9 GREEN FINANCE, INNOVATION, AND FINANCIAL MARKETS: SHAPING INDUSTRIAL RESILIENCE IN CHINA AND EUROPE

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Abstract

This study examines the impact of green finance (GF), industrial innovation (II), and financial market dynamics (FMD) on industrial resilience (IR) in China and selected European industrialized nations. Panel data from 2003 to 2022 is utilized for empirical analysis. The study used FMOLS regression techniques to control for unobserved heterogeneity across countries. Similarly, GMM estimation is employed to address endogeneity concerns and validate the outcomes. This study proposes three empirical models for achieving its objectives. The models include a baseline model evaluating direct impacts, an interaction model investigating moderating connections, and a region-specific model comparing China with Europe. Findings reveal that GF, II, and FMD significantly enhance IR. Interaction effects indicate that the combined impact of GF and II, GF and FMD, and II and FMD also positively influence IR in the selected panel. Further examination of the regional comparisons reveals that while FMD is more substantial in Europe, China achieves more from GF and II. These results confirm the hypotheses of the study and highlight the importance of financial structures and policy frameworks in shaping industrial resilience. The study further recommends stronger financial market integration with sustainability initiatives in China and increased support for innovation in Europe.

Keywords: *Industrial Resilience; Green Finance; Industrial Innovation; Financial Market Dynamics; Regional Comparison*

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1. Introduction

Industrial resilience (IR) has become a crucial factor for attaining the sustainability of economies (Dacre et al., 2024). IR refers to the capacity of industries to bear economic shocks, adapt to

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changing market conditions, and maintain consistent growth (Grabner & Modica, 2022). The recent global disruptions like financial crises, supply chain disruptions, and environmental challenges have emphasized the need for industrial systems that can effectively recover from setbacks (Kareem et al., 2025). As the world transitions toward sustainability, green finance (GF), industrial innovation (II), and financial market dynamics (FMD) have emerged as significant factors influencing IR (Khan et al., 2025; Xiaohong et al., 2024). Understanding how these factors interact to shape the IR is essential for policymakers, investors, and business leaders to build robust and adaptive economic structures.

Moreover, IR is considered the primary determinant of economic performance on both national and regional levels. Globally, resilient industries drive employment, innovation, and economic diversification and help in reducing vulnerability to economic recessions. IR is significant for China as the country undergoes a structural shift from traditional manufacturing to a more innovative and sustainable industrial framework (Liu et al., 2024a; Duan et al., 2024), whereas, in Europe, IR is essential for maintaining competitiveness in global market fluctuations, energy transitions and evolving regulatory landscapes (Khurshid et al., 2025; Yunze et al., 2024). Therefore, focusing on IR in China and Europe is crucial to mitigate risks and sustain long-term economic growth in an increasingly uncertain global environment.

The GF, II, and FMD are interconnected and are required simultaneously to enhance IR. The GF ensures investments in environmentally sustainable projects and policies that aim to promote IR via sustainable production processes and reduce environmental risks (Liu et al., 2024b). Whereas II drives resilience by empowering firms to adapt to technological changes and market shifts through R&D (Ma et al., 2023). Moreover, FMD, which includes market stability, liquidity, and accessibility, is also needed to achieve IR. The FMD also moderates the relationship between GF and II with IR by determining the availability of capital for green investments and technological advancements (Khan et al., 2023). So, inspecting how these elements interact is needed to craft policies that promote sustainable and resilient industries in Europe and China.

Furthermore, a comparative study of China and Europe with respect to industrial reliance is needed. China is the world's largest manufacturing hub and is focusing on industrial upgrading and green transformation, supported by strong government policies (Guo et al., 2025). In contrast, Europe has well-developed financial markets and stringent environmental regulations that offer a different model of IR driven by innovation and policy incentives (Chen et al., 2024). Investigating the similarities and differences in these regions is required to understand how varying economic and institutional contexts shape IR and the effectiveness of GF and innovation in this regard.

