ORIGINAL RESEARCH

The impact of public climate change concern on sustainable product consumption: a case study of new energy vehicles in China

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Abstract
With global climate change problems becoming increasingly serious, sustainable consumption has become an inevitable trend. In this paper, we take the Chinese new energy vehicle market as an example and research the relationship between the public climate change concern and sustainable product consumption behaviour, while considering the time decay effect of public concern. We collect authoritative secondary data on climate change Baidu search index and the monthly sales of new energy vehicle brands and use panel data to test the hypotheses empirically. The result shows that there is a significant positive effect of public climate change concern on new energy vehicle consumption behaviour. This effect is also present when the time decay effect is considered. The result shows that public new energy vehicle concern has a significant negative effect on new energy vehicle consumption behaviour. The findings provide theoretical support for government policymakers and corporate managers to promote the adoption and diffusion of sustainable products.

1 Introduction

The problems of resource scarcity and environmental degradation have led the world to focus on sustainable development. Circular economy (CE), as a new economic development model, can contribute to sustainable development goals through a range of efficiency- and productivity-enhancing activities collectively known as circular strategies (Kristoffersen et al., 2020). Under the CE model, sustainable business management (SBM) has become an important way for modern companies to achieve sustainable operation and development. Sustainable consumption (SC) is a concrete form, and an integral part of the CE systems. It is, therefore, important to shift traditional product consumption to SC (Tseng et al., 2020). Over

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the last 20 years, international organisations have paid increasing attention to SC, developing a range of strategies and action plans for SC. In 1992, at the United Nations Conference on Environment and Development in Rio de Janeiro, sustainable consumption and production (SCP) was identified as the overarching theme linking environmental and development challenges (Liu et al., 2016). In 2002, the Johannesburg Plan of Implementation called on countries to promote SCP patterns (Wang et al., 2019a, 2019b). In 2012, the United Nations further adopted the 10 Year Framework for SCP, which integrates policies and actions on SCP (Liu et al., 2016). These SCP strategies and action plans have encouraged and guided companies and sectors to integrate SCP into their corporate strategic planning (Deveci et al., 2023; Voola et al., 2022; Wang et al., 2019a, 2019b). For example, both Jaguar Land Rover and Volkswagen Germany have shifted their strategies towards new energy vehicles, announcing that they will no longer produce fuel vehicles by 2025 and 2040 respectively. In terms of the consumer level, consumers are increasingly concerned about sustainable products and consumption. However, it is clear that there is an attitude-behaviour gap in the process of SC, i.e., although consumers have positive attitudes towards sustainable products, they often have weak purchasing power for sustainable products in the real purchasing process (Park & Lin, 2020; Pristl et al., 2021). Therefore, it is important for governments and companies to understand what are the main motivations that influence consumers' actual purchasing behaviour towards sustainable products in order to promote the adoption and diffusion of sustainable products throughout society.

The realistic motivation for our research is to promote the social diffusion and adoption of sustainable products as a way to mitigate and eliminate global environmental problems. At present, countries around the world are suffering from the severe consequences of global environmental problems such as global warming and global climate change (Leimbach et al., 2017). For example, in 2021, Texas suffered from persistent blizzards and low temperatures; many areas in the Mediterranean region experienced temperatures above 40 °C; Mongolia suffered from persistent and intense dust storms and blizzards. In 2022, many European countries such as France, Germany, Spain and the UK experienced historic high temperatures and heat waves; Pakistan suffered multiple rounds of heavy rainfall and flooding; African countries such as Kenya, Somalia and Ethiopia faced their worst drought in a decade. In addition, these global warming and global climate change problems severely impact operational decisions in various areas, including power supply (Sivrikaya et al., 2017), venture capital (Benedetti et al., 2021), transportation (Pamucar et al., 2022), etc. Furthermore, they are exposing business management to a variety of risks (Blanco, 2021) and affecting society and market patterns (Chen et al., 2019a, 2019b). Therefore, eliminating and mitigating global environmental problems such as global warming and global climate change is one of the critical problems to be solved by all countries and societies in the twenty-first century. As an important part of SBM in CE, exploring the drivers of sustainable consumption is one of the most important ways to promote its development. Currently, the explosion of media contributes to the problems of global warming and global climate change being widely concerned by consumers (Chen et al., 2019a, 2019b). Therefore, it is worth investigating whether consumers' public concern about global environmental problems such as global warming and global climate change influences the social promotion and adoption of sustainable products. On the one hand, the identification of this motivation can guide governments and companies in marketing business management to eliminate the attitude-behaviour gap of consumers, thus promoting the social promotion and adoption of sustainable products. On the other hand, from the perspective of sales and operations planning (Thomé et al., 2012) in supply chain business management, the identification of this motivation can improve the accuracy

of demand forecasting for sustainable products from the sales side, thus facilitating the SBM on the supply side of companies.

