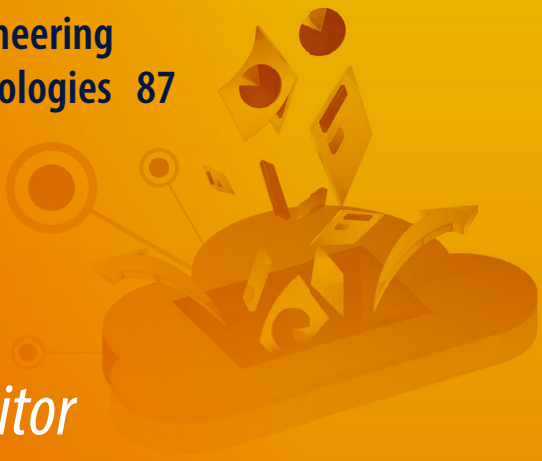
Lecture Notes on Data Engineering and Communications Technologies 87



Leonard Barolli *Editor*

Complex, Intelligent and Software Intensive Systems

Proceedings of the 18th International Conference on Complex, Intelligent and Software Intensive Systems (CISIS-2024)

Springer

Lecture Notes on Data Engineering and Communications Technologies **87**

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Leonard Barolli
Editor

Complex, Intelligent and Software Intensive Systems

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Welcome Message of CISIS-2024 International Conference Organizers

Welcome to the 18th International Conference on Complex, Intelligent and Software Intensive Systems (CISIS-2024), which will be held from July 3 to July 5, 2024, in conjunction with the 18th International Conference on Innovative Mobile and Internet Services in Ubiquitous Computing (IMIS-2024).

The aim of the conference is to deliver a platform of scientific interaction between the three interwoven challenging areas of research and development of future ICT-enabled applications: Software Intensive Systems, Complex Systems and Intelligent Systems.

Software Intensive Systems are systems, which heavily interact with other systems, sensors, actuators, devices, other software systems and users. More and more domains are involved with software intensive systems, e.g. automotive, telecommunication systems, embedded systems in general, industrial automation systems and business applications. Moreover, the outcome of web services delivers a new platform for enabling software intensive systems. The conference is thus focused on tools, practically relevant and theoretical foundations for engineering software intensive systems.

Complex Systems research is focused on the overall understanding of systems rather than its components. Complex Systems are very much characterized by the changing environments in which they act by their multiple internal and external interactions. They evolve and adapt through internal and external dynamic interactions.

Research in the field of intelligent systems, robotics, neuroscience, Artificial Intelligence (AI) and cognitive sciences are very important factor for the future development and innovation of software intensive and complex systems.

This conference is aiming at delivering a forum for in-depth scientific discussions amongst the three communities. The papers included in the proceedings cover all aspects of theory, design and application of complex systems, intelligent systems and software intensive systems.

We are very proud and honored to have 2 distinguished keynote talks by Prof. Sriram Chellappan, University of South Florida, USA and Prof. Chao-Tung Yang, Tunghai University, Taiwan, who will present their recent work and will give new insights and ideas to the conference participants.

The organization of an International Conference requires the support and help of many people. A lot of people have helped and worked hard to produce a successful technical program and conference proceedings. First, we would like to thank all authors for submitting their papers, the Program Committee Members and the reviewers who carried out the most difficult work by carefully evaluating the submitted papers. We are grateful to Honorary Co-chairs Prof. Makoto Takizawa, Hosei University, Japan, and Prof. Kuo-En Chang, Tunghai University, Taiwan, for their guidance and support.

Finally, we would like to thank Web Administrator Co-chairs for their excellent and timely work.

We hope you will enjoy the conference proceedings.