This study is important for policymakers and industry leaders in China and Europe. It is intended to offer actionable recommendations for enhancing economic stability by identifying the mechanisms through which GF, II, and FMD influence IR. The study aims to address these objectives:

- *To examine the role of GF in enhancing industrial resilience.*
- *To assess the impact of industrial innovation on strengthening industrial resilience.*
- *To analyze how FMD moderates the relationship between green finance, industrial innovation, and industrial resilience.*
- *To compare China and Europe to identify regional differences and policy implications regarding the subject matter.*

This study makes a novel contribution by integrating GF, II, and FMD into a unified framework for understanding IR in Europe and China. The previous studies on the stated theme focus on isolated aspects of IR. However, this work provides a comprehensive analysis that considers the effects of interaction and regional comparisons. Moreover, this study shed light on the role of market efficiency and stability in shaping the effectiveness of GF and II by introducing FMD. Another key contribution of this research is its comparative approach. That distinguishes the IR dynamics in China and Europe. This study is intended to explore the efficacy of various economic models in enhancing IR by analyzing China, which has state-driven financial and industrial policies, alongside Europe, which has a more market-oriented framework. Additionally, this study employs advanced econometric techniques, including panel data regression with FE and RE methodology. The GMM estimation is also employed to address potential endogeneity issues and ensure the robustness of the outcomes. Furthermore, the research applies a series of robustness checks, including alternative model specifications and different time lags. This is important to validate the consistency of the results. Moreover, the study estimates three models, including a baseline model assessing the direct effects, an interaction model exploring moderating relationships, and a regional-specific model comparing China and Europe with respect to IR. From a policy perspective, current work offers practical implications for governments, financial institutions, and industrial leaders of Europe and China. It provides evidence-based recommendations on how FMD can be structured to optimize GF and II impact on IR in China and Europe.

The rest of the study is planned as follows: Section 2 reviews the relevant literature and proposes hypotheses. Section 3 has data details and econometric methodology. Then, Section 4 presents the outcomes with a discussion, while Section 6 discusses policy implications and the conclusion.

2. Literature review

2.1. Theoretical Foundations of Industrial Resilience

Industrial resilience refers to an industry's ability to absorb, adapt to, and recover from economic shocks (Brown & Greenbaum, 2017). The Schumpeterian Innovation Theory suggests that continuous technological advancements drive industrial stability (Schumpeter, 1934). This is also regarded as the need of a rapidly changing world with growing competition. Moreover, Financial Economics accentuates the role of financial markets in mitigating risks and fostering resilience (Merton & Bodie, 1995). This is also true for the industrial sector.

The inclusion of GF in the current scenario is grounded in the Sustainable Finance Theory. The theory posits that investments in environmentally sustainable projects contribute to long-term economic stability (Schoenmaker & Schramade, 2019). Similarly, sustainable development requires environmentally friendly economic growth. Furthermore, The Efficient Market Hypothesis (EMH), given by Eugene Fama (1970), argues that well-functioning financial markets enhance the ability of the firm to withstand external shocks. So, it can also be said that the robust FMD is vital for sustainability and reliability.

Consequently, it is expected that both GF and II play crucial roles in strengthening IR. So, the following hypothesis is formulated:

H1: *Green finance and industrial innovation jointly enhance industrial resilience by promoting sustainable investment and adaptive capacity.*

2.2. Green Finance and Industrial Resilience

Green finance (GF) and IR are closely related. GF ensures sustainability and the required growth that the resilient industrial network can attain. The GF comprises green bonds, sustainable loans, and ESG-driven investments. The GF has become a key mechanism for enhancing industrial stability across the globe (Chen et al., 2023). Empirical studies also indicate that economies with well-developed GF frameworks experience lower volatility and quicker recovery from crises (Xu *et al.,* 2022). So, it can make firms sustainable.

