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DRIVERS OF NEW PRODUCT ENVIRONMENTAL PERFORMANCE UNDER UNCERTAINTY

The impact of business income, innovations, and urban population on the environmental indicators of new products has been investigated. In this context, the uncertainty of economic policy and external shocks such as COVID-19 are taken into account as moderating factors to assess whether external shocks disrupt the sustainability of new products. The panel data from 30 Chinese provinces for the years 2013 to 2024 were analysed using a two-step GMM regression system. (GMM – Generalized Method of Moments in statistics and econometrics). The analysis results highlighted the negative role of income from the main business and urban population on the environmental

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РУШІЙНІ СИЛИ ЕКОЛОГІЧНОЇ ЕФЕКТИВНОСТІ НОВОГО ПРОДУКТУ В УМОВАХ НЕВИЗНАЧЕНОСТІ

Досліджено вплив доходів бізнесу, інновацій та міського населення на екологічні показники нових продуктів. При цьому невизначеність економічної політики і зовнішні шоки на кшталт COVID-19 враховуються як пом'якшувальні фактори для оцінки того, чи порушують зовнішні шоки сталий розвиток нових продуктів. Проаналізовано панельні дані 30 китайських провінцій за 2013–2024 рр. за допомогою двоетапної системи регресії GMM (GMM – узагальнений метод моментів у статистиці й економетриці). Результати аналізу свідчать про негативний вплив доходів основного бізнесу та міського населення на екологічні показники нових продуктів,

indicators of new products, while innovations exhibit a positive influence. In addition, EPU (EPU – Economic Policy Uncertainty) plays a positive moderating role, but at the same time demonstrates a negative impact on the relationship between innovations and the environmental indicators of new products. It has been found that the moderating influence of COVID-19 is significantly positive. Considering the political implications, businesses should ensure that profitability does not come at the expense of sustainability. There should be a balance between financial goals and environmental issues. Additionally, the government should tackle uncertainty in economic policy, as stable policy can stimulate the development of green products.

Keywords: environmental indicators, urban population, innovations, economic policy uncertainty, two-step GMM system.

тоді як інновації відбиваються позитивно. Крім того, EPU (EPU – невизначеність економічної політики) відіграє позитивну пом'якшувальну роль, але водночас демонструє негативний вплив на зв'язок інновацій з екологічними показниками нових продуктів. Встановлено, що пом'якшувальний вплив COVID-19 є доволі позитивним. З огляду на політичні наслідки, підприємствам слід переконатися, що досягнення прибутковості не відбувається через сталий розвиток. Має бути баланс між фінансовими цілями та заходами з вирішення екологічних проблем. Крім того, уряд має подолати невизначеність в економічній політиці, оскільки стабільна політика може стимулювати розвиток екологічних продуктів.

Ключові слова: екологічні показники, міське населення, інновації, невизначеність економічної політики, двоетапна система *GMM*.

JEL Classification: C12, D80, O47, Q21.

Introduction

Adopting environmentally sustainable methods in the products development has become paramount in today's business landscape. The growing concerns about climate change and environmental degradation have forced the businesses to adopt eco-friendly production (Fernando & Wah, 2017; Warner et al., 2009). Environmental performance of new products (EPNP) relates to the capability of newly developed products to influence the level of environmental sustainability at all stages of the product life cycle (Zhang et al., 2022; Xie et al., 2019). Achieving high EPNP is crucial from a compliance perspective to reduce environmental and respond to customers' increasing demand for sustainable products. The adoption of an environmental sustainability approach could therefore, be appealing to businesses who wish to introduce their new products in the market under the eco-friendly "green" label (D. Wang et al., 2023; Deng et al., 2022; Ranjbari et al., 2021). Businesses cannot make informed decisions regarding the environmental performance of new products without a reliable, cutting edge and advanced life cycle assessment (Xie et al., 2019). Otherwise, this could lead to financial burden for businesses, ambiguity for customers, and a potentially missed opportunity to endorse genuinely green products that uphold environmental integrity (Popp et al., 2011). Main business income (MBI) refers to measurements of revenues and profitability that determine the likelihood of businesses to finance sustainable initiatives and develop environmentally friendly product designs (Fernando & Wah, 2017; Guoyou et al., 2013). Liu et al. (2009, January) have pointed out that the EPNP is improved when environmental considerations are integrated into the product life cycle, and profitable businesses possess the resources and strategic direction necessary to do so. Previous studies argued that businesses with strong financial

positions have better environmental performance because these businesses can afford investments in green technologies and meet environmental standards (Deng et al., 2022; Farza et al., 2021).