There have been a few attempts by scholars to explore the impact of environmental concerns on SC. Mainieri et al. (1997) showed contradictions in the effect of environmental concern on consumers' green purchasing behaviour in 1997. However, the findings obtained by some subsequent scholars remained in a state of contradiction. Zhang et al. (2011) showed that there is no significant effect of consumers' environmental awareness on the use of electric vehicles. Mohamed et al. (2016) showed that consumers' concern for the environment had an indirect effect on purchase intention. Adnan et al. (2017) and Cui et al. (2021) suggested that environmental concern has a positive impact on the promotion of new energy vehicles. The contradictions in these research findings lead to a general suspicion: Is consumer concern for the environment related to sustainable product consumption behaviour? The attitude-behaviour gap phenomenon in the purchase of sustainable products by consumers leads to unreliability in the data obtained from questionnaire surveys, which directly contributes to the contradictory results of existing research. Furthermore, due to the limitation in data collection from questionnaire surveys, the existing research on environmental concern is mainly limited to the individual level of environmental concern and lacks the public level of environmental concern.

Combining the practical motivation as well as the contradiction and gap in academic research, our research aim is to collect authoritative secondary data and innovatively explore the impact of a new environmental motivation, public climate change concern, on sustainable product consumption at a public level, to promote the promotion and adoption of sustainable products in society and the SBM in companies. We select the star product of sustainable products—new energy vehicles (including hybrid, electric and hydrogen-based types), to study the effect of public climate change concern on sustainable products consumption behaviour. After we use the existing artificial intelligence system and crawler technology to obtain key variable data, we select data on new energy vehicle brands for our empirical research. The results are as follows. (1) there is a statistically significant positive effect of public climate change concern on consumers' new energy vehicle consumption behaviour, and this effect is also present when the lagged dependent variable and the time decay effect are taken into account. (2) there is a statistically significant negative effect of public new energy vehicle concern on consumers' new energy vehicle consumption behaviour.

The main contributions of our research are as follows.

First, due to the limitations of data sources, existing research on the impact of environmental concerns on sustainable product consumption behaviour is limited to the individual level of consumer concerns. We collect authoritative secondary data based on existing artificial intelligence systems to measure public concern at the public level and explore the impact of public concern on sustainable consumption behaviour. To the best of our knowledge, it is the first time that public concern is linked to sustainable product consumption behaviour, which provides a bridge between them.

Second, the evidence on the impact of public concern on consumer behaviour is limited. Our research contributes to this field. We provide new evidence that public climate change concern can positively influence consumers' sustainable consumption. Furthermore, our research clarifies that public concern about new energy vehicles has a negative impact on consumers' purchase of new energy vehicles. The evidence on the impact of these two public concerns on consumers' sustainable consumption behaviour offers the new ways of achieving SBM.

Third, by extending environmental concern from the individual level of consumers to the public level, we further clarify the role of public concern in the area of sustainable

consumption. Public concern can effectively contribute to social influence (social learning and peer effects) in the area of sustainable consumption, which in turn influences consumers' sustainable consumption behaviour.

The rest of this paper is organised as follows. We conduct a literature review in Sect. 2. Section 3 focuses on new energy vehicle purchase motivations and our hypotheses. Section 4 focuses on data sources and model construction. In Sect. 5, we report findings, conduct relevant robustness check and predictive analysis. Section 6 presents theoretical and managerial implications, and further suggests existing limitations and future research directions.