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CISIS-2024 Keynote Talks

Integrating AI, Citizen-Science, Social-Media and Innovative Hardware Tech for Public Health

Sriram Chellappan

University of South Florida, Tampa, FL, USA

Abstract. Among many public health concerns, mosquito-borne diseases are most challenging. The problem is global now. Rising temperatures, floods, mobility are all exacerbating challenges today. Diseases like Zika fever, malaria, dengue and chikungunya have no vaccines or cures, as a result of which around a million people die each year from mosquito-borne diseases with a vast majority of them being children. In this talk, we will present our R&D on a spectrum of solutions geared to combat mosquito-borne diseases. Our technologies combine innovative/explainable AI algorithms, novel methods of citizen-science engagement and systems, Social-media data mining, and innovative hardware to address a range of problems in mosquito surveillance, control, and disease management under outbreaks. Some results of successful deployments will also be highlighted.

Application of Artificial Intelligence and Internet of Things for Building Smart Services

Chao-Tung Yang

Tunghai University, Taichung, Taiwan

Abstract. The integration of Artificial Intelligence (AI) and Internet of Things (IoT) technologies has revolutionized the concept of smart services. Intelligent systems influence many aspects of daily life. Also, with the emergence of IoT, AI and Machine Learning (ML) opportunities have been created for smart computing infrastructure. We have proposed iSEC (Intelligent Sensors, Edge Computing, and Cloud Computing) framework. The project deploys a smart cloud edge-computing architecture to provide ML and deep learning in the cloud edge environment. By leveraging the iSEC architecture and real-time streaming services, AI and IoT can be effectively combined to enhance smart services. One prominent application is the utilization of YOLO (You Only Look Once) image recognition and object detection for intelligent service delivery. This approach enables the identification and analysis of objects in real time, allowing for efficient and accurate decision-making in various smart service scenarios.

Contents

A Systematic Review of the External Influence Factors in Multifactor Analysis and the Prediction of Carbon Credit Prices

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Abstract. Carbon credit trading is a crucial strategy to achieve emission reduction goals at the lowest possible cost. However, carbon credit prices exhibit non-stationary and non-linear characteristics. This is compounded by the lack of a data-driven analysis of external factors that impact the future price of carbon. This article addresses this gap by conducting a comprehensive systematic literature review to identify the significant factors that contribute to the instability of the price of carbon credits. To achieve our goal, four electronic databases, namely IEEE Xplore, SpringerLink, ScienceDirect, and ACM, were searched systematically from January 1, 2005, to January 1, 2024. Upon conducting an exhaustive screening and analytical process, 41 articles were determined to meet the predefined quality assessment criteria, qualifying them for inclusion in this review. The study investigates the impact of 20 factors reported in the 41 shortlisted articles, including similar carbon markets, energy markets, environmental, macroeconomic, policy, social, economic, sustainable industry, and public awareness factors. Furthermore, the research methodically formulates and introduces a detailed taxonomy of the main factors affecting carbon credit prices, offering a structured approach to understanding the multifaceted influences on the carbon credit market. Researchers can build on these findings to further explore the dynamics of carbon markets and develop advanced models for price prediction and risk assessment.

Keywords: Carbon credit · Carbon trading market · Carbon price drivers · Influencing factors · Multifactor prediction

1 Background and Motivation

Carbon emission trading is one of the primary objectives in the fight to reduce emissions at the lowest possible cost while meeting environmental goals [30–32].

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CET is a market-based approach introduced in the Kyoto Protocol in 1997 [32]. CET aims to reduce greenhouse gas emissions, including CO2, by implementing a "cap and trade" mechanism [32]. Carbon credits are used in CET as tradable units that represent emission reductions, allowing entities to meet their regulatory obligations while supporting emission reduction projects [33]. These credits are in the form of digital assets, with one carbon credit equivalent to one tonne of emissions [33].

