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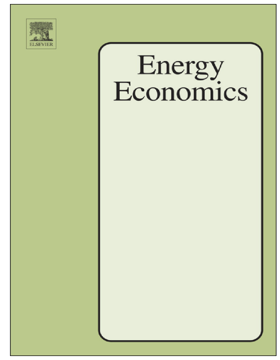

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Jian Yu, Xunpeng Shi, Dongmei Guo, Longjian Yang

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Economic policy uncertainty (EPU) and firms' carbon emissions: evidence using a China provincial EPU index

Jian Yu[1] Xunpeng Shi[2,*] Dongmei Guo[3] Longjian Yang[4]

1. School of Economics, Central University of Finance and Economics, Beijing 102206, China. Email: jianyu@cufe.edu.cn.

2.Australia-China Relations Institute, University of Technology Sydney, NSW 2007, Australia. Email: xunpeng.shi@uts.edu.au. * *Corresponding author*

3. School of Economics, Central University of Finance and Economics, Beijing 102206, China. Email: guodongmeicufe@163.com.

4. School of Taxation, Central University of Finance and Economics, Beijing, 100081, China. Email: longjiany@cufe.edu.cn.

Abstract

Although there have been numerous studies on economic policy uncertainty (EPU), its impact on firms' emissions has not often been examined. Using an unbalanced panel data of firms and a newly constructed provincial EPU index in China, this paper estimates the impact of EPU on manufacturing firms' carbon emission intensity. We further test the likely channels through which EPU can affect firm emission intensity, including the innovation channel, share of fossil fuels in the total energy consumption channel, and energy intensity channel. The findings show that China's provincial EPU imposes a significant positive impact on firms' carbon emission intensity. The channel analysis shows that EPU influences carbon emission intensity through the share of fossil fuels in the total energy consumption and energy intensity in the short run, but not firm innovation. The results indicate that manufacturing firms prefer to use cheap and dirty fossil fuels to respond to the rising EPU. This paper suggests that policymakers should pay careful attention to the increasing effect of EPU on carbon emission intensity which could undermine China's sustainable development goals.

Keywords: economic policy uncertainty; carbon emissions; energy intensity; fossil fuel consumption; China

JEL code: C23; D21; D81; O13

1 Introduction

Since the seminal work of Bloom (2009) and the subsequent development of Baker et al. (2016), studies on economic policy uncertainty (EPU) have proliferated, but the impact of EPU on firms' emissions has not been examined extensively. Furthermore, in the existing studies, the Chinese EPU indexes are only at the national aggregated level, and are either not well-constructed or cannot account for China's overall circumstances and regional heterogeneities (Shi et al., 2020; Yu et al., 2019). This paper investigates the impact of EPU on emissions from China's manufacturing firms. With a newly constructed provincial EPU, it also examines the channels through which EPU can affect firms' emission intensity.

EPU may affect firms' carbon emissions. The literature has well documented that EPU can affect macro-economic and financial variables, including oil prices (Cheng et al., 2019; Elder and Serletis, 2010; Kang and Ratti, 2013; Van Robays, 2016), firms' investment decisions (Bernanke, 1983; Bloom et al., 2007; Handley and Limão, 2015; Kellogg, 2014) and choice of energy fuels (Adedoyin and Zakari, 2020; Yong Jiang et al., 2019; Pirgaip and Dinçergök, 2020). Since EPU affects the external business environment of firms, their financial performance and investment decisions, will also be indirectly affected by EPU, and this could also affect their emission performance (Adedoyin and Zakari, 2020).

However, the impact of EPU on emissions is under-accounted for and no study examines the relationship at the firm level. While many studies have investigated the influencing factors of emissions, little attention has been devoted to the impact of macroeconomic institutional factors, such as EPU (Yong Jiang et al., 2019). Among the numerous studies on the influencing factors of emissions at the macro level, such as Adedoyin and Zakari (2020), Huang et al. (2020), Dietz and Venmans (2019), and Hepburn et al. (2019), only Dietz and Venmans (2019) found that economic policy does affect emissions. Although studies that investigate the influencing factors of carbon emissions at the firm level are also emerging in some other countries, such as

Sweden (Forslid et al., 2018) and Germany (Richter and Schiersch, 2017), the relationship between EPU and emissions has not been investigated. The limited studies on the impact of EPU on emissions have either been focused on the national level (Adedoyin and Zakari, 2020; Pirgaip and Dinçergök, 2020), or on the sectoral level (Yong Jiang et al., 2019).

In China's case, while EPU has been widely studied, no study has considered the heterogeneities in regional economic development and the policy implementation level. The existing studies adopted the monthly Barker China index (Baker et al., 2016), which is aggregated at the national level, to investigate the impact of EPU on macro-economic indicators, firm behaviors, and capital markets. Studies on influencing factors in China have often used aggregated data at the city or industry level to study China's carbon emissions behavior but have not looked at the heterogeneous effects at the firm level (Du et al., 2019; Ye et al., 2020; Zhang et al., 2019b). As there are significant regional heterogeneities in China's energy use, the regional heterogeneities are essential to understanding China's emission factor (Sheng et al., 2014; Shi et al., 2020, 2018) and emissions (Li et al., 2019; Wang et al., 2019). Since energy consumption and the associated carbon emissions are closely related to firms' decisions, investigating the relationship between EPU and carbon emissions at the firm level can help China, the world's largest carbon emitter, formulate policies that encourage firms to work toward sustainable development.

Using a set of provincial EPU indexes for China, we investigated how EPU affects the emission intensity of manufacturing firms. We further tested the likely channels through which EPU can affect firm emission intensity, including the innovation channel, share of fossil fuels in the total energy consumption channel, and energy intensity channel. Given that China emits the largest amount of CO_2 in the world, and that firms are the most important agents that implement emission mitigation, this study can assist in the design of industrial emission policies in China. Furthermore, the findings on the impact of EPU on emissions are also applicable to firms in other countries.

Our study contributes to the literature in the following ways. Our major contribution is to propose an EPU index for China by province and over time. There are two main categories of methods to measure the uncertainty index of China's EPU. For data, this study used each province's daily newspapers because they are considered to provide the most official information. We carried out keyword searches to construct the EPU of China's 31 provinces. The construction of a provincial EPU index has never been attempted before. Our EPU index can accommodate China's regional heterogeneities. The provincial EPU can be applied to uncertainty studies in many other cases and enhance the accuracy of the existing studies. Secondly, this is the first study to examine the causal relationship between EPU and carbon emission intensity at the firm level in any country. This paper uses a sample of more than 660,000 Chinese manufacturing firms' observations to investigate emission behavior. This large number ensures accurate and reliable empirical results. Finally, to the best of our knowledge, this is the first paper to propose and test empirically the three channels through which EPU affects manufacturing firms' emission intensity. The proposed channels, specifically the firm innovation channel, share of fossil fuels in the total energy consumption channel, and energy intensity channel, are applicable to studying the carbon emission impact of other uncertainty indexes.