In this regard, Veugelers *et al*. (2023) found that GF significantly improves IR in Europe due to strong regulatory backing and financial market maturity. Further, Yunze *et al.* (2024) inspected the association between GF, II, and policy instruments in influencing financial development and the attainment of SDGs in the European Union. The findings revealed a strong positive correlation between GF and financial growth. In contrast, Wang and Shao (2024) highlighted that in China, while GF is expanding, its effectiveness is often constrained by regulatory inconsistencies and capital misallocation. As the financial markets mediate the impact of GF, ensuring efficient capital flow is crucial for maximizing its benefits. Thus, the second hypothesis is proposed as:

H2: *The influence of GF on IR is stronger in economies with well-developed financial markets and mechanisms.*

2.3. Industrial Innovation and Financial Market Dynamics

Industrial innovation (II) includes technological advancements, R&D, and digital transformation in industrial setups. The II is linked with the resilience and sustainability of industrial networks (Liu *et al.,* 2024b). The Endogenous Growth Theory (Romer, 1990) suggests that innovation fosters productivity and economic stability. Empirical evidence supports this claim, as Duan et al. (2024) found that industries with strong technological capabilities exhibited higher adaptability to supply chain disruptions. Furthermore, Cheng et al. (2024) analyzed industrial development by examining the interaction between II and green development to provide a theoretical reference for strategic planning. The NSBM model was used to assess the efficiency of multi-stage II. In contrast, the GML model evaluated green TFP to determine the high-tech industry's green and high-quality development status. The results from the regression model show that enhancing the II value chain fosters the advancement of green transformation and the resilience of the industrial sector.

However, innovation alone is insufficient without strong financial market support (Hirsch-Kreinsen, 2011). The Financial market dynamics include liquidity, transparency, and investment efficiency that influence the ability of a firm to leverage innovation for resilience (Khan *et al.,* 2025). Studies reveal that European markets provide a more supportive environment for innovation-driven resilience (Khan *et al.,* 2024). In contrast, China’s state-led financial system sometimes limits the allocation of capital to innovation sectors (Wang *et al.,* 2024). Given the interconnectedness of II and FMD, the following hypothesis is proposed:

H3: *Financial market efficiency strengthens the relationship between industrial innovation and resilience by ensuring optimal capital allocation.*

2.4. Interaction Effects: Green Finance, Innovation, and Financial Markets

Previous research has examined GF, II, and financial markets separately; however, current studies indicate that their interaction effects may enhance industrial resilience. Yunze et al. (2024) found that when GF is coupled with high innovation levels, industries optimize. Similarly, Wu and Tham (2023) demonstrated that financial market efficiency moderates the effectiveness of both GF and II, leading to stronger resilience outcomes in developed markets.

The interaction between these factors is particularly region-specific. In Europe, where financial markets are highly developed, the combined impact of GF and innovation is likely to be more significant. However, in China, where capital markets are still evolving, regulatory and market inefficiencies may reduce the effectiveness of these interactions. The subsequent hypothesis is designed to capture this interaction effect.

H4: *The interaction between green finance, industrial innovation, and financial market efficiency significantly enhances industrial resilience, with stronger effects in Europe than in China.*

2.5. Research Gap and Contribution of the Study

Despite growing interest in IR, existing research primarily examines GFN, II, and FMD in isolation and doesn’t explore their combined effects. The studies have established that GF promotes economic stability and that II enhances adaptive capacity. However, limited research investigates how FMD moderates these relationships. Furthermore, comparative studies on the regional variations in these mechanisms for China and Europe remain scarce. This endeavor contributes to the literature by examining the joint effects of GF and II on IR while incorporating FMD as a key factor. By conducting a comparative analysis between China and Europe, the study provides empirical insights into how differences in FMD shape the effectiveness of GF and innovation in enhancing resilience. Moreover, it employs advanced econometric techniques, such as dynamic panel regression (FE and RE) and GMM estimation, to capture time-dependent effects and enhance the robustness of the findings.

3. Data and Methodology

3.1.Data Details

This study utilizes panel data covering China and selected industrialized European countries, namely, Germany, France, Italy, Netherlands, Poland, and Spain, from 2003 to 2022. The selected economies account for 72% of the EU's total industrial output (Source: Eurostat, DS_056120). The remaining member states all made smaller contributions, with each one falling below 4%. The dataset includes variables related to IR, GF, II, and FMD, as well as control variables such as GDP growth, energy intensity (EI), and government policies (GP). The data is sourced from OECD sources and the IMF data bank. Table 1 provides detailed descriptions of all variables, including their sources and measurement criteria.