Likewise, industrial innovations (INO) contribute to the improved efficiency and production of new products that have lesser ecological impacts (Blichfeldt & Faullant, 2021). The effective number of innovation patents and high R&D expenditures are the firm's long-term sustainable strategies for production and remaining market competitiveness. The literature highlights technological developments as critical to attaining better environmental performance because innovative businesses efficiently adopt eco-friendly technology and processes (Horbach et al., 2012; Cainelli et al., 2015). Similarly, the increase in population density in urban areas has both beneficial and deleterious effects on the EPNP. Urbanization is often linked with higher levels of product consumption and this may lead to environmental degradation if not appropriately managed. But there is also a positive side, as the urban areas are the sources of the ideas and practices related to sustainable product development (Stark et al., 2017). Therefore, these urban areas drive the economy of scale in sustainable production and distribution systems, which boosts the EPNP. Also, consumers in urban areas are more conscious and raise concerns about environmental causes, which in turn creates pressure on businesses to adopt sustainable practices (He et al., 2023; Gao et al., 2023; Hussain et al., 2020).

Economic policy uncertainty (EPU) can harm the management of businesses in the formulation of environmental strategies related to green innovations thereby, dissuading businesses from investing in sustainability programs. Because of unpredictability in policy changes, businesses may prioritize immediate financial stability rather than environmental objective (Latan et al., 2018). On the other hand, the COVID-19 pandemic increased awareness of global risks, which spurred businesses to make more concrete environmental pledges (Rume & Islam, 2020; Ranjbari et al., 2021). Therefore, CSR theory insists that businesses have a responsibility to benefit society and the environment beyond profit maximization. It proposes that businesses must incorporate social and environmental responsibilities into their management and production processes. Businesses with high financial performance should invest more capital in the research and development of green products that can prove their CSR commitment (Bhardwaj, 2016). Furthermore, according to real options theory, product innovations can be seen as the real options for the businesses. These innovations create the chances of responding to shifts in potential environmental regulations and consumer preferences. Consequently, the businesses with increased levels of innovative competence are likely to have the capability to create eco-friendly products, which in turn can be considered as the exercise of the real options.

We have selected China for empirical investigation because its social objectives (environmental and climatic conditions) were negatively impacted by its massive production-oriented focus during the early globalization phase. China's environmental crisis, which has been caused by several decades of

industrialization, does not only endanger people's lives and health in this country but also the global fight against climate change (Gao et al., 2023). The Chinese government is very active in encouraging innovation and production of new products, as evident in the "Made in China 2025" policy (Wübbeke et al., 2016; Zenglein & Holzmann, 2019). With the growing concerns over the effects of products on the environment, China has formulated sound environmental policies and measures to improve the environmental attributes of new products and services (Zhang et al., 2021; Liu et al., 2021) through its renowned slogans "Harmonious Society" and "Greener GDP". Chinese businesses are also increasing their investments towards research and development to create and introduce better innovative and sustainable products in the global markets (Hussain et al., 2025; Xu et al., 2020). However, China has started some actions that would help reduce emissions and halt further degradation of the environment like the ratification of the Paris Agreement on Climate Change 2015.

Thus, in this study, we examine the data of Chinese provinces to assess the outcomes of main business income, share of the urban population, and industrial innovations on the environmental performance of new products. Besides this, we innovatively introduced a unique concept by introducing EPU and COVID-19 as moderating factors.

Therefore, the purpose of our study is to determine whether EPU and COVID-19 can modify the above-mentioned relationships.

For our analysis, we methodologically relied on two-stage systematic GMM regression due to the panel nature of the data set of this study and to address the endogeneity problem. The results of this study will help enterprises formulate appropriate policies to improve the environmental performance of their new products.