The rest of this paper is organized as follows: Section 2 is the literature review. Section 3 provides a detailed description of the empirical method, data sources, and construction of the key variables. Section 4 reports the empirical results. Section 5 presents the conclusions and implications.

2 Economic policy uncertainty and carbon emissions: a literature review

Our study is related to four streams in the literature. The first stream pertains to EPU in China. The numerous EPU studies in China all follow Baker et al. (2016), either directly applying the Baker China EPU index, or recalculating it on the basis of various newspaper sources. Furthermore, most of these empirical studies used monthly data and focused on aggregated data (see Table 1). A major drawback of the Baker China index is that the key source -- the *South China Morning Post* (SCMP) -- is an English newspaper. As a regional newspaper, it pays more attention to the dynamics of southern China and also Southeast Asia, and thus cannot reflect major news in mainland China. This single national index also fails to identify regional heterogeneity, which has been demonstrated as being significant with respect to energy and emissions (Shi et al., 2020; Yang et al., 2021).

[Insert Table 1 here]

To the best of our knowledge, only two recent studies constructed their own EPU indexed based on the Baker method. Li et al. (2020) constructed a China monthly EPU spanning January 1998 to April 2016 using three national newspapers: *People's Daily*, *Guangming Daily*, and *Economic Daily* as sources. Using monthly import data for about 5,000 kinds of products in China, they estimated the impact of EPU on the imports of these products. Huang and Luk (2020) counted the frequency of articles discussing EPU in ten leading Chinese-language newspapers.

The second stream is concerned with the factors that influence carbon emissions. There are many such studies, mainly at the cross-country level, aggregated level or sector levels. The factors include, but are not limited to, economic policy (Dietz and Venmans, 2019), economic development (Hepburn et al., 2019; Jorgenson, 2014), foreign direct investment (Abdouli and Hammami, 2017), financial development (Boutabba, 2014; Katircioğlu and Taşpinar, 2017; Zhang, 2011), income (Liu et al., 2019; Richmond and Kaufmann, 2006), trade (Ling et al., 2015), urbanization (Bekhet and Othman, 2017), technology progress (Du et al., 2019; Ye et al., 2020; Zhang et al., 2019b), R&D investment (Awaworyi Churchill et al., 2019), and even natural resource abundance (Balsalobre-Lorente et al., 2018; Li et al., 2019). Most of these studies are at the theoretical or macro level. Some of them found that economic policy, though not its uncertainty, does have an influence on emissions.

Studies that investigate the influencing factors on carbon emissions at the firm level are also emerging. Forslid et al. (2018) theoretically explained that firms' endogenous abatement investment is a key mechanism for achieving lower emission intensity in exporting firms when emissions are taxed and empirically demonstrated by Swedish firm-level data. Using a German firm dataset, Richter and Schiersch (2017) also found a negative relationship between export intensity and emission intensity. Alam et al. (2019) used a large set of firm-level data from G-6 countries and found that there is a significant negative effect between R&D investment and firms' energy consumption or carbon emission intensities.

The third stream of literature relates to the impact of EPU on firms. Empirical evidence suggests that higher EPU affects macroeconomic indicators, including tourism and GDP, and firms' financial performance and investment (Adedoyin and Zakari, 2020). The existing literature has demonstrated that EPU can affect economic activity, firm operation, and consumer behavior (Baker et al., 2016; Caldara et al., 2016; Dibiasi et al., 2018) and innovation (Bhattacharya et al., 2017). The literature has well documented that firms' investment decisions will be delayed by increased uncertainty (Bernanke, 1983; Bloom et al., 2007; Dibiasi et al., 2018; Kellogg, 2014). Through investigating the impact of policy uncertainty on Japanese manufacturing firms' investment sequence, Delios and Henisz (2003) found that countries with less policy uncertainty attracted more investment entries. Kalamova et al. (2013) found that policy uncertainty significantly causes a decrease in environmental patent activity, a proxy for innovation, while government support for R&D has a significant opposite effect. Bhattacharya et al. (2017) demonstrated that while firms' innovation activities are not affected by policies, they drop significantly during the period of policy uncertainty. Handley and Limão (2015) theoretically and empirically demonstrated that firms' investment and exports are damaged by trade policy uncertainty. In China's case, Feng et al. (2017) demonstrated that a decrease in trade policy uncertainty within fine product-level markets could induce firm entries to and firm exits from export activity. Julio and Yook (2016) revealed that FDI flows from US firms to foreign firms, and outward FDI (OFDI) dropped when uncertainty was high. A recent paper found that EPU will depress investment in fossil fuels but promote investment in renewable forms of energy in China (Liu et al., 2020).

The fourth stream is about the role of EPU on emissions. Only recently have there been some studies which have investigated the relationship between EPU and emissions. Using the carbon emissions data at the sector-level in the US, Yong Jiang et al.(2019) were the first to estimate the relationship between EPU and carbon emissions. They assumed that EPU could affect emissions through two channels: change of environmental governance and damage to firms' performance. Through the first channel, firms will reduce their efforts to reduce emissions. Through the second channel, firms could have ambiguous emission performance: low emissions due to poor performance or high emissions due to switching to cheaper but more polluting fuels. They found that EPU in the US not only affects the carbon emissions uncertainty, but also imposes a positive impact on carbon emissions growth in the tails of the emissions growth distribution. However, this study used sectoral aggregate data and was therefore not able to test how EPU might affect emissions.

The second paper on this topic investigated the causal relationship between EPU and emissions, and also energy consumption in G7 countries from 1998 to 2018. The authors found a unidirectional causality running from EPU to CO_2 emissions in Canada, Italy, the USA and Germany (Pirgaip and Dinçergök, 2020). The third and latest paper on this topic is Adedoyin and Zakari (2020), which used annual data between 1985 and 2017 for the UK within the framework of the energy-consumption emission nexus. Their study showed that the EKC hypothesis holds: low EPU reduces the growth of CO_2 emissions in the short run, while its long-run effect is positive. They argued that high EPU discourages firm investment and economic growth, which, in turn, reduces environmental concerns. In the depressed environment, industries will make up for the low turnover by shifting to cheap energy for production. However, over time, when the industries have increased their income, they might shift to cleaner energy for production and thus reduce emissions.

Unfortunately, there has been no study on whether and how the EPU may impact firms' carbon emissions. To fill this gap, we investigated the impact of EPU on the carbon emissions of manufacturing firms in China. In addition to the causal relationship between EPU and carbon emissions, based on the literature review, we put forward the following hypotheses:

EPU can affect firms' emissions through three channels: the firm innovation channel, share of fossil fuels in the total energy consumption channel, and energy intensity channel. With the continuous advance of technology, firms' emission intensity will decline. Increasing EPU could cause firms to delay investment (Bernanke, 1983), including in cleaner production technologies that reduce energy intensity and capital, and which increase energy intensity.