One of the biggest problems with carbon credits is that traders find it very challenging to predict the price accurately, as the price of carbon credits over time exhibits nonstationarity, nonlinearity, irregularity characteristics [28]. The concept of nonstationarity in the data implies that the statistical properties of carbon credit prices are not constant over time [17]. This could involve sudden spikes or drops in carbon credit prices, which do not adhere to a consistent pattern. Consequently, carbon credit prices do not follow a predictable trend, and this fluctuation can be challenging to analyse and forecast accurately. The presence of nonlinearity in the dataset implies that the relationship between carbon credit prices and their determinants is not linear or straightforward. These challenges are the result of the influence of external factors on the price of carbon credits [53], such as the price in the energy market, environmental conditions, microeconomic variables, societal factors, and public awareness. Therefore, the analysis of the factors that influence the price of carbon credit trading has attracted increasing attention in the literature [1,22,41,52].

Identifying these irregularities is crucial for risk management and decision-making in the carbon market, as they can have a significant impact on investment strategies and carbon credit trading. Acknowledging and addressing these non-stationarity and non-linearity characteristics is imperative for robust data analysis and forecasting in the carbon credit market. Furthermore, it is essential to obtain a comprehensive view of how external factors and market dynamics impact carbon credit prices, as they may have different effects on shorter and longer time horizons. The contribution of this study to the literature is as follows:

- **Comprehensive Review:** This study marks the first known attempt to carry out a systematic literature review (SLR) aimed at uncovering the external factors influencing carbon credit prices. Through a carefully analysis of the articles, our research offers a comprehensive interdisciplinary overview of the subject.
- **Detailed Analysis of Impact Factors:** This research clarifies the impact of 20 key factors on carbon credit prices across different markets. Our analysis integrates insights from a wide range of studies and reveals the complex relationships between various influencing factors, providing a comprehensive view of carbon credit market dynamics.
- **Development of a Taxonomy for Carbon Credit Price Influences:** A significant advancement made by this study is the development of a comprehensive taxonomy that organises the identified factors into nine coherent categories: similar carbon markets, energy market prices, environmental,

microeconomic, policy, societal, economic, sustainable industry, and public awareness factors.

The remainder of this paper is organised as follows: Sect. 2 provides a detailed description of the procedure used to shortlist articles for this SLR, including the inclusion and exclusion criteria for conducting the literature search. The results derived from the shortlisted articles are presented in Sect. 3, which offers an in-depth analysis of the influential factors on carbon credit prices. Finally, Sect. 4 concludes the article and makes a recommendation for future research work.

2 Systematic Review Protocol

To investigate the factors that influence the price of carbon credits, an SLR was conducted following Kitchenham's guidelines [20]. This methodological approach ensures a comprehensive and transparent review of existing research within a defined scope. Through a systematic review, the researcher can more accurately identify the factors that impact carbon credit prices. Systematic reviews and meta-analyses are highly regarded because they offer the most reliable evidence, being positioned at the top of the evidence hierarchy in research [24].

The SLR comprised five main steps, executed meticulously to gather, select, and analyse relevant studies. Initially, a literature search was performed on five key electronic databases, namely IEEE Xplore Library, SpringerLink, ScienceDirect, and ACM Digital Library. This search targeted articles published between 2005 and 2024, as the Kyoto Protocol came into force in February 2005. The search strategy utilised specific keywords and Boolean operators to refine the focus on factors affecting carbon credit prices, yielding a total of 25,743 articles. The keywords selected to search for the factors which influence carbon credits are ("Carbon Credit" OR "Carbon emission" OR "Carbon Offset" OR "Carbon trading") AND (price OR value OR cost) AND (factor OR driver OR determinant).

The selection of relevant articles was guided by defined inclusion and exclusion criteria. Studies were included based on their publication date, focus on carbon credit prices, and the analysis of related influencing factors. Exclusions applied to non-English articles, non-peer-reviewed materials, and studies not directly focusing on carbon credit prices, resulting in 17,705 articles proceeding to the next stage.

A two-stage study selection process was then used to further refine the selected articles. The first stage involved screening titles and keywords for relevance, followed by a detailed review of abstracts to assess alignment with the research objective. This process led to the identification of 32 articles. Additionally, backward citation searching was used as a complementary strategy, adding 9 more articles to the final selection, totalling 41 studies for in-depth analysis.