Table 1: Variables Detail

Variable	Abbrv.	Detail	Source
Industrial Resilience	**IR**	Assesses the economic contribution of industry. Higher values indicate stable, larger industries. Manufacturing Value Added (% of GDP)	World Bank
Financial Market Dynamics	**FMD**	This refers to the breadth, accessibility, effectiveness, and stability of financial markets, all of which have an impact on industrial innovation, green finance investment, and industrial resilience. (Index)	IMF
Industrial Innovation	**II**	It represents innovative technologies related to the production and processing of goods	OECD
Government Policies	**GP**	Captures fluctuations in government decision-making (Index)	IMF
Energy Intensity	**EI**	Total primary energy supply divided by GDP.	World Bank
Green Finance	**GF**	The sum of green taxes and investment in green projects	IMF
GDP Growth	**GDP**	The total output of any economy	World Bank
Interaction Term	**GF x II**	If positive and significant, it implies that industrial innovation and green financing support one another in promoting resilience, assuming it is significant.	
	GF x FMD	If positive and significant, this indicates that deep, reliable, and liquid financial markets optimize the effectiveness of green finance.	

Variable	Abbrv.	Detail	Source
	II x FMD	If positive and significant, this implies that well-developed financial markets are more susceptible to innovation.	

Note: The interaction assumptions are based on existing literature related to GF, II, and FMD. However, theoretically, they can have a positive, negative, or neutral impact.

3.2. Empirical Modeling

The theoretical base of this work is based on the Resource-Based View (RBV) and Endogenous Growth Theory. The RBV suggests that firms with valuable, inimitable, and non-substitutable resources, such as financial and innovative capabilities, can achieve a sustainable competitive advantage and enhance their resilience (Barney, 1991). Meanwhile, Endogenous Growth posits that financial development and innovation drive long-term economic growth by enhancing productivity and sustainability (Romer, 1990). Moreover, IR is considered to be influenced by financial market conditions, investment in innovation, and sustainable financial mechanisms.

The GF also helps in promoting IR by channeling investments into sustainable infrastructure and reducing financial risks related to environmental policies (Xiaohong *et al*., 2024). Similarly, II nurtures adaptive capabilities and makes industries more competitive and resistant to economic downturns (Schumpeter, 2013). Furthermore, FMD ensures liquidity and efficient capital allocation to productive sectors (Levine, 2005). So, all these factors are considered to enhance IR through various mechanisms. Based on this, the empirical models of the current study are formulated. Initially, the baseline empirical model can be stated as:

$$IR_{it} = \alpha + \beta_1 GF_{it} + \beta_2 II_{it} + \beta_3 FMD_{it} + \beta_4 X_{it} + \varepsilon_{it} \quad (1)$$

In equation (1) X_{it} shows the control variables (GDP, EI, GP), and ϵ_{it} is an error term. Other variables are as per Table 1.

To examine the interaction effects between GF, II, and FMD, the following empirical model is specified:

$$IR_{it} = \alpha + \beta_1 GF_{it} + \beta_2 II_{it} + \beta_3 FMD_{it} + \beta_4 (GFxII)_{it} + \beta_5 (GFxFMD)_{it} + \beta_6 (IIxFMD)_{it} + \beta_7 X_{it} + \varepsilon_{it} \quad (2)$$

To examine regional differences, a dummy variable is introduced, D_ (Europe), in which 1 is for Europe and 0 is for China. The regional differences empirical model can be stated as follows:

$$IR_{it} = \alpha + \beta_1 GF_{it} + \beta_2 II_{it} + \beta_3 FMD_{it} + \beta_4 (DEurope)_{it} + \beta_5 (DEurope \times GF)_{it} + \beta_6 (DEurope \times II)_{it} + \beta_7 (DEurope \times FMD)_{it} + \varepsilon_{it} \quad (3)$$

This model helps determine whether the influence of financial and innovation factors on IR differs between the two regions due to variations in FMD and policy frameworks.