3 Methods and data

3.1 The empirical model

Based on the literature, we proposed the hypothesis that EPU will influence carbon emissions. Using an unbalanced panel data constructed from the China Taxation Survey (CTS) spanning 2008 to 2011, and a newly measured provincial EPU index in China, this paper employed a two-way fixed effect model to estimate the impact of EPU on manufacturing firms' carbon emission intensity (CEI). The specific model is shown as follows:

$$log\_CEI_{ijkt} = \alpha_0 + \alpha_1 \times log\_epu_{kt} + \alpha_2 \times X_{ijkt} + \theta_i + year_t + \varepsilon_{ijkt} \quad (1)$$

Here, i, j, k, t represent firm, industry, province, and year, respectively. log_CEI is the log value of manufacturing firms' CEI. The key explanatory variable is log_epu, which measures the log value of EPU in each province of China. Its construction is explained carefully in the following subsection. X is a set of control variables. The control variables are typical firm-level characteristics, including age, export status, subsidy, size, profit rate, and leverage ratio. θ_i and $year_t$ are firm- and year-specific fixed effects, ε_{ijkt} is the unobserved exogenous error term.

Our channel analysis is broadly based on a STIRPAT model (Stochastic Impacts by Regression on Population, Affluence and Technology). The STIRPAT model (Rosa and Dietz, 1998) was proposed to augment the standard IPAT framework that was proposed in the 1970s to understand the influence of changes in population (P), affluence (A), and technology (T) on environmental impacts (I) (Ehrlich and Holdren, 1971). Based on the IAPT framework, the Intergovernmental Panel on Climate Change (IPCC, 2000) further introduced the Kaya Identity to identify the main driving forces of GHG emissions.

The modified Kaya Identity of firm's emission intensity is shown as below:

$$e = \frac{C}{Y} = \frac{C}{F} \times \frac{F}{E} \times \frac{E}{Y} \tag{2}$$

in which, e is emission intensity measured as emission per unit of economic output; F is fossil fuel consumption; E is total energy consumption, and Y is economic output. $\frac{C}{F}$ measures the average emission efficient of fossil fuels, which indicates fuel switching among coal, natural gas and oil. $\frac{F}{E}$ is the share of fossil fuels in the total energy consumption. $\frac{E}{Y}$ is energy intensity.

While the Kaya Identity provides a basic framework to analyze the driving factors of emissions, it suffers from a few limitations, such as failure to accommodate other factors, linear relations, etc. (Vélez-Henao et al., 2019). For example, technical progress is often considered to be a key channel to reduce emissions (Beder, 1994), but cannot be reflected in the Kaya Identify. The STIRPAT model with regression methods can test the impact of various factors on the environment beyond population and affluence, such as technology progress and random variables not observable or controllable in the model. For example, the STIRPAT framework also allows cultural, institutional, and political factors to be considered as drivers of environmental impacts (Dietz and Rosa, 1994). Since our primary interest is on the firm level, rather than the aggregate environmental performance, we need to modify the framework. Based on the STIRPAT model, we test three channels through which EUP influences emission intensity at the firm level: the firm innovation channel, share of fossil fuels in the total energy consumption channel, and energy intensity channel.

3.2 Measurement of provincial EPU in China

Following the methodology of Baker et al. (2016), we constructed a set of EPU indexes at the provincial level in China. The steps were as follows: first, we selected the daily newspapers of 31 provinces in China as the source for news media reports.[1] Second, we made the following provisions on the definition of the EPU index obtained through keyword searches: if there was at least one economic policy keyword and at least one keyword expressing uncertainty, the news article was considered a target article. Third, we calculated the annual total number of target articles for each of the 31 provinces, and divided it by the total number of target articles in the newspapers that contained the keyword "economy" in that year, to obtain the article proportion of the EPU in the 31 provinces. Fourth, we standardized the proportion of EPU articles in the 31 provinces by using the standard deviation of each province to obtain the EPU index for the 31 provinces. In this paper, EPU was measured as the log value. Finally, according to the province-year code, we merged the EPU index of each province from 2008 to 2011 into each manufacturing firm

[1] Detailed information about the newspapers is provided in Table A.1 of the Appendix.

listed in the CTS.

China's provincial EPU index as constructed in this paper is significantly different from, and better than, Baker China EPU index in three aspects: it is the provincial EPU, which is more accurate, reliable and comprehensive. Baker et al. (2016) used English keywords for screening and index construction. However, the English keywords usually have less complicated semantics than Chinese keywords. For example, many Chinese keywords that are not included in Baker et al. (2016) also represent uncertainty, such as expected (*yuji, yuqi, youdai*), probably (*keneng, huoxu*), pilot (*shidian*), demonstration (*shifan*). From the perspective of index portrayal, Baker China EPU index used the *SCMP* as its textual data source. This paper is inclined to publish more subjective judgments about China's economic situation and policy adjustments. Therefore, Baker China EPU tended to understate or even distort EPU in China. For the selection of economic policy keywords, we followed the Baker principles, but modified them to account for China's specifical context. Firstly, we compiled word frequency statistics based on the *Annual Report of the Work on the Government (zhengfu gongzuo baogao*) and the "Five-year Plans" of the Chinese central government over the past 50 years, and manually screened out high-frequency keywords related to economic policy. Secondly, based on these, we randomly selected 3,000 articles from each of *People's Daily, Guangming Daily, and Economic Daily*. Employing the machine learning method, we verified whether each of these 9,000 articles was related to economic policy. Thirdly, after screening out the target articles, we then performed another round of manual screening to exclude irrelevant key words and finalized the basic terms of the economic policy keywords (see the details in Table 2). Following the same method, we finalized the key words for uncertainty. In order to exclude the economic policy and uncertainty of other countries, we made country prefix restrictions (*zhongguo, woguo, guonei*) for the above keywords (see the details in Table 2).

Second, our EPU is province specific and thus can introduce regional heterogeneity, while Bakers China EPU index treats China as a homogenous entity and is skewed toward South China. The provincial EPU constructed in this article has a broader coverage than Bakers China EPU. This geographical limitation in Baker China EPU not only limits the accuracy of its interpretation of the central government's policies, but also fails to reflect fully and comprehensively on the regional differences among China's provinces. By contrast, our work was not limited to one newspaper as the source of information, but employed the mainstream newspapers from 31 provinces (details can be found in Table A.1). This much broader scope ensured that our database contained more comprehensive information, with far better coverage of economic policy issues. Our provincially sourced information allowed us to construct EPU for each province. Most importantly, these mainstream newspapers from across the country are the main information sources of Chinese market participants. To a large extent, enterprises make their decisions on the basis of the reporting in these newspapers. Hence, the provincial EPU index constructed in this article is relevant to micro-enterprises' emission reduction behavior.