In the current business research, the relationship between business income and environmental performance has gained significant attention. Implementing green production processes in new product development bring value and enhance business productivity. Eco-friendly innovation signify-cantly improves the environmental performance of new products. Therefore, financially stable businesses inclined to invest more in green innovations (Deng et al., 2022). According to Fernando and Wah (2017), businesses with strong financial performance are better equipped to integrate green practices and technologies. This integration enables them to pursue environment strategies in product development. Guoyou et al. (2013) conducted a study on Chinese businesses and found that financially sound businesses often invest in R&D to manufacture products that meet environmental standards. Empirical studies suggest that businesses benefit from higher returns and improved reputation because of eco-friendly initiatives. Hence, according to Farza et al. (2021), businesses that engage in green practices in their operations enjoy increased customer loyalty and a better market image. It ultimately leads to increased sale of new products and profitability. Based on the following discussion, we hypothesize that:

H1. Main business income positively influences the environmental performance of new product.

The industrial innovations are instrumental in the development of products that are environmentally friendly. The green technologies and eco-innovations emphasize the integration of environmental aspects into R&D activities. These integrations make new green innovations highly effective in the reduction of the environmental impact of new products. Horbach et al. (2012) discussed that through their R&D activities, businesses possess the capability to produce lesser ecological harmful products. Also, Cainelli et al. (2015) found that businesses with strong R&D ingenuities and investments develop products that have high ecological efficiency R&D enables these businesses to set up new technologies and practices and manufacture products that have lower effects on the environment. Similarly, the firm's ability to innovations and commitment to environmental sustainability is assessed by the effective number of its invention parents. Green patents are especially essential because they highlight the firm's efforts for innovations to tackle ecological challenges (Popp et al., 2011). Oyebanji et al. (2022) focused on the Spanish industries and stated that if the businesses have innovation patent, they better perform environmentally. These green innovation patents have a very direct implications towards the environmental sustainability of the new products. These patents also include efficient energy utilization and the use of environmentally friendly resources. Based on the following discussion, we hypothesize that:

H2. Industrial innovations positively influence the environmental performance of new products.

Population density in urban areas causes an upsurge of resource utilization and the production of waste that puts pressure on the environment. He et al. (2023) revealed that environmental performance generally worsened since urbanization increases transport and industrial activities which, result in an increase in greenhouse gas emissions. Rapid urbanization accelerates the pressure and exploitation of natural resources and causes the environmental pollution. Cheng and Hu (2023) conducted a study on China and found that urban areas cause CO_2 emissions, especially developed and resource-based cities. But urbanization is also capable to diminish the negative impacts on ecology by promoting green innovations. Gao et al. (2023) experienced China's Innovation Pilot City (IPC) project and revealed that innovative city construction enhances environmental performance through stimulating technological advancements and restructuring industrial processes. Further, Pera (2020) investigated 153 published articles on the environmental sustainability performance of urban systems and revealed that green innovation initiatives in urban areas enhance environmental sustainability. The findings further indicate that urban growth, backed by strict ecological policies, can help to reduce the negative effects of urbanization on the environment. Based on the following discussion, we hypothesize that:

H3. Urban population positively influences the environmental performance of new products.

Economic policy uncertainty can impact businesses' operations and management, especially regarding environmental sustainability. High EPU may incline the businesses to focus more on short-term financial gains rather than long-term

sustainability projects. This situation also reduces efforts towards embracing sustainable green practices, hence developing products that could be a nuisance to the environment (Qureshi et al., 2023). Similarly, Jiang et al. (2019) concluded that when faced with EPU, businesses are willing to give up on projects for industrial innovations that would enhance environmental performance because of being directed to utilize such resources to manage uncertainty. He et al. (2020) noted that businesses cut their environmental investments during high EPU in order to concentrate their efforts on crucial business operations. Moreover, Demir and Ersan (2017) observed the BRIC countries and found that businesses hold more cash to shield against uncertainty hence leaving limited funds for environmental projects. Based on the following discussion, we hypothesize that:

H4. The moderating role of economic policy uncertainty is significant.

The ethical position adopted during the pandemic enables the businesses to perform better on the environmental front because stakeholders expect the businesses to be more environmentally responsible during crises (Al Amosh & Khatib, 2023; Obrenovic et al., 2020). Urban areas, because of dense population and resource utilization on a large scale have majorly impacted during COVID-19 pandemic. This has prompted the urban areas to adopt sustainable environmental policies. According to Gong et al. (2020), urban areas that have competent governance have done well economically and ecologically in the COVID-19 pandemic. In addition, during the pandemic, Rehman and Yaqub (2021) discovered that businesses increased their innovative abilities with the application of modern technologies, thereby helping to enhance environmental performance. Furthermore, Thomas et al. (2022) revealed that businesses that have adopted sustainable green innovations to manage their operations have been able to satisfy regulatory requirements and foster stakeholders 'expectations. Based on the following discussion, we hypothesize that:

H5. The moderating role of COVID-19 is significant (*Figure 1*).