2 Literature review

2.1 Sustainable business management and sustainable consumption

As a new economic mode, circular economy (CE) aims at the efficient use of resources through waste reduction, long-term value preservation, reduction of primary resources and recycling of products, product components and materials, thus contributing to environmental protection and socio-economic benefits (Morseletto, 2020). To use resources efficiently and protect the ecological environment, the globalisation of CE will be one of the focus areas for the world in the future (Geng & Bleischwitz, 2019). In industry, CE thinking can be effective in enhancing the Sustainable Business Management (SBM) in companies (Genovese et al., 2017). SBM can be defined as the management of business that recognizes its embeddedness in social, environmental and economic systems, and focuses on management and relationships to meet the environmental, social, and economic requirements of many different stakeholders in its networks (Granovetter, 2018; Van Kleef & Roome, 2007), including marketing, supply chain, operations, human resource and finance (Hardy et al., 2005; Pal et al., 2021). At present, the marketing management of companies is gradually transforming into SBM (Brindley & Oxborrow, 2014). How to shift existing consumption patterns to be more sustainable is a critical problem in sustainable marketing management (White et al., 2019). Ding et al. (2021) confirmed that air pollution causes consumers to prefer to buy blue products and attributes it to compensatory consumption due to demand deprivation. Although compensatory consumption satisfies consumers' psychological needs to a certain extent, it is difficult to eliminate the negative environmental and social impacts of consumption. Therefore, the existing consumption pattern urgently needs to be transformed towards SC. In 1994, at the Oslo Symposium, SC was defined as "the use of services and related products which respond to basic needs and bring a better quality of life while minimizing the use of natural resources and toxic materials as well as emissions of waste and pollutants over the life cycle of the service or product so as not to jeopardize the needs of future generations" (UNEP, 2010). The definition shows that promoting the diffusion and adoption of sustainable products throughout society is one of the important ways to promote SC in society. However, the existence of an attitude-behaviour gap in consumers' SC is a serious barrier to the diffusion and adoption of sustainable products. Although consumers' awareness of SC is growing, consumers' SC attitude is not well translated into sustainable purchasing behaviour.

How to effectively mitigate the attitude-behaviour gap phenomenon has been an important problem for society to promote SC. Existing literature has focused more on the research of motivation factors of consumers' SC, including consumers' behavioural characteristics (Diamantopoulos et al., 2003; White et al., 2019), social factors (Bollinger & Gillingham, 2012; Kim et al., 2020) and psychological factors (Pagiaslis & Krontalis, 2014; Sharma &

Jha, 2017) (for a summary, see Table 1). The existing literature on social motivation mainly considers pro-social behaviour and environmental protection. Pro-social behaviour includes social status, intrinsic responsibility, and social norms (Peters et al., 2015), and environmental protection includes environmental attitudes, environmental values, environmental sensitivity and environmental responsibility (He et al., 2021). Some of the literature has explored the impact of environmental concerns on SC (Adnan et al., 2017; Cui et al., 2021; Mainieri et al.,

Table 1 Comparison of related literature

Study	Research method	Contribution
Drivers of sustainable product consumption		
Diamantopoulos et al. (2003)	Primary-data empirical investigation	It provides a strong argument for a fresh look at the role of socio-demographics in profiling green consumers
White et al. (2019)	Literature review	It develops a comprehensive framework for conceptualizing and encouraging sustainable consumer behavior change, including social influence, habit formation, individual self, feelings and cognition, and tangibility
Bollinger and Gillingham (2012)	Secondary-data econometric study	It documents and estimates the magnitude of peer effects in the diffusion of an environmentally beneficial technology, solar photovoltaic (PV) panels
Kim et al. (2020)	Primary-data econometric study	It investigates how social power, parasocial interaction, and social capital influence the consumer's purchase intention of sustainable fashion products in the fashion YouTube context
Pagiaslis and Krontalis (2014)	Primary-data econometric study	It examines the effect and interrelationships of the key constructs of environmental concern, consumer environmental knowledge, beliefs about biofuels, and behavioral intention (i.e., willingness to use and pay) in the context of biofuels
Sharma and Jha (2017)	Primary-data econometric study	It explains that the influence of personal values on sustainable consumption behaviour is moderated by the cultural and consumption context in which the relationship is studied

Table 1 (continued)