Third, the denomination of the two indexes are different and our provincial EPU excluded non-economy news. Baker China EPU was obtained by dividing the target articles by all the articles, while the provincial EPU constructed in this paper was obtained by dividing the target articles by articles that related only to the economy. The latter is superior to the former because many articles in the provinces are not related to economics, but to literature, sports, and culture.[2]

[2] The differences between Huang and Luk (2020) and China's provincial EPU in this article are mainly reflected in three aspects. The first difference is that this article selected 31 local newspapers from 31 provinces, , while Huang and Luk (2020) selected ten newspapers in mainland China (i.e. *Beijing Youth Daily, Guangzhou Daily, Jiefang Daily, People's Daily Overseas Edition, Shanghai Morning Post, Southern Metropolis Daily, The Beijing News, Today Evening Post, Wen Hui Daily, and Yangcheng Evening News*). The second difference between Huang and Luk (2020) and this article is in the selection of keywords on economic policy and uncertainty. The third and most important difference is that Huang and Luk (2020) calculated EPU at the national level, while this article constructed EPU at the provincial level.

[Insert Table 2 here]

3.3 Data sources and variable constructions

We employed comprehensive microdata on Chinese manufacturing firms from the China Taxation Survey (CTS) to examine the effect of EPU on manufacturing firms' CEI. Launched in 2007 by the Ministry of Finance of the People's Republic of China and Chinese State Administration of Tax, the CTS is a nationally representative annual longitudinal survey of Chinese firms (Chen et al., 2018). With firms as the target of sampling, the CTS provides detailed information on ownership, location, production, energy consumption (e.g., oil, coal, and electricity), and the balance sheet of manufacturing firms. Thus, this dataset allows us to measure manufacturing firms' carbon emissions. Within each province of China (excluding Tibet), the manufacturing firms were selected using an implicitly stratified and probability proportion to size sampling design. We had access to the CTS from 2008 to 2011 and obtained a subsample with a re-sampling ratio of about 50%. An unbalanced panel of manufacturing firms was used in this paper, with the number of manufacturing firms ranging from 86,071 in 2008 to 196,620 in 2011. In total, the observations amounted to 666,517.

Dependent variables

Manufacturing firms' CEI was the dependent variable in this paper. First, the total carbon emissions of each enterprise were obtained by multiplying the actual consumption of various energies (e.g., oil, coal, and electricity) in each enterprise by the carbon emission factor corresponding to each form of energy. From 2008 to 2011, the carbon emission factor of electricity fluctuated within the range of 0.8-1.3.[3] The carbon emission factor of coal was 1.829KgCO_2/Kg, while that of petroleum was 3.073KgCO_2/Kg (IPCC, 2006). Second, the CEI is equal to total carbon emissions

[3] All the details are presented in Table A.2 in the appendix.

divided by total business income. Third, we took the log value of the CEI in this paper (the unit is tons per thousand Chinese yuan).

Control variables

When we explored the effect of EPU on manufacturing firms' CEI, we controlled for a large set of firm characteristics that are recorded in the CTS to address issues with omitted variables. We constructed six variables to capture firms' age, export status, subsidy, size, profit rate, and leverage ratio, respectively (Cheng et al., 2021, 2020). Firm age was measured as the log value of the number of operating years since the firm's establishment. If a firm reported a positive exporting value in the survey year, we defined it as an exporter. Otherwise, it was treated as a non-exporter. Export status was a dummy variable, which equaled 1 if the firm was an exporter and 0 if it was a non-exporter. The subsidy was also a dummy variable. If the enterprise had received the government financial subsidy, it was denoted as 1, otherwise 0. Firm size was proxied by total assets and was measured as the log value of total assets. We divided total liability by total assets to define the leverage ratio, and used total profits divided by total sales to measure the profit rate.

In addition to these control variables, we used firm innovation, the proportion of fossil fuel consumption, and energy intensity, to test the potential channels of manufacturing firms' CEI responses to EPU. Innovation was taken as the log value of R&D expenditure divided by fixed assets. The proportion of fossil fuel consumption referred to the proportion of enterprise fossil fuel consumption (including coal and oil in this paper) in total energy consumption (including coal, oil, and electricity). Energy intensity was equal to energy consumption divided by gross output. Subsequently, we aimed to exclude obvious outliers. To mitigate the concern of outliers, we winsorized the top and bottom 0.5% of all the continuous variables from their distributions.

Table 3 reports the descriptive statistics of the key variables in this paper. Table 3 indicates that the average log value of the CEI was 0.102 and its standard deviation was 0.176. This demonstrates that the CEI of different enterprises was obviously different. The average log value and standard deviation of EPU was 0.989 and 0.696, respectively. This result shows that the EPU of the 31 provinces demonstrated a huge difference from 2008 to 2011, which could also be verified from the minimum value (0.041) and the maximum value (3.683). Among the enterprises surveyed, about 26.6% were exporters, and about 17.6% had received government subsidies. The average value of the enterprises' profit rate was -0.6%, and the median was 0.7%, indicating that the profit rate of the surveyed enterprises was at a low level. The average value of the debt ratio of the enterprises was 56.1%. The mean of the log value of R&D intensity was 0.01, indicating that the R&D density of Chinese manufacturing enterprises was at a low level. From the perspective of the enterprises' energy consumption, the average share of fossil fuel consumption was 31.2%, and the average CEI value was 0.029 tons of standard coal per thousand Chinese yuan.

[Insert Table 3 here]

Figure 1 indicates that from 2008 to 2011, the EPU index of the 31 provinces showed obvious dynamic characteristics that changed over time, and there were significant differences in the EPU index across provinces. In 2008, the EPU index of Liaoning province was the highest. Ningxia Hui Autonomous Region had the second-highest value and Jiangxi province had the third-highest value. In 2009, the top three provinces in the EPU index were Zhejiang province, Jiangsu province, and Heilongjiang province, and the EPU index of the three provinces exceeded 120. Compared with the previous year, the EPU index of these three provinces exhibited rapid growth in 2009. In 2010, Guangdong province replaced Zhejiang province as the one with the highest EPU index and its value was over 250, indicating that Guangdong province's economic policies underwent major changes in 2010. Zhejiang province and Shanghai ranked second and third, respectively, and their EPU index was also over 200. Shanghai's EPU index ranked first in 2011, with a value of 368. Inner Mongolia and Tibet closely followed, sharing an EPU index of 137. Overall, the EPU index of the eastern coastal areas was generally higher than that of western inland areas.

[Insert Figure 1 here]

4 Empirical analysis

In this section, we investigate the impact of EPU on Chinese manufacturing firms' CEI and test the potential channels of manufacturing firms' CEI responses to EPU.

4.1 Baseline results

Table 4 indicates the effect of EPU on Chinese manufacturing firms' CEI. Column (1) is the simplest case in which we did not control for firm-level characteristics and without clustering standard errors. It shows a significant positive coefficient for EPU, meaning that a higher EPU can increase manufacturing firms' CEI. Controlling for fixed effects and firm-level characteristics, Columns (2) and (3) show the regression results without and with clustering standard errors. The results were still the same as Column 1. This result indicates that increased EPU would increase the carbon intensity of manufacturing enterprises. In other words, reducing the economic policy uncertainty and maintaining policy stability will help reduce the carbon intensity of manufacturing enterprises. One possible explanation is that when enterprises face increased economic policy uncertainty, in order to avoid the risks caused by policy fluctuations, enterprises tend to use cheap and dirty fossil fuels for faster recovery of investment, resulting in increased carbon emission intensities. This view is consistent with the research conclusions of the existing literature (Yong Jiang et al., 2019). In order to carefully verify the findings, this paper empirically tested this view in the following mechanism analysis.