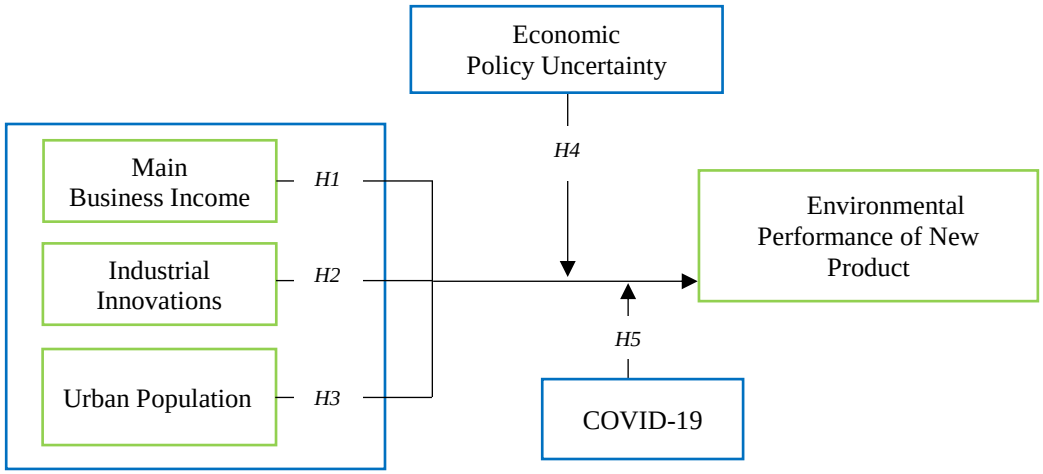

Figure 1. Conceptual Framework

Source: developed by the authors.

Research Methodology. To examine the nexus between the main business income, industrial innovations and urban population and new products' environmental performance, we have selected Chinese data over the years 2013 to 2024. The sample involves using panel data from 30 provinces, and data has been collected from China's Statistical Yearbook, High-tech Statistical Yearbook, and Energy Statistical Yearbook databases. The environmental performance of new products is an independent variable in this study, calculated as dividing the data of new product sales by total energy consumption. Further, the main business income, industrial innovations and urban population are the independent variables.

We included economic policy uncertainty and COVID-19 as moderator variables. The data of EPU was extracted from a news-based EPU index developed by Baker et al. (2016) based on the South China Morning Post. EPU is a national level variable. However, we have used it as panel data at the provincial level. We replicated the EPU values for each province by adhering to the method suggested by Adil et al. (2025). COVID-19 is included as a binary variable to gauge the impact of the COVID-19 pandemic on the environmental performance of new products. *Table 1* provides the further description of study variables along with their acronyms.

Econometric Model. By scrutinising the impact of main business income, industrial innovations and urban population on the environmental performance of new products, we used the following baseline regression models with year and region effects.

$$\mathrm{EPNP}_{i,t} = \alpha + \beta_1(\mathrm{MBI}_{i,t}) + \beta_2(\mathrm{INO}_{i,t}) + \beta_3(\mathrm{UP}_{i,t}) + \beta_4(\mathrm{EPU}_{i,t}) + \beta_5(\mathrm{COVID}-19_{i,t}) + \varepsilon_t. \quad (1)$$

$$\mathrm{EPNP}_{i,t} = \alpha + \beta_1(\mathrm{MBI}_{i,t}) + \beta_2(\mathrm{INO}_{i,t}) + \beta_3(\mathrm{UP}_{i,t}) + \beta_4(\mathrm{EPU}_{i,t}) + \beta_5(\mathrm{COVID}-19_{i,t}) + \beta_6(\mathrm{MBI}\cdot\mathrm{EPU}_{i,t}) + \beta_7(\mathrm{INO}\cdot\mathrm{EPU}_{i,t}) + \beta_8(\mathrm{UP}\cdot\mathrm{EPU}_{i,t}) + \varepsilon_t. \quad (2)$$

