

Literature Review of Frontier Research on Meteorological Economics

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After its emergence, Meteorological Economics has been enriched and developed more than 40 years. Currently, scholars have already made a plenty of relevant explorations, mainly in the areas of peak carbon dioxide emissions, carbon neutrality, extreme weather, food security, etc. These researches are of great significance in deepening the theory and practice of meteorological economics as well as constructing meteorological economics with Chinese characteristics.

1. Research Related to Peak Carbon Dioxide Emissions, Carbon Neutrality

At present, more than 100 countries world have made commitments on carbon neutrality and the issue of emission peak has also received widespread concern. Consequently, countries around the world have begun to develop carbon taxes and carbon markets. As a result of the outbreak of Ukraine Crisis, the increase in uncertainty in the international carbon market has led to a gradual increase in research on the variables that influence the carbon market.

Park et al. (2023) studied the impact of climate and socio-economic changes on fire carbon emissions. The authors build a fire carbon emissions simulation by historical data to categorize the impact on global warming and socioeconomic development (land use). The results show that though increased population density reduces carbon emissions in most areas, population growth leads to fire growth in less densely populated areas, while growth in GDP per capita can reduce future fire carbon emissions. In contrast to previous findings, the study concluded that changes in GDP per capita and land use result in larger future fires in SSP3 states than in SSP2.

Wongpiyabovorn, Plastina and Crespi (2022) discussed the current state of the voluntary Ag carbon markets and analysed the main challenges to agricultural carbon credits from both the supply and demand side. This paper infers that setting a specific international carbon credit trading standard could help to reduce the systemic risk of farmers, ranchers and private forest landowners participating in the voluntary carbon market and thus expand the market. The authors proposed some hypothesis: if demand for carbon credits is high but awareness of agricultural carbon credits is low, market liquidity will be low and average price volatility will be high; and subsidizing low-carbon-credit-demand firms leads to market inefficiencies.

With the crisis in the European energy market, the importance of new energy sources has been highlighted. Wind power, hydro power and many other modes of power generation are closely linked to meteorological conditions which makes European researchers focus on the factors that influence the price of electricity. A recent study (Sgarlato & Ziel 2023) attempted to construct an hourly electricity cost prediction model using forecast data directly from European weather rather than the traditional forecasts based on the energy production and consumption model. The results show that benefiting from autoregressive effects, weather forecasts one day in advance could improve the accuracy of electricity price forecasting models, but longer-range forecasts are less effective. Forecasts featuring meteorological data showed greater accuracy, with regional meteorological indicators improving accuracy by 10%-20%.

2. Research Related to Extreme Weather Issues

The issue of extreme weather has received a lot of attention in recent years, so scholars are beginning to devote to the

study of the possible impacts of climate shocks on economic development. Choudhary and Sirohi (2022) focus on the vulnerability of agricultural production systems to climate stresses. They analysed the vulnerability characteristics and their spatial distribution in the Gangetic Plain region using data from the northern plains of India. The outcomes show that developing accurate warning system of extreme heavy rainfall, and developing low-cost precision agricultural and dairy farming techniques are good methods to deal with high exposure levels in the subtropics. The authors argue that the economic viability of mechanisation on small resource-poor farms is low and suggest that dairy can be an important means of building the adaptive capacity of smallholder farmers.

The economic impact of flooding has likewise received attention from researchers in recent years. Economic losses due to flood-induced business interruptions have been examined (Tanoue, Yamazaki & Hirabayashi 2022). The researchers used the CaMa-Flood model in combination with atmospheric and geographic data to simulate flood risk. The study concluded that business interruption losses are greater in flat river basins and are more susceptible to climate change, while changes in flood control levels do not affect the ratio of business interruption losses to GDP losses.

An earlier paper similarly examined the economic losses in manufacturing due to extreme weather-induced flooding (Li, Wen, Xu, Li & Du 2018). The authors' estimates of firms' output losses are based on asset and labour losses data of Shanghai firms from the China Industrial Enterprises Database. The results indicate that a 1,000-year flood without levee protection would result in direct asset losses of about \$21 billion for affected manufacturing firms in the Huangpu River Basin, including \$12 billion in fixed asset losses and \$9 billion in inventory losses.