For the control variables, we found that the impacts of firm age, export status, and leverage ratio on manufacturing firms' CEI were insignificantly negative at the 10% significance level. Furthermore, the results showed that the larger the scale and higher the profit rate of the enterprises, the lower their carbon emission intensities. By contrast, government subsidies increased the intensity of enterprises' carbon emissions.

[Insert Table 4 here]

4.2 Channels analysis

In this paper, we tried to analyze the impact of EPU on the CEI of Chinese manufacturing enterprises from three mechanisms. Columns (1) and (2) in Table 5 were mainly used to test whether the EPU can affect the CEI of enterprises through the innovation mechanism. We can see that EPU had no significant impact on enterprise innovation, and the effect of enterprise innovation on reducing enterprise carbon emissions was not significant. This result is different from the existing literature. One possible reason is that enterprise innovation is a long-term behavior. Thus, because the time span of this paper was only four years (2008-2011), it could not fully reflect the innovation transmission channel through which EPU affects the carbon emission intensity of enterprises. In the future, if enterprise survey data covering a longer time span can be obtained, a more rigorous empirical test could be conducted.

Columns (3) and (4) in Table 5 were mainly used to test whether EPU could pass through the channel of the proportion of fossil fuel in the total energy consumption to affect the intensity of firms' carbon emissions, or *energy mix effect*. Columns (3) and

(4) in Table 5 present the impact of EPU on the proportion of fossil fuel consumption and its impact on manufacturing firms' CEI, respectively. We found that EPU has a significant positive effect on the proportion of fossil fuel consumption. The coefficient was 0.078, indicating that when EPU increased by 1%, the proportion of fossil fuel consumption could increase by 0.078%. Furthermore, Column (4) indicates that the impact of the proportion of fossil fuel in the total energy consumption on manufacturing firms' CEI was significantly positive. This suggests that the proportion of fossil fuels in the energy mix is an important mediation to link EPU and firms' CEI. The mediation effect played by the proportion of fossil fuels in the total energy consumption, in the total effect of EPU on firms' CEI, accounted for 15.6%.

Columns (5) and (6) in Table 5 were mainly used to test whether the EPU could affect the enterprise's CEI through the energy intensity channel. Columns (5) and (6) in Table 5 show that both the impact of EPU on firms' energy intensity and the influence of firms' energy intensity on the CEI were significantly positive at the 1% significance level. This result suggests that the energy intensity channel is an important mediation to link EPU and manufacturing firms' CEI in China. More importantly, this result strongly supports the conclusion of the existing research that when enterprises face increasing economic policy uncertainty, they tend to use more of the relatively cheap fossil fuels, and this in turn leads to increased carbon emission intensity. From the magnitude of the mediation effect, the energy intensity channel accounted for 69.6%, suggesting that the mediation effect of energy intensity was greater than that of the proportion of fossil fuels in the total energy consumption.

[Insert Table 5 here]

4.3 Robustness check

We conducted a battery of robustness checks for our baseline analysis. First, we used the instrument variables to solve the missing variables and endogenous problems that could exist in the estimation. On the one hand, we used the previous year's EPU of the province where the enterprise was located as the instrumental variable of the current year's EPU. On the other hand, we also used the difference between the previous year's EPU of the province and the average EPU of the local area in the previous year (i.e., eastern region, central region, western region, and northeastern region) as the instrument variable of the current year. The regression results are shown in Table 6. It can be seen that EPU had a significant negative correlation with both instrument variables, and that it had a significant positive impact on the enterprises' CEI, which manifests that the basic results in Table 4 are robust. At the same time, all the F statistics were higher than 10, indicating that the weak instrument variable test had been passed. One possible explanation for the negative correlation between EPU and the two instrumental variables was that policymakers generally consider the impact of policy changes on economic activities when formulating or changing policies. Therefore, when policymakers implement a policy, they always allow it to operate for a period of time before making any changes to it. This kind of policy continuity often reduces the uncertainty of the economic policy in the next year.

[Insert Table 6 here]

Second, we replaced the CEI of enterprises with a total amount of enterprises' carbon emissions. The regression results are shown in Table 7. The results indicated a significant positive coefficient for EPU at the 1% significance level, meaning that a higher EPU can increase manufacturing firms' CEI in China. This is completely consistent with the result in Table 4.

[Insert Table 7 here]

Third, we replaced the unbalanced panel data with balanced panel data to examine the impact of EPU on the CEI of continuously existing enterprises. The regression results are shown in Table 8. Table 8 indicates that EPU had a significant positive effect on firms' CEI, which is consistent with Table 6.

[Insert Table 8 here]

Finally, we excluded the 2009 data to control interference from the global financial crisis on the conclusions of this article. The global financial crisis broke out in the second half of 2008, and the Chinese government only began to formulate various stimulus plans at the end of 2008 to deal with the negative impact of the crisis. In November 2008, the State Council launched a four-trillion economic stimulus plan to further expand domestic demand and promote steady and rapid economic growth. But it took some time from the launch of economic policies to the adjustment and change in enterprise production. In other words, there was a time lag in the transmission chain from the government's policy formulation, implementation, to the effect of the policy, and the final impact on enterprise carbon emissions. Therefore, we believe that the impact of the global financial crisis on Chinese enterprises' emission reduction occurred mainly in 2009 rather than 2008. Therefore, we added the regression results, excluding the observations in 2009, and carried out econometric regressions respectively by using unbalanced panel data and balanced panel data. The results are shown in Table 9. After excluding the 2009 observations, China's provincial EPU still had a very significant positive impact on enterprise carbon emissions. This is completely consistent with the baseline results in this article. All of the robustness checks suggested that the empirical results in this paper were robust.

[Insert Table 9 here]

5 Conclusions and implications

Studies on economic policy uncertainty have proliferated in recent years, but until now, the impact of EPU on firms' emissions has not been examined. Using a newly constructed provincial EPU, this paper investigated the impact of EPU on the emissions from China's manufacturing firms. It is the first paper to propose and test empirically the three channels through which EPU affects manufacturing firms' emission intensity.

The results indicate that increased EPU increases the carbon intensity of manufacturing enterprises. Furthermore, the larger the scale and higher the profit rate of the enterprises, the lower their carbon emission intensity. Government subsidies increase the intensity of corporate carbon emissions. Among the three channels, the innovation channel was found to be insignificant, while the share of fossil fuels in the total energy consumption (the fuel mix channel), and the energy intensity channels were found to be significant.