$$\mathrm{EPNP}_{i,t} = \alpha + \beta_1(\mathrm{MBI}_{i,t}) + \beta_2(\mathrm{INO}_{i,t}) + \beta_3(\mathrm{UP}_{i,t}) + \beta_4(\mathrm{EPU}_{i,t}) + \beta_5(\mathrm{COVID}-19_{i,t}) + \beta_6(\mathrm{MBI}\cdot\mathrm{COVID}-19_{i,t}) + \beta_7(\mathrm{INO}\cdot\mathrm{COVID}-19_{i,t}) + \beta_8(\mathrm{UP}\cdot\mathrm{COVID}-19_{i,t}) + \varepsilon_t. \quad (3)$$

Equation 1 highlights the impact of main business income, industrial innovations, urban population, economic policy uncertainty and COVID-19 on the environmental performance of new products. While equations 2 and 3 present the separate interaction terms of EPU and COVID-19 to gauge the moderating influence of economic policy uncertainty and COVID-19 on the relationship of main business income, industrial innovations, and urban population with environmental performance of new products. The main study model has been given in *Table 1*.

Table 1

Variables elucidation

Variable	Acronym	Description
Main business income	MBI	The primary revenue generated by enterprises within a province from their core business activities
Industrial innovations	INO	Advancements in technology and industrial processes based on R&D expenditures and effective number of innovation patents
Urban population	UP	The proportion of population residing in urban areas
Environmental Performance of new products	EPNP	The environmental efficiency of all newly developed products in industries, calculated as new product sales divided by total energy consumption
Economic policy uncertainty	EPU	Measures the level of uncertainty in economic policy based on South China Morning Post newspaper articles
COVID-19 pandemic	COVID-19	Binary variable indicating 1 during the pandemic and 0 otherwise

Source: developed by the authors.

The first section of the main part of the article presents the descriptive statistics used in the study; the second section presents their interpretation taking into account pairwise correlation and variance inflation factor; and the third section presents the main empirical results of the two-stage GMM regression.

Results

1. Descriptive statistics

Table 2 provides the descriptive statistics of all the variables being studied, including the number of observations, mean, median, standard deviation, and ranges of values (minimum and maximum).

Table 2

Descriptive statistics

Variable	Obs	Mean	Std.Dev	Min	Max
EPNP	360	0.087	0.732	0.000	11.960
MBI	360	7.207	1.703	2.708	10.823
INO	360	7.222	2.073	0	12.510
UP	360	57.048	12.773	29.89	89.6
EPU	360	178.712	102.282	92.114	390.388
COVID-19	360	0.166	0.373	0	1

Source: calculated by the authors based on the study data.

The balanced dataset consists of 360 observations from 30 provinces of China between the years 2013 to 2024. According to our analysis, the mean value of EPNP is 0.087, indicating the low environmental performance of new products because of insufficient focus on environmental factors during product development. The MBI has mean value of 7.207, suggesting

that businesses in all sampled provinces of China are generating a moderate level of revenue, which is a sign of sound profitability. The INO also has a moderate level mean value of 7.222, indicating a strong focus on innovations, which may be due to competitive pressure and technological progressions. Further, our findings show that the mean value of UP is 57.048, with a standard deviation of 12.773. The mean value of EPU is 178.712, indicating the strong influence of economic policy uncertainty on the strategic planning of the businesses due to unpredictability and instability of policy changes. Meanwhile, the mean value of COVID-19 is 0.166, showing a relatively low influence of the COVID-19 pandemic.

2. Pairwise correlation and variance inflation factor

Figure 2 reports the regression results of pairwise correlation analysis, showing the strength and direction of the linear relationship between study variables. Also, high correlation values between variables with large coefficients indicated the presence of multicollinearity. Tackling and managing high correlation between variables is crucial in order to obtain precise results and might involve omitting variables that exhibit high correlation.