The quality assessment of the selected studies was carried out using a predefined set of criteria as listed below, focusing on the clarity and relevance of the research to factors influencing the price of carbon credits.

- QA1: Does the paper analyse the effect of influencing factors on carbon credit prices?
- QA2: Does the paper propose a solution to predict carbon credit prices considering the influencing factors?
- QA3: Are the experiments and experimental setup clearly described and the solutions evaluated in the paper?
- QA4: Does the article provide clear findings with justifiable conclusions and results?

We found that the 41 candidate articles were of robust quality and were selected for further analysis as presented in the next Sect. 3.

3 Result and Discussion

The price of carbon credits fluctuates due to several factors that affect their value. A comprehensive understanding of these factors is crucial not only for the effective management of carbon emissions and financial liabilities, but also for the development of advanced models for price prediction and risk assessment. Through the data analysis and validation process of the articles shortlisted in this SLR, 20 factors were identified that influence the price of carbon credits.

The identified factors were extracted from both empirical and conceptual studies and listed in Table 1. The table lists the external factors that influence carbon credit prices and their effects based on the 41 articles. The type of effect is categorised into positive, negative, no effect, or not specified in the literature. Figure 1 visualises the data in the table, showing the percentage impact of each factor on the price of carbon credits, based on studies that consider a specific factor. It highlights the diverse effects of each factor on carbon credit prices, with some factors showing more consistent and significant impacts, while others exhibit mixed or uncertain effects based on the available literature. This article categorises these factors into nine broad classifications, as shown in Fig. 2. The following subsections explore each classification in detail, examining key factors and their impact on carbon credit prices based on Table 1 and Fig. 1 as documented in the existing literature.

Similar Factors: Similar products, such as European Union allowances (EUAs), play a crucial role in the carbon market. The EU ETS, initiated in January 2005, is the world's largest carbon trading scheme, exercising significant influence over global carbon prices [8]. As the largest carbon demander, the EU's carbon price reflects global trends [46], thereby significantly impacting both the carbon trading market and credit prices. In the EU-ETS scheme, two main products are traded: EUAs and Certified Emission Reductions (CERs). EUAs take the form of electronic certificates that represent the right to emit one tonne of CO_2. CERs, on the other hand, are granted by the United Nations to emission reduction projects in developing nations. Some emerging nations, such as China, have not been able to submit CER project indicators to the EU

Table 1. Influencing factors and their effect on the price of carbon credits based on the shortlisted articles

Factor Classif.	Influencing Factor	Positive Effect	Negative Effect	No Effect	Not Specified
Similar factors	International Carbon Markets	[48]	[50]		[4,14,36,43,44,46,49,51]
Energy prices	Natural Gas Market	[1,3,7,26,46,48]	[10,19,27,29,34,37,40,42,49,50,54]	[11]	[4,6,12–14,22,36,39,43–45,51,52]
	Coal Market	[2,37,41,46,47]	[1,3,10,15,16,19,26,29,34,35,39,40,42,48–50,52,54]	[11]	[4,6,7,12–14,22,36,43–45,51]
	Crude Oil Market	[2,3,7,15,16,26,42,47–49]	[11,19,29,34,37,39,46,50,54]		[4,6,12–14,27,36,43,44,51,52]
	Electricity Market	[1–3,26,48,54]	[13]		[12,14,39]
Environmental	Air Temperature	[3,15,19,34,41,52]		[22,38]	[4,9,12,36,43,44]
	Air Quality Index (AQI)	[34,47]			[4,14,43,44]
Macroeconomic	Industrial Income	[47]	[34]	[49]	[22]
	Stock Market	[26,29,37,42]	[7,15,16,50,54]		[4,36,40,43]
	Exchange Rate	[11,46,48,52]	[10,42,45]		[12,14,36,40,43,44,51]
Policy	Carbon threshold	[15,23,34,38,48]			[4,9,22,35,39]
Societal	PerCapita Growth Rate	[25]			
	Population Growth Rate	[25]			
Economic	Raw Material Price	[1]	[15]		
	Product Price	[15]			
	Science and Technology Innovation Index		[15,41]		
Sustainable industry	Green Technology Maturity	[34]			
	Development Degree of Low-carbon Industries	[34]			
	Clean Energy Penetration	[34,50]			
Public awareness	Web Search Index	[39]			[4,14,43,44,51]

since April 2021. In the context of this study, EUAs are considered a similar external factor.