Study	Research method	Contribution
Peters et al. (2015)	Primary-data econometric study	It indicates that intention (the stated importance of fuel consumption) is explained to a lower degree than behavior. And it is mainly expressed according to an inner feeling of obligation (personal norm) and influenced by symbolic motives (to express one's self and social position through the car)
He et al. (2021)	Primary-data econometric study	It shows that behavior motivation, behavior intentions, residential characteristics, social norms, behavior ability, and institutional and technological context are the main factors of green purchase
Mainieri et al. (1997)	Primary-data econometric study	It examines the effect of awareness about environmental impacts of products, specific environmental beliefs of consumers, several general environmental attitude scales, demographic variables, and several pro-environment behaviors other than buying behavior on green buying
Zhang et al. (2011)	Primary-data econometric study	It determines the factors that contribute to consumers' acceptance of electric vehicles, their purchase time and their purchase price. And environmental awareness has no obvious effect on consumer's adoption of electric vehicles
Mohamed et al. (2016)	Primary-data econometric study	It shows that attitude, perceived behavioural control, and norms (moral and subjective) have significant direct impacts on behavioural intention, while a household's concern for the environment has an indirect impact

Table 1 (continued)

Study	Research method	Contribution
Adnan et al. (2017)	Literature review	It reviews ten key features that influence the adoption of plug-in hybrid electric vehicles. And it concludes that consumer attitude towards adopting plug-in hybrid electric vehicles/electric vehicles is positive when impacted by environmental concerns
Cui et al. (2021)	Primary-data econometric study	It shows that environmental concern is the most significant predictor of EVs purchase motivation, followed by price consciousness, openness to experience, social influence, and self-esteem
The role of public concern in sustainable consumption		
Chen et al. (2015)	Secondary-data text analysis	It explores how social media facilitates information seeking, interpretation, and dissemination during extreme weather
Li et al. (2022)	Secondary-data econometric study	It shows that the suppression effect of public attention on air pollution is stronger in large, first-tier, and ministerial cites and cities with severe air pollution. And public attention could reduce air pollution through "complaint to the government" and "concern about health"
Xu et al. (2022)	Secondary-data econometric study	It investigates the mediation effects of online public attention on the relationship between air pollution and precautionary behavior
Zhang et al. (2015)	Modeling method	It studies observational learning in networks of friends versus strangers
Kim and Ellison (2022)	Primary-data econometric study	It seeks to clarify the mechanism that social media can facilitate offline political participation

Table 1 (continued)

Study	Research method	Contribution
Chung et al. (2021)	Literature review	It elucidates the ways in which social media use among adolescent peer influences eating behaviors
Salazar et al. (2013)	Primary-data experimental method	It studies the social influence that peer groups like colleagues, family and friends may exert in the decision to choose for environmentally friendly products rather than conventional ones
Wolske et al. (2020)	Literature review	It examines recent findings on social influence in energy behaviour and discuss pathways through which social influence can result in peer effects
Gillingham and Bollinger (2021)	Primary-data natural experiment	It investigates a large-scale behavioral intervention designed to actively leverage social learning and peer interactions to encourage adoption of residential solar photovoltaic systems

1997; Mohamed et al., 2016; Zhang et al., 2011). The data on environmental concerns in these studies were mainly collected using questionnaires. However, the existence of attitude-behaviour gap phenomenon among consumers makes it difficult to ensure the reliability of the data, which in turn leads to apparent contradictory findings. The confirmation of different motivations provides important theoretical support for governments and companies to popularise sustainable products. However, much of the literature has not considered any particular theory in explaining the phenomenon of SC. Therefore, some scholars provided theoretical foundations during their research, including the theory of planned behaviour, the theory of reasoned action, the value-belief-norm theory, the signalling theory and the social network theory (Quoquab & Mohammad, 2020). Lim (2017) provided a powerful 'theoretical toolbox' for understanding SC based on three theoretical perspectives on consumption: responsible consumption, anti-consumption and mindful consumption.