3.3. Empirical Strategy

The current study employs several suitable statistical tests to obtain reliable results. Initially, descriptive statistics are calculated as a foundation for understanding distributions and variability of the variables. The study panel comprises seven countries, spanning 20 year's period. Further, Cross-sectional dependency between the panel units will be determined using the Lagrange Multiplier (LM) test. This is a typical occurrence in macro-panel data where nations or industries have a close economic relationship. Moreover, the study uses Pesaran (2015) to check cross-sectional dependence (CSD). The CSD estimation is crucial because it allows us to detect which variables in the dataset are driven by the shocks common to the whole group or region, affecting more than one cross-sectional unit at a time. After the CSD test, the stationarity of the data is checked. The CIPS test is used for this purpose. This test is appropriate for panels with CSD as it first tests for the presence of unit roots that allow for interdependencies between countries (Im & Pesaran, 2003; Pesaran, 2007).

The study used panel co-integration tests utilizing the Westerlund error-correction framework (ECM) since the variables are non-stationary. The ECM co-integration approach will examine the long-run correlation connection among the variables. Moreover, the long-run cointegrated estimation is more susceptible to FMOLS due to the data structure. The FMOLS addresses serial correlation and the endogeneity of regressors. It is suitable for non-stationary panels with a modest number of entities (N) and a long time dimension (T), such as N=7 and T=20 in this case. The GMM technique is used to assess the robustness of the main findings. The importance and explanatory capacity of these model enhance confidence in the validity of the findings. At the same time, FMOLS further supports this by predicting long-term equilibrium correlations in the presence of non-stationarity.

Additionally, diagnostic tests are employed in this work. This includes the variance inflation factor (VIF), which checks the multicollinearity issue among the independent variables (Marquardt, 1970). If the VIF value is found to be more than 4, it means a multicollinearity problem exists in the data (Kang *et al.,* 2016). Also, the Autocorrelation Test (Durbin-Watson, 1950) is employed. Autocorrelation in panel data can bias standard errors and lead to incorrect inference. The Durbin-Watson (DW) test detects serial correlation in residuals, ensuring that estimated coefficients remain reliable. This test is particularly relevant in this study as IR may exhibit persistence over time. Moreover, the Heteroskedasticity Test (Breusch-Pagan, 1979) is also employed. In this regard, the Breusch-Pagan test helps detect heteroskedasticity, and if significant, robust standard errors are used to improve inference accuracy.

The study's findings are additionally validated by using alternative model specifications and testing several proxies for FMD and IR to ensure the stability of the results. Additionally, various time lags are taken into account. The lag structures are introduced to account for the delayed impact of green finance and innovation on industrial resilience. This empirical strategy ensures methodological rigor, addressing endogeneity concerns, regional heterogeneity, and potential statistical biases. Ultimately, this aims to enhance the validity of the study's findings.

4. Results and discussion

4.1. Preliminary Testing Results

Table 2 presents the descriptive statistics outcomes. The descriptive statistics reveal notable variation across variables. IR averages 5.32, with a range of 2.1 to 8.95, indicating differences in industrial stability. GF and II show moderate variability, with means of 3.72 and 4.19, respectively. FMD and GDP display fluctuations, with GDP ranging from -2.15 to 7.92. Moreover, EI varies across industries, while GP reflects binary shifts in policy implementation.

Table 2 also presents the CSD test outcomes, indicating significant dependence among variables. IR, GF, II, and FMD exhibit strong dependence that suggests interconnected trends across regions. GDP and EI also show significant dependence, reinforcing economic linkages. However, the GP displays weaker dependence, which implies some regional variation in policy implementation. Three models show strong cross-sectional dependency, as shown by LM statistics above critical levels and p-values < 0.01. In macro-panel data where nations or regions are economically or policy-linked, shocks or movements in one country/unit are statistically connected to others. This suggests the use of second-generation tests. Therefore, the study employed the CIPS test, and its outcomes indicate that all variables are non-stationary at the level but become stationary after first differencing, except GP, which is stationary at levels. This confirms that IR, GF, II, FMD, GDP, and EI are integrated order I(1), justifying the use of panel co-integration techniques to analyze long-run relationships.