In this SLR, as shown in Table 1, ten studies used the EUA price as a benchmark for the global carbon trading market due to its significant impact on carbon emission allowances. Figure 1 illustrates that 80% of these ten studies did not specify the final effect of this factor on the price of carbon credits and only incorporated this factor into their prediction models without explicitly delineating its effect on credit prices.

Energy Price Factors: Energy markets significantly influence carbon credit prices, with energy production and consumption being major CO2 emission sources. A literature review found that 37 out of 41 studies focused on how energy demand and carbon emissions affect carbon credit prices, specifically looking at the natural gas [1,46,48], coal [2,37,46], crude oil [2,16,48], and electricity markets [1,2,48].

For natural gas, 31 studies explored its impact, 42% including it in prediction models without a detailed analysis of its effect on credit prices, and 35% noting a negative correlation with carbon credit prices.

The impact of the coal market was analysed in 36 studies, with 14% observing a positive effect, 50% a negative effect, and 33% not specifying its impact on carbon credit prices.

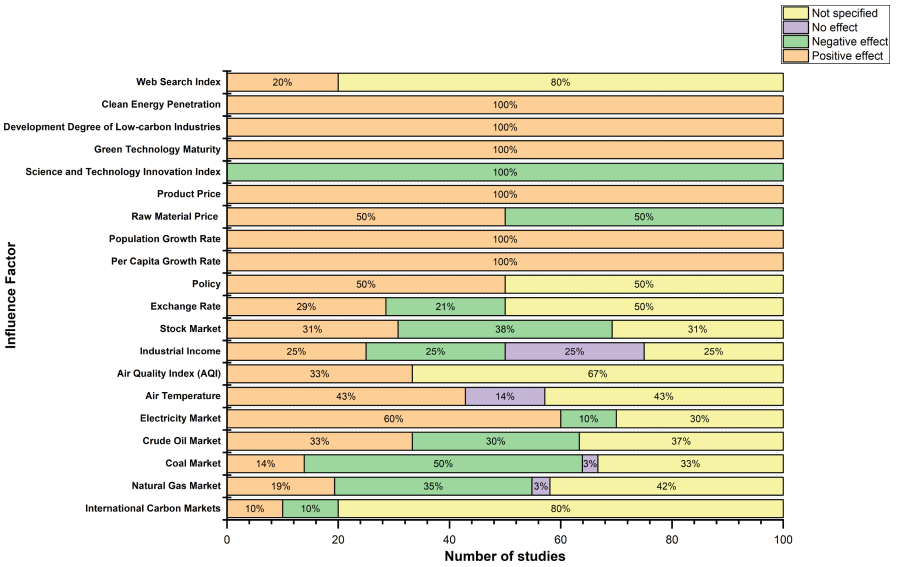

Fig. 1. The percentage of studies by the effect of each influencing factor

Crude oil market studies (30 in total) showed varied results: 33% found a positive effect, 30% a negative effect, and 37% did not report a clear correlation with carbon credit prices.

The review highlights the complex relationship between energy markets and carbon credit prices. Increased demand for fossil fuel energy typically increases carbon emissions and carbon credit demand, thus increasing prices. However, the findings vary, reflecting various impacts.