These findings and the three-channel analysis have the following implications. First, the Chinese government should strive to maintain the continuity and stability of domestic economic policies to reduce the negative impact of economic policy fluctuations on optimization of the country's energy consumption structure and the emission reduction efforts of the enterprises. This paper found that changes in economic policies affect the energy consumption and emission reduction behaviors of the enterprise. When enterprises face increasing economic policy uncertainty, they use cheaper and dirtier fossil fuels, and this leads to increased carbon emission intensities. This is very much contrary to the emission reduction targets that China is actively pursuing.

Second, since government financial subsidies have an inhibitory effect on enterprise emission reduction efforts, they have another reason to be abolished. The money saved could be diverted to support research, development, and deployment of low carbon technologies. Third, the phase-out of fossil fuels and the improvement in energy intensities should be continuously promoted. The existing policies on energy caps, energy intensity targets, and emissions trading are all conductive to reduce firm emissions.

Lastly, firm merger and conglomeration should be supported and promoted in order to achieve better emission performance. Using the same logic, improvements in financial performance should also be advanced, given the external benefits from emission reduction. The implications drawn from the China case are applicable to other countries, especially developing countries with poor economic policy stability. In the global quest to reduce emissions, firms are key agents, and how to weaken the inhibitory effect of EPU on enterprise emissions is a common challenge faced by all governments.

One caveat of this paper is that the CTS survey data cannot accurately identify the investment destination of the enterprise, that is, whether to invest in the traditional forms of energy or in clean forms of energy. Therefore, it is impossible to verify the impact of economic policy uncertainty on the carbon emission intensity of enterprises from the investment transmission channel. In the future, if relevant data becomes available, we would like to conduct much more detailed mechanism inspection and analysis.

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Tables and figures

Table 1 China case studies that applied EPU from Baker et al. (2016)

Article	Indexes	Issues
(Z. Wang et al., 2020)	monthly EPU of China and US	Investigate the asymmetric volatility spillovers between EPU and stock markets
(Fontaine et al., 2018)	monthly EPU of China	Study the spillover effect from a shock of Chinese EPU to developed and emerging economies
(Yonghong Jiang et al., 2019)	monthly EPU of China and US	Explore determinants of spillovers of categorical policy uncertainties within and across China and the US
(Xia et al., 2020)	monthly EPU of China	Examine the dynamic characteristics of information spillover effect among EPU, stock and housing markets in China's first-, second- and third-tier cities
(Yen and Cheng, 2020)	monthly EPU of China, US, Japan, and Korea	Investigate the relationship between EPU and cryptocurrency volatility
(Sha et al., 2020)	monthly EPU of China	Investigate the relationship between EPU and mergers and acquisitions (M&As) in China
(Zhang et al., 2019a)	monthly EPU of China and US	Investigate the relationship between the EPU of China and the US and estimate their impact on the global markets.
(Dang et al., 2019)	monthly EPU of China	Study how EPU affects the corporate tax burden in China
(Chen et al., 2020)	EPU of China	Investigate the impact of EPU on China's exchange rate volatility
(Li and Zhong, 2020)	global EPU	Explore the global EPU on China's financial conditions index and analyze the sources of uncertainty shocks
(Liu et al., 2020)	quarterly EPU of China	Investigate the differential impact of EPU on different types of energy enterprises' investment
(X. Wang et al., 2020)	monthly EPU of China	Estimate the impact of EPU on volatility of China's financial stocks
(He et al., 2020)	EPU of China	Examine the effects of EPU on corporate innovation

Table 2 Comparison of keywords criteria between Baker's China EPU and China's provincial EPU

Keywords criteria	Baker's China EPU	China's provincial EPU
Economic	economy, economic	经济
Policy	policy, spending, budget, political, interest rate, reform, government, Beijing, authorities, tax, regulation, regulatory, Central Bank, People's Bank of China, PBOC, deficit, WTO	（促进、刺激、扩大）消费、调整利率/利率调整、（扩大、减少）投资、（增加、减少）税收/减税/税收政策/财税改革、财政支出/财政体制/财政刺激、货币/货币政策、扩大出口、增值税/消费税/企业所得税/个人所得税/房产税/关税、转移支付、地方债务、养老金、政策试点、加强监管
Uncertainty	uncertain, uncertainty	不确定、预测、预计、试点、试行、示范、或许、可能、有待、有望
Country	China, Chinese	中国，我国，国内
Sources	From Baker et al. (2016)	In this article

Table 3 Descriptive statistics of primary variables

Variables	Description	Observations	Mean	S.D.	Min	Median	Max
log_CEI	Log value of firms' carbon emission intensity	666,517	0.102	0.176	0.001	0.038	1.333
log_epu	Log value of economic policy uncertainty	666,517	0.989	0.696	0.041	0.836	3.683
log(age)	Log value of firm age	643,519	1.949	0.642	0	2.079	3.091
export	Export status	666,476	0.266	0.442	0	0	1
subsidy	Dummy variable	615,305	0.176	0.381	0	0	1
Firm size	Log value of total assets	645,046	9.271	1.700	4.934	9.255	14.48
rate_profit	Total profits divided by total sales	648,997	-0.006	0.137	-0.997	0.007	0.498
leverage	Total liability divided by total assets	595,160	0.561	0.283	0	0.602	1
log_RD inten	Log value of R&D intensity	337,650	0.010	0.055	0	0	0.693
share_fuel	Share of fossil fuels in the total energy consumption	655,174	0.312	0.355	0	0.127	0.986
energy_y	Energy intensity	617,991	0.029	0.065	0.000	0.007	0.615

Notes. The value of EPU for Tibet in 2008 is missing. Export status equaled 1 if the firm was an exporter, and 0 otherwise. Subsidy is a binary variable taking a value of 1 if the firm had received fiscal subsidies from the government, and 0 otherwise. All the monetary values are in units of thousand Chinese yuan. The unit of log_CEI is thousand Chinese yuan per ton. The unit of energy_y is tons of standard coal per thousand Chinese yuan.