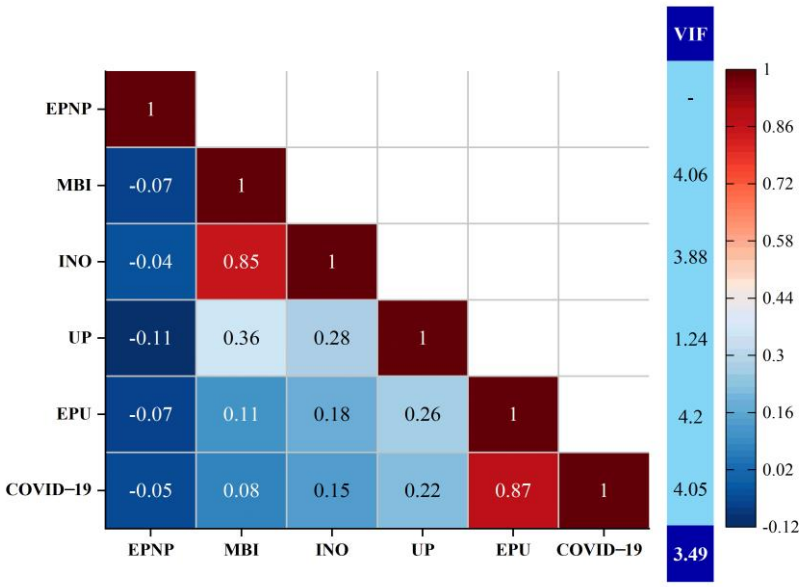

Figure 2. Pairwise correlation and VIF results from authors' computations

However, in our case, the correlation values between the study variables are within permissible limits, and there is no such issue of multicollinearity. In addition to our inspection of pairwise correlations, we also undertaken the VIF test to validate our apprehension about multicollinearity. Based on Studenmund (2014), a variable may face multicollinearity problems if its VIF value exceeds 10. The findings from our VIF test are encouraging, as the average VIF value for all variables is below 10. This result indicates that multicollinearity is not an issue in our model.

Further, *Table 3* notifies the outcomes of unit root analysis.

Table 3

Findings of unit roots tests

Variable	Im-Pesaran-Shin		Harris-Tzavalis	
	Level	First Difference	Level	First Difference
EPNP	–3.4740*	–8.3729*	0.2622*	–0.5020*
MBI	–3.5060*	–3.3868*	0.8362	0.2914*
INO	15.9795	–4.9827*	1.0870	0.4553*
UP	9.6746	–5.0645*	0.9981	–0.1282*
EPU	14.8911	–3.9339*	1.1018	0.5844*
COVID-19	7.3720	–7.1267*	0.9000	–0.1111*

Source: authors' own computations. Asterisk (*) denotes significance at the 1% level.

The findings confirm that all variables are stationary at first difference with significant p-values at 1%.

3. Main empirical results of two-step gmm regression

Table 4 reports the findings of the two-step system GMM regression. In Model 1, the MBI has been found to be negatively impacted the environmental performance of new products as indicated by coefficient (β_{MBI} = –0.2417*).

Table 4

Findings of two-step sys

Variable	Model 1	
	Coefficient	*p*-value
L.EPNP[1]	–0.1086*	0.000
MBI	–0.2417*	0.000
INO	0.0473*	0.000
UP	–0.0022*	0.000
EPU	–0.0192*	0.000
COVID-19	0.0240*	0.000
Instruments	72	
Sargan test	29.284	0.819
AR (1)	0.057	
AR (2)	0.381	

Source: authors' own computations. Asterisk (*) denotes significance at the 1% level.

Ambec and Lanoie (2008) argued that the focus of high revenue in traditional business lines sometimes result in insufficient concentration in the development of eco-friendly products. Also, businesses choose cheaper and less environmentally friendly options in product design and manufacturing. It results in the introduction of products into the market that cause ecological

[1] "L" of the dependent variable in GMM regression typically refers to its lagged value.

problems during their lifecycle (Trumpp & Guenther, 2017). Upon this finding, we reject the initial hypothesis *H1*, which suggests a positive link. Moreover, industrial innovations have been found to be positive and significant impact on EPNP in the results, as indicated by the coefficient value (β_{INO} = 0.0473*). Innovations contribute positively by forming the basis of green technologies and processes that help to manufacture eco-friendly products. For instance, Horbach et al. (2012) and Oyebanji et al. (2022) found that a rise in R&D expenses could lead to the attainment of energy-efficient manufacturing methods and the production of energy-efficient products. These findings also support our hypothesis *H2* which implies positive correlation between INO and EPNP. Further, the findings indicated the adverse impact of the urban population on the EPNP with a coefficient (β_{UP} = –0.0022*). York et al. (2003) found that the higher resource consumption and waste generation urban areas cause environmental problems and also hinder eco-innovations. In a similar vein, Grimm et al. (2008) pointed out that the high demand pressures diminished the efficiency of sustainable product development. Based on this finding, we reject our hypothesis *H3* which suggests a positive association between UP and EPNP.