3. Research Related to Food Security Issues

Reed et al. (2022) examined the impact of floods on food security in Africa. The study uses the number of times floods occur and the area affected by floods from a macro perspective to compare with differences in levels of food security. The data show that the occurrence of floods is associated with a weakening of food security; and the meteorological conditions that trigger floods can have both positive and negative impacts on food security, which can occur independently or simultaneously and manifest themselves in different time steps after their occurrence. This paper models and provides quantitative evidence of the relationship between flood preparedness and food security for a quantitative analysis of the extent to which floods affect food security at different times and locations.

Ahmadzai, Malhotra and Tutundjian (2023) analysed the inter-annual stochastic variation of dust storms in Mongolia using fixed-effects regression to assess the impact of dust storms on crop yields and livestock income. The study used a panel data model to estimate agricultural outcome variables and showed that an additional dust storm would lead to a decline of about 3% in crop and livestock gross product, with losses equivalent to \$37.8 million. Most crops have experienced a significant decrease in yield due to sandstorms, with wheat being the most affected, followed by fruits and vegetables.

Ravichandran et al. (2022) identified the overall drought impact area through the Multiple Drought Severity Index (MDSI). They compared the findings with socio-economic factors to highlight pockets of vulnerability, revealing the ability of individuals and management to mitigate the impact of future events. Studies have shown that higher population and household densities can lead to overexploitation of regional resources, which makes the local capacity to overcome severe droughts poorer. Regions with surface water will benefit from water resources and will only suffer relatively minor socio-economic stresses when severe droughts occur. The article argues that crop rotation is necessary in drought-affected agricultural areas to maintain soil moisture and nutrient levels.

The unpredictability of food prices resulting from recurrent extreme weather conditions has raised concerns among certain scholars, leading to a gradual increase in research on the subject. Gu et al. (2022) concentrate on analyzing the influence of climatic anomalies on the price fluctuations of agricultural products in Korea. They attempted to predict the price and trading volume of agricultural products using meteorological data through Dual Input Attention Long Short Term Memory neural network. The agricultural price forecasting model proposed in this paper will be useful to stabilize the supply and demand of agricultural products by providing more accurate predictions, ultimately reducing the risk of price fluctuations.

Petrović et al. (2023) analysed the impact of changes in long-term climatic factors on maize yields in two regions of Serbia. The authors used the Pearson correlation coefficient to express the relationship between maize yields or prices and

weather parameters. The degree of correlation was determined by analysing regression models and random variables. The findings of the study revealed that air temperature, sunlight, temperature and precipitation were correlated with maize yield, with precipitation having the most significant impact (positive correlation), influencing maize yield by approximately 62.9%. The authors argue that monitoring and early warning systems for drought, water scarcity, and heat stress contribute to the economic benefits of low inputs and high outputs.

Shekhar and Shapiro (2022) were concerned with yield changes in rainfed agricultural systems when subjected to climate change. This paper used data from rain-fed agriculture experiments from 1986 to 2016 to identify similarities in historical data and predicted future climate. By using partial budgeting, the authors calculated the treatment income returns of maize and soybean. The findings indicate that wetter winters and springs slightly lowers corn production, while dry summers reduce corn and soybean yields significantly. To accurately predict the impact of extreme weather conditions on prices and income returns,

4. Research Related to Other Issues

In addition to the aforementioned directions, there are also scholars who try to analyse the intricate connections between meteorological changes and economic life from a fresh perspective. Habib (2022) investigates and examines the role of migrant remittances from developing countries in addressing the impact of climate change on GDP. In 5 North African countries, this research assesses the responsiveness of migrant remittances to GDP fluctuations caused by climate change shocks through VAR estimation. Study finds that climate shock can have a significant adverse effect on GDP per capita in the short term, while increasing temperature due to raising precipitation can also bring down GDP per capita. The response of remittances to climate change between the first and second years after a shock is countercyclical and can contribute to smoothing macroeconomic shocks.

Antw-Agyei, Amanor, Hogarh, and Dougill (2020) studied the willingness of farmers to pay for meteorological information from a gender perspective. The study selected two agricultural communities in climate vulnerable areas in northeastern Ghana and analyse household characteristics, financial characteristics, and environmental factors by logistic regression. The results indicate that plenty of local farmers are not prepared to pay to receive meteorological information and women are less willing than men. Training will increase the probability of obtaining meteorological information, especially for local women. Obtaining credit convenience can increase the probability of obtaining meteorological information. The authors argue that agricultural agencies need to avoid one-size-fits-all weather policies and weather information service delivery systems. Rather, meteorological information services should be tailored to different socio-economic groups. Gender-specific agricultural training courses and government subsidies could be a way for farmers to increase their access to weather information.

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