The electricity market, a significant source of carbon emissions, was investigated in 10 studies. Sixty percent reported a positive impact on carbon credit prices, 10% a negative impact, and 30% found no clear correlation. Increased demand for electricity from carbon-intensive sources boosts carbon credit demand and prices, while a shift to renewable energy can reduce carbon emissions and lower carbon credit demand and prices.

Environmental Factors: The impact of weather and the Air Quality Index (AQI) on electricity production indirectly influences carbon credit prices [3,18]. Weather events like severe drought or extreme temperatures can shift fossil fuel energy production, affecting carbon allowance demand. For example, hot summers increase the demand for electricity and coal, while cold winters increase the need for heating fuel, impacting carbon prices. This SLR revealed that 14 studies focused on environmental factors that affect the price of carbon credits. About 43% found that extreme weather conditions, such as unanticipated temperature changes, positively impact CO2 prices due to abnormal demand shifts. In contrast, studies such as [22,38] suggested the insensitivity of the carbon market

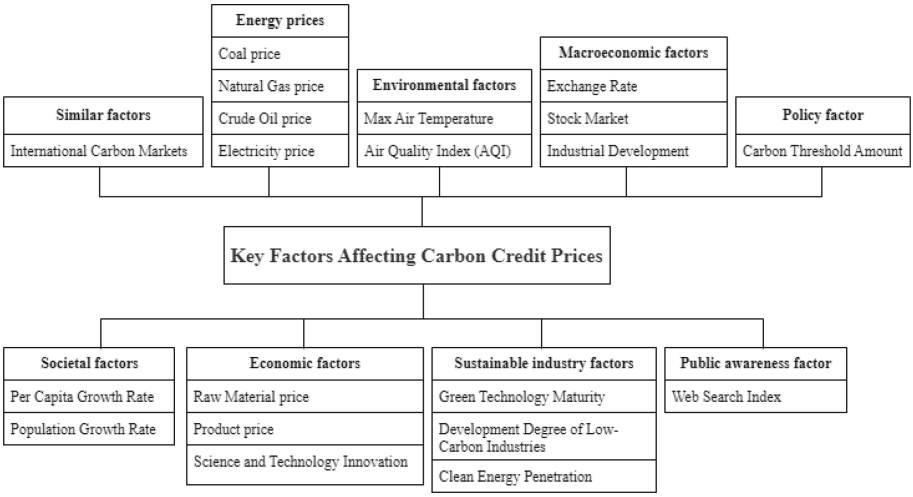

Fig. 2. The taxonomy of influencing factors on carbon credit prices

to temperature changes, with the rest not specifying their impact. Furthermore, AQI measures air pollution levels and CO2 concentrations. High AQI levels signal poor air quality and could lead to stricter emission controls, affecting carbon credit demand and prices. Of the studies examining AQI, 67% did not clarify its effect on carbon prices, while the rest indicated a positive impact.

Macroeconomic Factors: Macroeconomic factors, such as exchange rates, stock market performance, and industrial income, indirectly influence carbon credit prices by affecting investor sentiment and economic growth, affecting the demand for carbon credits. The SLR showed that of 41 studies, 27 examined macroeconomic factors: exchange rates in 14 studies, stock markets in 13 studies, and industrial income in 4 studies.

Exchange rates affect carbon credit prices by altering production costs and industry competitiveness [3,18,28]. A strong currency may reduce domestic product demand, lowering carbon credit demand. Of the studies, 21% reported a negative impact of exchange rates on carbon credit prices, while 29% observed a positive impact. 50% did not specify the impact.

The stock market influences carbon credit prices through investor sentiment and economic growth [46]. A robust stock market can increase investor confidence, increasing demand for carbon credits, whereas a weak market may decrease it. The results varied, some showing a positive correlation with EU ETS prices [26,29,37], and others an inverse relation [7,50,54]. In China, studies on the impact of the stock market on carbon credit prices also showed mixed results, with positive effects noted by [42] and negative effects by [15].

Industrial development also affects carbon emissions and the demand for carbon credits, influencing carbon trading prices. This SLR found that industrial