Table 5 reports the findings of interaction terms with EPU as a moderator.

table 5

findings of two-step system GMM with interaction of EPU

Variable	Model 2	
	Coefficient	*p*-value
L.EPNP	–0.1308*	0.000
MBI	0.0097	0.381
INO	–0.4797*	0.000
UP	0.0238*	0.000
EPU	–0.1494**	0.032
COVID-19	–0.0079*	0.000
MBI · EPU	–0.0539*	0.000
INO · EPU	0.1098*	0.000
UP · EPU	–0.0053*	0.000
Instruments	75	
Sargan test	23.431	0.781
AR (1)	0.090	
AR (2)	0.201	

Source: authors' own computations. Asterisk (*) denotes significance at the 1% level.

Our analysis discovered that EPU negatively moderates the relationship between MBI and EPNP, as indicated by the coefficient ($\beta_{MBI \cdot EPU}$ = 0.0539*). The findings show that the upsurge in EPU caused businesses to reduce their use of eco-friendly practices in product development. He et al. (2020) noted that businesses cut their environmental investments during high EPU in order to concentrate their efforts on crucial business operations. Moreover, Demir and Ersan (2017) observed the BRIC

countries and found that businesses hold more cash to shield against uncertainty hence leaving limited funds for environmental projects. However, we found the positive moderating role of EPU in the association between INO and EPNP, as indicated by the coefficient ($\beta_{INO \cdot EPU} = 0.1098$*). Aghion et al. (2016) argued that during uncertain situations, businesses pursue eco-innovations to mitigate risks and gain a competitive edge in the market. Similarly, Lee et al. (2014) confirmed that businesses invest in sustainable product innovations to differentiate themselves and comply with evolving standards in times of EPU. While, we discovered that EPU has a negative moderating effect on the association between UP and EPNP, as demonstrated by the coefficient ($\beta_{UP \cdot EPU} = –0.0053$*). According to Baker et al. (2016) EPU triggers decreases in R&D spending within environmentally sensitive sectors thus urban areas usually known for innovation show inferior environmental outcomes in times of policy unpredictability. Based on these above findings of EPU as a moderator, we accept our hypothesis *H4* that EPU's moderating role is significant.

Furthermore, *Table 6* reports the findings of interaction terms with COVID-19 as a moderator. Our analysis discovered that COVID-19 positively moderates the associations of MBI and INO with EPNP, as indicated by the coefficients ($\beta_{MBI \cdot COVID\text{-}19} = 0.0911$*) and ($\beta_{INO \cdot COVID\text{-}19} = 1.5206$*), respectively.

Table 6

Findings of two-step system GMM with interaction of COVID-19

Variable	Model 3	
	Coefficient	*p*-value
L.EPNP	–0.1235*	0.000
MBI	–0.2308*	0.000
INO	0.0284*	0.000
UP	0.0009	0.899
EPU	–0.0084*	0.000
COVID-19	–0.7163*	0.000
MBI · COVID-19	0.0911*	0.000
INO · COVID-19	1.5206*	0.000
UP · COVID-19	0.0013**	0.024
Instruments	75	
Sargan test	19.35	0.336
AR (1)	0.020	
AR (2)	0.151	

Source: authors' own computations. Asterisks indicate significance at 5% (**) and 1% (*), respectively.

Obrenovic et al. (2020) highlighted that COVID-19 pandemic heightened global awareness about the ecological challenges, and consumers became more conscious and demanded sustainability. This situation has put pressure on businesses to integrate eco-friendly processes in their operations

and manufacture green products that are less harmful to the environment. Similarly, Rehman and Yaqub (2021) indicated that the pandemic calamity has pushed the businesses to incorporate eco-friendly strategies into their operations to meet customers' expectations about sustainability and regulatory requirements. Therefore, businesses changed their business models and moved towards the adoption of green practices in their operations, which ultimately enhanced the environmental performance of new products (Amosh & Khatib, 2023; J. Wang et al., 2023). In the same way, we also revealed that COVID-19 positively moderates the association of UP with EPNP, as indicated by the coefficient (β_{UP} = 0.0013**). Previous research supports our finding that environmental consciousness together with green innovation attained rapid growth during crises such as COVID-19 (Adil et al., 2024; Obrenovic et al., 2020). According to Sarkis et al. (2020), the pandemic functions as a trigger to provoke new perspectives on how sustainability should be applied in urban and industrial systems. Based on these above findings of COVID-19 as a moderator, we accept our hypothesis *H5* that COVID-19's moderating role is significant.