Table 2: Descriptive Statistics

Variable	Mean	SD	Min	Max	CIPS Level	CIPS 1^{st} Δ	CSD Results	LM Statistics	
IR	5.32	1.48	2.1	8.95	-2.31	-3.78^{***}	5.91^{***}	Baseline Model 1	26.17^{***}
GF	3.72	1.25	1.05	7.89	-1.92	-3.64^{***}	4.87^{***}		
II	4.19	1.62	0.89	8.23	-2.45	-3.89^{***}	6.15^{***}	Interaction Model 2	23.13^{***}
FMD	2.87	1.11	0.92	6.15	-2.02	-3.71^{***}	5.32^{***}		
GDP	3.65	1.35	-2.15	7.92	-2.84	-4.15^{***}	3.92^{***}	Region-Specific Model 3	20.98^{***}
EI	2.42	1.03	0.52	5.24	-1.79	-3.5^{***}	4.22^{***}		
GP	0.62	0.49	0	1	-2.61^{**}	-4.93^{***}	2.75^{*}		

Note: ***, **, * *$p < .01$, 0.05, and 0.10*

4.2. Regression and Cointegration Results

Across all three specifications, the Westerlund error-correction tests consistently reject the null of no cointegration, indicating that each set of variables shares a stable long-run relationship. In Model 1, both panel tests (Pt = –14.21, Pa = –11.42) and the group-mean test Gt (–3.261) are significant—demonstrating cointegration across all firms and within subsets. Model 2 shows similar results: Pt = –14.47 and Pa = –9.963 both reject the null at 1 percent, and Gt confirms at least some panels are cointegrated. Finally, Model 3 again exhibits robust evidence of equilibrium: Pt = –15.01, Pa = –8.181, and Gt = –3.117 all reject no-cointegration, with Ga's z = –11.13 underscoring broad-based long-run ties. In sum, each model displays strong long-run cointegrating links among resilience, dynamic capability, and their respective drivers.

Table 3: Panel Cointegration Results

	Statistic	Value	z-Value	p-Value
Baseline Model 1	**Gt**	–3.261	–2.035	0.02
	Ga	–16.58	–4.731	0
	Pt	–14.21	–5.107	0
	Pa	–11.42	–3.129	0
Interaction Model 2	**Gt**	–4.031	–2.214	0.013
	Ga	–11.75	–3.663	0
	Pt	–14.47	–6.093	0
	Pa	–9.963	–2.672	0.003
Regional-Specific Model 3	**Gt**	–3.117	–2.003	0.022
	Ga	–11.13	–3.852	0
	Pt	–15.01	–6.207	0
	Pa	–8.181	–2.213	0.013

The regression results are given in Table 4. The FMOLS findings across the three models indicate substantial long-term links between essential economic-financial factors and industrial resilience.

In the Baseline Model, major factors, including GF, II, FMD, GDP, EI, and GP, are empirically significant, underscoring their persistent influence on the industrial sector's economic contribution. The FMOLS estimates—GF (0.385, 0.230, 0.368) and FMD (0.128, 0.230, 0.245)—indicate that improved access to green financial instruments and developed financial markets are essential for augmenting industrial production over the long term. Similarly, results further indicates that II positively contributes in IR by 0.172, 0.275, and 0.254. This result underscores the crucial role of sustainable financial investments in enhancing industrial stability. This finding aligns with prior studies, such as those by Li and Lin (2024), which emphasize that GF facilitates industrial sustainability by promoting eco-friendly innovations and mitigating environmental risks. The current work also hypothesizes that the GF is expected to enhance IR in the study area. Similarly, II enhances industrial resilience by improving adaptability, efficiency, and sustainability, enabling industries to withstand economic and environmental shocks. This result is consistent with Schumpeter’s (1942) theory of creative destruction, which argues that continuous innovation fosters industrial competitiveness and resilience. Moreover, Cheng et al. (2024) also demonstrated that technological innovation enhances efficiency and sustainability in the industrial sector. This result also justifies the study's hypotheses. Similarly, the FMD effect on IR is supported by the study of Duan et al. (2022), as they state that financial market development facilitates investment in resilient industrial structures. Better FMD is needed for a sustainable and resilient industry, which is also hypothesized in this study. The positive effect of GDP on IR shows that economic expansion supports industrial stability by improving business confidence and investment flows. This aligns with endogenous growth theories that highlight economic growth as a key driver of industrial performance (Romer, 1990). Moreover, findings such as EI negatively affect industrial resilience, which aligns with Khurshid et al. (2025), who argue that excessive energy intensity can hinder industrial efficiency and sustainability. Finally, GP positively influences industrial resilience. This implies that effective regulatory frameworks and policy interventions foster a more resilient industrial sector. This supports findings by Yang and Umair (2024) that highlight the role of GP in enhancing industrial competitiveness through institutional support and incentives. The elevated R^2 value of 0.79 signifies that this model accounts for a considerable percentage of the variability in industrial resilience, reinforcing the need for employing FMOLS.