Table 4 Effect of EPU on manufacturing firms' CEI

	(1) log_CEI	(2) log_CEI	(3) log_CEI
log_epu	**0.004*** **	**0.004*** **	**0.004*** **
	(0.000)	(0.000)	(0.000)
log(age)		-0.003**	-0.003
		(0.002)	(0.002)
export		-0.001	-0.001
		(0.001)	(0.001)
subsidy		0.002***	0.002***
		(0.001)	(0.001)
Firm size		-0.006***	-0.006***
		(0.001)	(0.001)
rate_profit		-0.098***	-0.098***
		(0.004)	(0.006)
leverage		-0.001	-0.001
		(0.002)	(0.002)
Fixed Effects?	Y	Y	Y
Clustering SE?	N	N	Y
Observations	464,555	344,258	344,258
Adjusted R-squared	0.676	0.689	0.689

Notes. Fixed effects included *individual- and year-fixed effect.* We clustered standard errors at the four-digit industry level when indicated. Standard errors are in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

Table 5 The channel analysis with the full sample

	(1) log_RDinten	(2) log_CEI	(3) share_fuel	(4) log_CEI	(5) energy_y	(6) log_CEI
log_epu	0.000	-0.000	**0.078*** **	**0.003*** **	**0.002*** **	**0.001*** **
	(0.000)	(0.001)	(0.003)	(0.000)	(0.000)	(0.000)
log_RDinten		-0.007				
		(0.005)				
share_fuel				**0.008* **		
				(0.004)		
energy_y						**1.392*** **
						(0.031)
log_output						
log(age)	0.001	0.003	0.005	-0.004**	0.000	-0.004***
	(0.001)	(0.003)	(0.004)	(0.002)	(0.001)	(0.001)
export	-0.001	-0.003*	-0.019***	-0.002	-0.001	-0.001
	(0.001)	(0.002)	(0.006)	(0.001)	(0.001)	(0.001)
subsidy	0.004***	-0.001	0.012***	0.002**	0.000	0.001
	(0.001)	(0.001)	(0.003)	(0.001)	(0.000)	(0.001)
Firm size	-0.001*	-0.007***	-0.001	-0.006***	-0.002***	-0.002**
	(0.001)	(0.002)	(0.002)	(0.001)	(0.000)	(0.001)
rate_profit	0.003*	-0.086***	0.023***	-0.100***	-0.020***	-0.070***
	(0.002)	(0.011)	(0.009)	(0.006)	(0.002)	(0.005)
leverage	0.000	0.004	0.002	-0.003	-0.000	-0.003*
	(0.001)	(0.003)	(0.004)	(0.002)	(0.001)	(0.002)
Fixed Effects?	Y	Y	Y	Y	Y	Y
Clustering SE?	Y	Y	Y	Y	Y	Y
Observations	145,324	145,324	336,991	336,991	311,512	311,512
Adjusted R-squared	0.784	0.750	0.725	0.688	0.644	0.809

Notes. Fixed effects included *individual- and year-fixed effect.* We clustered standard errors at the four-digit industry level when indicated. *** p<0.01, ** p<0.05, * p<0.1.

Table 6 IV regression for the effect of EPU on manufacturing firms' CEI

	(1) log_epu	(2) log_CEI	(3) log_epu	(4) log_CEI
log_epu		**0.004***		**0.009*****
		(0.002)		(0.003)
IV_1	**-0.239*****			
	(0.011)			
IV_2			**-0.233*****	
			(0.018)	
log(age)	0.003	-0.000	0.008	-0.000
	(0.013)	(0.003)	(0.013)	(0.003)
export	0.388***	-0.004**	0.390***	-0.005***
	(0.021)	(0.002)	(0.021)	(0.002)
subsidy	-0.019**	0.001	-0.020**	0.001
	(0.008)	(0.001)	(0.008)	(0.001)
Firm size	-0.022***	-0.003*	-0.019**	-0.003*
	(0.007)	(0.002)	(0.008)	(0.002)
rate_profit	0.011	-0.085***	0.021	-0.085***
	(0.023)	(0.010)	(0.023)	(0.010)
leverage	0.024**	-0.003	0.024*	-0.003
	(0.012)	(0.003)	(0.012)	(0.003)
Fixed Effects?	Y	Y	Y	Y
Clustering SE?	Y	Y	Y	Y
Observations	126,329		126,329	
F statistic	481		176	
Cragg-Donald Wald F statistic	5,652		4,330	
Kleibergen-Paap Wald rk F statistic	481		176	
Anderson-Rubin Wald test	Chi-sq(1)=5.87**		Chi-sq(1)= 21.36***	

Notes. Fixed effects included *individual- and year-fixed effect.* We clustered standard errors at the four-digit industry level when indicated. *** p<0.01, ** p<0.05, * p<0.1.

Table 7 Effect of EPU on manufacturing firms' carbon emission

	(1) Log(carbon emission)	(2) Log(carbon emission)	(3) Log(carbon emission)
log_epu	**0.142*****	**0.141*****	**0.141*****
	(0.003)	(0.004)	(0.007)
log(age)		0.037***	0.037**
		(0.013)	(0.016)
export		0.049***	0.049***
		(0.011)	(0.016)
subsidy		0.036***	0.036***
		(0.008)	(0.009)
Firm size		0.137***	0.137***
		(0.008)	(0.010)
rate_profit		0.587***	0.587***
		(0.030)	(0.047)
leverage		0.029*	0.029
		(0.017)	(0.019)
Fixed Effects?	Y	Y	Y
Clustering SE?	N	N	Y
Observations	454,229	336,866	336,866
Adjusted R-squared	0.786	0.808	0.808

Notes. Fixed effects included *individual- and year-fixed effect.* We clustered standard errors at the four-digit industry level when indicated. *** p<0.01, ** p<0.05, * p<0.1.

Table 8 Regression with the balanced panel data

	(1)	(2)	(3)
	log_CEI	log_CEI	log_CEI
log_epu	**0.008*****	**0.006*****	**0.006*****
	(0.001)	(0.001)	(0.001)
log(age)		-0.004	-0.004
		(0.003)	(0.003)
export		0.003	0.003
		(0.002)	(0.003)
subsidy		0.002	0.002
		(0.001)	(0.002)
Firm size		-0.005***	-0.005***
		(0.002)	(0.002)
rate_profit		-0.088***	-0.088***
		(0.008)	(0.010)
leverage		-0.012***	-0.012***
		(0.004)	(0.004)
Fixed Effects?	Y	Y	Y
Clustering SE?	N	N	Y
Observations	79,068	62,830	62,830
Adjusted R-squared	0.626	0.657	0.657

Notes. Fixed effects included *individual- and year-fixed effect.* We clustered standard errors at the four-digit industry level when indicated. *** p<0.01, ** p<0.05, * p<0.1.

Table 9 Regression results excluding the observations in 2009

	(1)	(2)	(3)	(4)
		Unbalanced panel		Balanced panel
	log_CEI	log_CEI	log_CEI	log_CEI
log_epu	0.003***	0.001**	0.008***	0.004***
	(0.000)	(0.000)	(0.001)	(0.001)
log(age)		-0.000		-0.004
		(0.002)		(0.003)
export		0.003**		0.008**
		(0.001)		(0.003)
subsidy		0.002**		0.003
		(0.001)		(0.002)
Firm size		-0.008***		-0.008***
		(0.001)		(0.002)
rate_profit		-0.090***		-0.090***
		(0.006)		(0.012)
leverage		0.001		-0.009**
		(0.002)		(0.004)
Fixed Effects?	Y	Y	Y	Y
Clustering SE?	Y	Y	Y	Y
Observations	274,942	196,933	70,284	52,523
Adjusted R-squared	0.699	0.716	0.641	0.683

Notes. Fixed effects included *individual- and year-fixed effect*. We clustered standard errors at the four-digit industry level when indicated. Standard errors are in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

