.944. This result implies that firms with stronger industrial base linkages are more likely to respond to uncertainty by expanding into new markets following a shock. Column (2) replaces industrial base relevance with export information relevance, revealing a negative coefficient -0.195 for the triple interaction term. This result suggests that stronger export information linkages between firms and development zones do not significantly enhance firms' resilience to shocks. These findings further confirm that industrial base compatibility is the primary mechanism driving firm resilience, whereas the export information channel does not play a decisive role.

In conclusion, both split-sample regressions and interaction term regressions provide empirical support for our theoretical hypothesis. The results clarify the mechanism through which development zones influence firm resilience and help identify the dominant channel. At least within the context of this study, the supply-side industrial base channel emerges as the primary driver of firm resilience, while the demand-side export information channel plays a more limited role.

Table 4.5 Mechanism analysis – DDD regresison

VARIABLES	**ln(number of new markets)**	
	(1)	(2)
$density1$·treat·after	0.944**	
	(0.368)	
$density2$·treat·after		-0.195*
		(0.116)
treat·after	-2.039***	0.975**
	(0.775)	(0.496)
$density$·after	0.110	-0.079***
	(0.072)	(0.024)
constant	4.598***	2.883***

	(0.072)	(0.053)
Observations	246,735	163,147
R2	0.935	0.812
Firm FE	YES	YES
Year FE	YES	YES

Robust standard errors in parentheses, **p<0.01,**p<0.05,*p<0.1.

7 Summary

In the current global trade landscape, escalating U.S.-China trade tensions and frequent international trade disputes have intensified the complexity and severity of external shocks faced by firms. As a result, enhancing firms' resilience to adverse shocks has become a pressing policy and academic concern. This study examines the role of development zones in strengthening firm resilience, using the 2011 AD-CVD duties imposed by the U.S. and the EU on China's PV industry as a natural experiment. Employing a DID model, this study analyzes export dynamics of PV firms under trade shocks and compares the differential responses of firms inside and outside development zones. The findings indicate that the AD-CVD duties significantly suppressed exports for firms outside development zones, while firms within development zones maintained relatively stable exports, suggesting that development zones serve as a buffer against trade shocks.

The mechanism analysis reveals that firms within development zones are more inclined to hedge adverse effects by expanding into emerging export markets. Drawing on cluster theory and international trade theory, this study hypothesizes two primary channels through which development zones facilitate firms' market expansion: (1) the industrial base channel and (2) the export information channel. The results demonstrate that the industrial base channel plays a dominant role. Specifically, firms with a higher degree of alignment with the industrial structure of their development zones are better positioned to leverage industrial support for market expansion, thereby mitigating the negative effects of external shocks. In contrast, the export information channel does not emerge as a primary mechanism in this study's context.

The findings of this paper not only contribute to the literature on industrial clusters and firm resilience but also have important policy implications. Given the intensification of global trade frictions, this study offers valuable insights for both policymakers and firms on strategies to enhance economic resilience, emphasizing the

critical role of industrial clusters in navigating economic uncertainty.