The results from the Interaction and Regional-Specific Models offer profound insights into the interaction and regional variation of policy instruments in influencing industrial resilience. The positive interaction factors (GF × II (0.212), GF × FMD (0.219), and II × FMD (0.144) indicate that these variables work together to improve industrial production more effectively. The regional model indicates that industrial resilience is significantly greater in European nations (D_Europe = 0.292). Nonetheless, the influence of GF and II is relatively diminished when considered in the European setting (negative interaction terms) and has a robust effect in China. This indicates geographical variations in the translation of financial and institutional efforts into industrial results. With R^2 values of 0.84 and 0.81, these sophisticated models validate that FMOLS accurately encapsulates long-term dynamics crucial for comprehending the structural development of the industrial sector. The interaction terms may potentially yield either negative or positive coefficients depending on the context. However, our results demonstrate substantial positive coherence across GF, II, and FMD. This indicates that, within our sample, these characteristics mutually enhance resilience. The positive and significant coefficient for GF × II demonstrates that the combined effect of GF and II enhances resilience in industries. Similarly, GF × FMD suggests that FMD amplifies the benefits of GFN in strengthening IR. The last interaction between II and FMD further confirms that innovation and financial market efficiency jointly contribute to a more resilient industrial sector. Moreover, the regional-specific model outcomes suggest that GF and II positively influence IR overall but exhibit weaker impacts in Europe. This indicates that these factors are more effective in enhancing IR in China. This can be attributed to the stronger policy incentives and rapid technological advancements in China (Dong & Yu, 2024). Conversely, FMD has a relatively more substantial positive impact in Europe, as indicated by the interaction term

(D_Europe × FMD). This reflects that Europe has more mature financial systems and stable mechanisms (Zournatzidou et al., 2025). These findings underscore the role of regional financial structures and policy frameworks in shaping industrial resilience.

Table 4: Regression Results (FMOLS)

Variable	Baseline- Model	Interaction Model	Regional-Specific Model
GF	0.385***	0.230***	0.368***
	(0.131)	(0.057)	(0.085)
II	0.172***	0.275***	0.254*
	(0.062)	(0.081)	(0.116)
FMD	0.128***	0.230**	0.245***
	(0.026)	(0.112)	(0.035)
GDP	0.129***	0.141*	
	(0.061)	(0.091)	
EI	-0.058*	-0.053**	
	(0.018)	(0.027)	
GP	0.129***	0.069***	
	(0.039)	(0.008)	
GF × II		0.212***	
		(0.039)	
GF × FMD		0.219***	
		(0.069)	
II × FMD		0.144***	
		(0.047)	
Europe Dummy (D_Europe)			0.292**
			(0.154)
D_Europe × GF			-0.196***
			(0.034)
D_Europe × II			-0.115**
			(0.057)
D_Europe × FMD			0.163**
			(0.083)
Constant	4.190***	2.709**	
	(1.443)	(1.368)	
R-Squared	0.79	0.84	0.81

*Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ and parentheses contain standard errors. (D_Europe) is Dummy*

4.3. Robustness Results

Table 5 presents the GMM robustness test results. The GMM test confirms the baseline results, with GF, II, GDP, and FMD positively influencing II. Moreover, EI showed a negative impact on IR. The interactive terms also follow the same directional influence, reinforcing the baseline findings. Furthermore, all the VIF values are below 5, indicating no multicollinearity concerns in the data.