Conclusions

We have investigated the impact of main business income, industrial innovations and urban population on the environmental performance of new product. Further, we incorporated economic policy uncertainty and COVID-19 as moderating factors. To investigate the associations between the above-mentioned variables, we relied on the panel data of 30 Chinese provinces from 2013 to 2024. In our examination, we discovered a significant negative influence of main business income and urban population on the environmental performance of new product, while the impact of industrial innovations was significantly positive. In the moderation case of economic policy uncertainty, the results confirmed a significant positive moderating effect on the associations of main business income and urban population with environmental performance of new product. In contrast, a significant negative was found between industrial innovations and environmental performance of new product. Moreover, we also found that COVID-19 has a significant positive moderating role in the associations of main business income, industrial innovations, and urban population with environmental performance of new product.

The adverse impact of main business income on environmental performance of new product suggests that sometimes businesses focus on quick gains in the form of monetary profit instead of implementing eco-friendly measures. This situation leads to the creation of products that adversely influence environmental sustainability. Moreover, the positive association between urban population and environmental performance of new product revealed that consumers in such urban regions are more educated and better understand environmental concerns. They are willing to use products that have minimal adverse environmental impact. Besides, cities have the strongest environmental standards, forcing businesses to enhance

product quality. These reasons could result in the positive impact of urban population on the environmental performance of new product. Additionally, the positive link between industrial innovations and environmental performance of new product emphasizes that innovations serve as the foundation for green technologies and processes through which various environmentally friendly products can be created. In addition, the negative moderating role of economic policy uncertainty suggests that businesses prioritize immediate financial gains because of uncertainty and unpredictability in a business environment. Businesses also hold more cash to shield against uncertainty, hence leaving limited funds for environmental initiatives in product manufacturing. However, in the case of industrial innovations, the moderating role of economic policy uncertainty is surprisingly positive, which highlights that during uncertain situations, businesses pursue eco-innovations to mitigate risks and gain a competitive edge in the market. Enterprises invest in sustainable product innovations to differentiate themselves in the market and comply with evolving standards in time of economic policy uncertainty. While, the significant positive moderating role of COVID-19 indicates that the pandemic heightened global awareness about ecological challenges. Thus, consumers became more aware and demanded eco-friendly products. Pandemic calamity has pushed the businesses to incorporate eco-friendly strategies into their operations to meet customers' expectations about sustainability and regulatory requirements. Therefore, businesses changed their business models and moved towards the adoption of green practices in their operations. These initiatives enhanced the environmental performance of new products.

The findings of current study suggest several recommendations for policymakers. First, businesses should make sure that profitability does not come at the expense of environmental sustainability. Business managers should maintain a symmetry between financial pursuits and measures of environmental concerns. Second, policymakers should encourage a conducive environment for industrial innovations. It is because these innovations are crucial for developing green products with improved environmental performance. Third, sustainable urban planning should be indorsed to diminish ecological strain in urban regions. Beside this, government should enforce stricter eco-design regulations for products development and consumption. The government should also promote such policies that encourage the reuse and recycling of materials used in new product development. In addition, a stable and transparent economic policy environment is crucial for businesses to pursue green initiatives in product development. Therefore, the government should tackle down the ambiguity surrounding economic policies. Policymakers must come up with economic policies that are favorable for businesses and explicitly supportive of green business practices.

Despite a detailed examination, the research has certain limitations that could serve as a future research direction. Only one country is involved in the study, and it does not adequately represent other regions. Secondly,

since the research relies solely on provincial-level data, it imposes a generalization constraint on different regions. Further studies can extend the analysis to other areas in order to gain a more in-depth understanding. In addition, future research can also proceed beyond the provincial level analysis to a firm level. In this scenario, the utilization of case studies of those firms in China that have successfully integrated environmental performance of new product procedures may be advantageous. The role consumer awareness and demand for environmentally friendly new products should also be incorporated into the future studies.

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