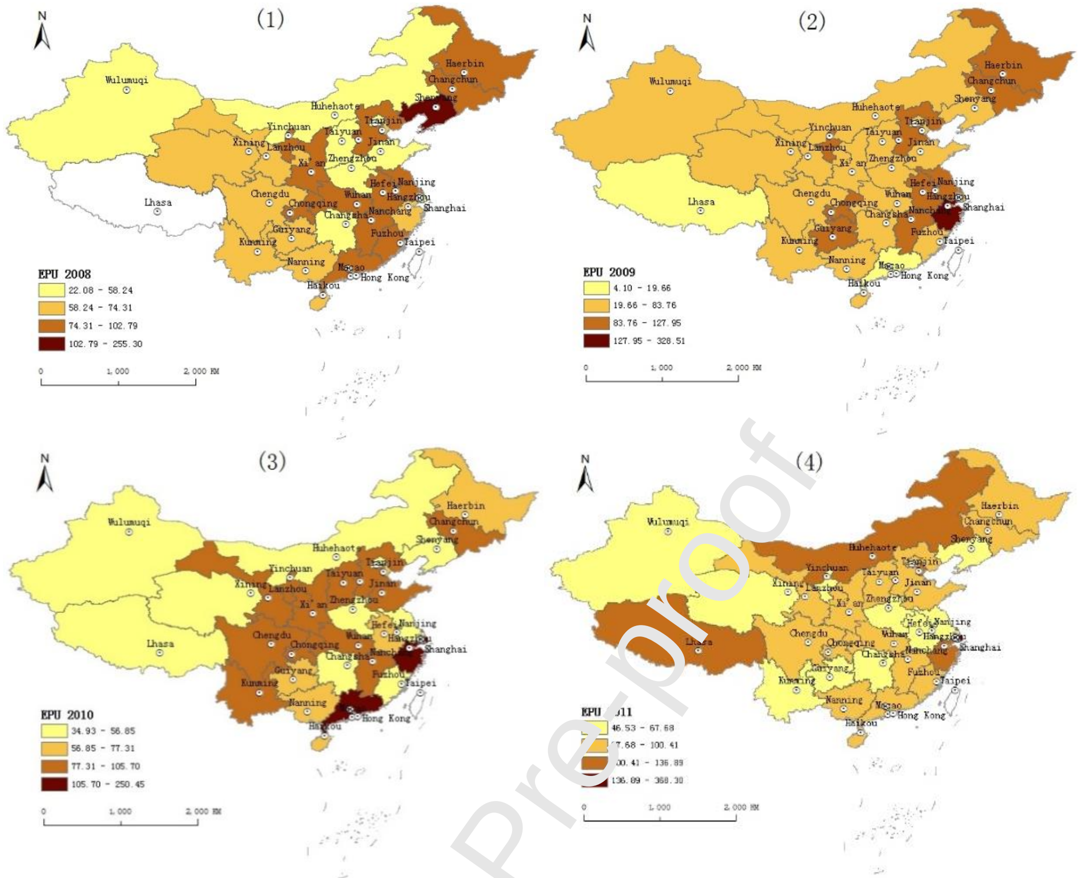

Fig. 1 Distribution of EPU index in 31 provinces in mainland China

Appendix A

Table A.1 The selection of newspapers and number of economy-related newspaper texts in each province

Province	Newspaper (all in Chinese)	The number of economy-related newspaper texts
Beijing	Beijing Daily	55,370
Tianjin	Tianjin Daily	33,370
Hebei	Hebei Daily	51,854
Shanxi	Shanxi Daily	70,638
Inner Mongolia	Inner Mongolia Daily	35,098
Liaoning	Liaoning Daily	48,839
Jilin	Jilin Daily	69,689
Heilongjiang	Heilongjiang Daily	46,724
Shanghai	Jiefang Daily	37,874
Jiangsu	Xinhua Daily	41,213
Zhejiang	Zhejiang Daily	37,215
Anhui	Anhui Daily	26,369
Fujian	Fujian Daily	40,693
Jiangxi	Jiangxi Daily	33,868
Shandong	Dazhong Daily	24,203
Henan	Henan Daily	47,257
Hubei	Hubei Daily	71,167
Hunan	Hunan Daily	37,887
Guangdong	Southern Daily	54,842
Guangxi	Guangxi Daily	43,432
Hainan	Hainan Daily	4,631
Chongqing	Chongqing Daily	34,539
Sichuan	Sichuan Daily	48,518
Guizhou	Guizhou Daily	37,622
Yunnan	Yunnan Daily	41,070
Tibet	Tibet Daily	26,294
Shaanxi	Shaanxi Daily	58,054
Gansu	Gansu Daily	65,637
Qinghai	Qinghai Daily	36,729
Ningxia	Ningxia Daily	29,429
Xinjiang	Xinjiang Daily	25,320

Sources: authors' calculation. China's provincial EPU in this article was constructed using monthly data from May 2000 to July 2017. However, since the time span of CTS was from 2008 to 2011, the matched data retained China's provincial EPU from only 2008 to 2011. According to the arithmetic mean, the annual EPU of China's provinces from 2008 to 2011 could be calculated.

Table A.2 Electricity emission factors for China's seven power grids

Year	North China Power Grid	Northeast China Power Grid	East China Power Grid	China Central Power Grid	Northwest China power grid	China Southern Power Grid	Hainan Power Grid
2008	1.1169	1.2561	0.9518	1.2783	1.1225	1.0634	0.8944
2009	1.0069	1.1293	0.8825	1.1255	1.0246	0.9987	0.8154
2010	0.9914	1.1109	0.8592	1.0871	0.9947	0.9762	0.7972
2011	0.9803	1.0852	0.8367	1.0297	1.0001	0.9489	0.9489

Notes: The North China Power Grid covers Beijing, Tianjin, Hebei, Shanxi, Shandong, and Inner Mongolia.
The Northeast China Power Grid covers Liaoning, Jilin, and Heilongjiang.
The East China Power Grid covers Shanghai, Jiangsu, Zhejiang, Anhui, and Fujian.
The China Central Power Grid covers Henan, Hubei, Hunan, Jiangxi, Sichuan, and Chongqing.
The Northwest China Power Grid covers Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang.
The China Southern Power Grid covers Guangdong, Guangxi, Yunnan, and Guizhou.
In 2011, Hainan Power Grid was incorporated into the China Southern Power Grid, so it was calculated with the emission factor of the China Southern Power Grid since 2011.

Jian Yu: Data curation, Writing- Original draft preparation; **Xunpeng Shi**: Conceptualization, Writing- Reviewing and Editing; **Dongmei Guo**: Software, Methodology; **Longjian Yang**: Writing

Highlights

- A new provincial economic policy uncertainty (EPU) index is constructed
- First study to investigate the impact of EPU on carbon emission intensity at the firm level in China
- The EPU index of eastern coastal areas is higher than that of western inland areas
- The fuel mix and energy intensity channels are significant, but the innovation channel is not
- Chinese firms prefer to use cheap and dirty fossil fuels to react to the rising EPU