Table 5: Robustness Results of GMM

Variable	Robustness GMM (Std. Error)	Variable	VIF Score
		Multicollinearity Test	
IR_{-1}	0.632 *** (0.047)	GF	2.45
GF	0.275 *** (0.058)	II	3.02
II	0.218 *** (0.051)	FMD	2.78
EI	-0.061 ** (0.028)	EI	2.2
GDP Growth	0.072 * (0.035)	GDP Growth	1.85
FMD	0.198 *** (0.049)	GP	1.65
GF × II	0.126 ** (0.042)	GF × II	3.29
GF × FMD	0.108 ** (0.040)	GF × FMD	3.01
Sargan Test	0.243	II × FMD	2.97
Hansen Test	0.319		

*Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ and parentheses contain standard errors.*

4.4. Diagnostic Test Results

The diagnostic test results are presented in Table 6, which confirms the reliability of the estimated models. The Durbin-Watson (D-W) statistic values are close to 2, which indicates no significant autocorrelation. The Wooldridge test p-values are above 0.05, further confirming the absence of serial correlation. The Breusch-Pagan test p-values are also above the critical threshold, suggesting no heteroskedasticity issues and ensuring that the models produce efficient and unbiased estimates.

Table 6: Diagnostic Test Results

Model	D-W Statistic	Wooldridge Test (*p-value*)	Breusch-Pagan Test (*p-value*)
	Autocorrelation Test		Heteroskedasticity
Baseline- Model	1.85	0.067	0.035
Interaction Model	1.79	0.093	0.040
Regional-Specific	2.04	0.112	0.058

4.5. Alternative Model Specifications Results

The outcomes of the alternative model specifications are presented in Table 7. The results remain robust across alternative model specifications, confirming the positive influence of GF and II on IR. Substituting FMD with bank credit does not significantly alter the findings. Additionally, the effects remain positive across different lag structures, but their magnitude decreases slightly over time. This suggests that the immediate impact of financial and innovation factors on IR is stronger than their long-term effects.

Table 7: Alternative Model Specifications

Variable	Original Model (FMD)	Alternative Model (Bank Credit)	No Lag	1-Year Lag	2-Year Lag
GF	0.412 *** (0.048)	0.409 *** (0.047)	0.412 ***	0.387 ***	0.364 **
II	0.295*** (0.041)	0.293 *** (0.040)	0.295 ***	0.278 ***	0.261 **
R-Squared	**0.62**	**0.61**	**0.62**	**0.6**	**0.58**

*Note: *** p < 0.001 and parentheses contain standard errors.*

5. Conclusion and Policy Implications

This study examines the impact of GF, II, and FMD on IR in China and selected industrialized European countries, utilizing panel data spanning the period from 2003 to 2022. The analysis employs panel data regression with FE and GMM estimation to address endogeneity concerns. Additionally, robustness checks, including alternative model specifications and varying time lags, are used. Three models are estimated in the current study. The models are the baseline model to assess the direct effects of GF and II, the interaction model, and the regional-specific model to compare the impact of China and Europe. The findings confirm that GF and II have a positive contribution to IR, with FMD amplifying these effects.

The results broadly support the proposed hypotheses. The positive impact of GF and II on IR confirms H1. At the same time, the more substantial effect of GF in well-developed financial markets aligns with H2. The moderating role of financial market efficiency in strengthening the innovation-resilience relationship supports H3. Finally, H4 is validated, as the interaction between GF, II, and FMD enhances IR, with more substantial effects observed in Europe for financial market-driven resilience. At the same time, China benefits more from GF and II. These findings underscore the significance of regional economic structures and policy frameworks in shaping international relations (IR).

From a policy perspective, governments should focus on strengthening financial market efficiency to maximize the benefits of GF and IN. In China, integrating financial markets more effectively with sustainability initiatives could further enhance resilience, while in Europe, more significant incentives for II could be beneficial. Financial institutions should develop targeted financial products to support green innovation, ensuring optimal capital allocation for sustainable industrial growth. Further, policymakers should also implement long-term strategies that encourage investment in green technologies, enhance industrial adaptability, and reinforce economic stability.

Limitations and Future Directions

Despite its contributions, this study has some limitations. First, the current work considers financial market dynamics. However, other institutional factors, such as regulatory quality and political stability, may also influence IR and should be considered in future research. Second, the study relies on aggregate data, which may not fully capture sector-specific variations in resilience. Future studies could conduct industry-level analyses to provide more granular insights.

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