Under the CE, SBM requires sustainable decision-making and optimisation with a CE mindset, thereby achieving sustainable operation of companies and promoting sustainable development of society. The emergence and development of new information technologies such as artificial intelligence and big data can effectively solve these sustainable decision-making and optimisation problems. Therefore, technologies such as artificial intelligence and big data can be considered as important enablers for the development of SBM (Di Vaio et al., Chauhan et al., 2022; Kristoffersen et al., 2020; Vaio et al., 2020). Nowadays, different business management areas have made use of intelligent decision systems for sustainable decision-making and optimisation, such as supply chain management (Devici et al., 2023;

Fahimnia et al., 2017; Olan et al., 2022; Xu et al., 2023), operations management (Atasu et al., 2020), human resource management (Vrontis et al., 2022) and finance management (Gan et al., 2020). Similarly, in the field of marketing, artificial intelligence and big data technologies have been applied to strategic decision-making (Zhang et al., 2021) and optimisation process of sustainable consumption management (Hermann, 2021; Wang et al., 2019a, 2019b).

The above review indicates the following gaps in existing research: (1) With the increasing severity of global climate change, the media has widely reported on global climate change problems and their negative impacts (Chen et al., 2019a, 2019b), which can effectively raise consumers' climate change concerns. Although a few scholars have studied the impact of environmental concerns on sustainable product consumption, more specifically, there is still a gap in empirical and theoretical research on whether consumers' climate change concerns affect sustainable product consumption behaviour. (2) Due to the subjective nature of consumer concerns, existing data on environmental concerns are derived from questionnaires, resulting in research being limited to the individual consumer level, with a gap in research on the public level of consumers. In addition, as there is a clear attitude-behaviour gap phenomenon in consumers' sustainable consumption behaviour, it is difficult to ensure the reliability of the data obtained from questionnaires, which leads to obvious contradictions in the existing research results. (3) As an emerging product, there is still a gap in research on whether consumers pay attention to the sustainable product itself and whether this concern affects sustainable product consumption behaviour. The rapid development of new information technologies such as artificial intelligence and big data, and their widespread use in SBM, provide an important way to fill these research gaps. Therefore, our research will combine existing artificial intelligent systems with the collection of authoritative secondary data to investigate the impact of public concern about climate change and sustainable products themselves on sustainable product consumption at a public level, and explain this impact through social influence theory.

2.2 The role of public concern in sustainable consumption

Mass media coverage is effective in promoting public concern (Hunt & Gruszczynski, 2021; Webster, 2011). Public concern is the extent to which multiple individuals are exposed to cultural products (television programs, news stories, video clips, Web sites, audio files, video games, etc.) across space and/or time (Webster, 2011). Existing literature has increasingly focused on the impact of public concern on public behaviour in the field of sustainable development. For example, public concern about pollution and health problems can be effective in increasing public participation in environmental management (Chen et al., 2015) and motivating the public to complain to government authorities about environmental pollution incidents (Li et al., 2022). Xu et al. (2022) showed that public concern mediates the relationship between air pollution and preventive behaviour. In the area of sustainable consumption, some studies showed that public concern for the environment can effectively enhance public sustainable consumption behaviour (Adnan et al., 2017; Cui et al., 2021), as shown in Table 1. Therefore, the role that public concern plays in influencing public sustainable consumption behaviour needs to be further clarified.

When environmental problems are covered on a large scale by mass media, such as global warming and climate change (Chen et al., 2019a, 2019b), public concern on environmental problems will continue to rise. This public concern on environmental problems can lead to

further propagation of information on environmental problems in the form of social information exchange in social networks, especially through the current fast-growing social media (Silver & Andrey, 2019). Social influence occurs widely when information about environmental problems is propagated in social media, i.e., the individual's attitude or behaviour results from the interaction with other individuals or social groups (Salazar et al., 2013). Social learning and peer effects, two theories of social influence, have been shown to be widespread in the propagation of information in social networks. For example, Zhang et al. (2015) showed that the explosion of social media has greatly expanded the scope and impact of consumers' social learning, and examined the characteristics of social learning within networks of friends and strangers. Kim and Ellison (2022) showed that social media encourage social learning of political engagement due to their unique affordances such as visibility (i.e., once-invisible political activities by others are now visible on social media feeds). Chung et al. (2021) showed that adolescent peer effect in social media environments spans the spectrum of healthy eating to eating disorders, as shown in Table 1. Meanwhile, in the area of sustainable consumption, it has been shown that social influence affects consumers' sustainable consumption behaviour (Salazar et al., 2013). More specifically. Bollinger and Gillingham (2012) investigated the impact of peer effects on the diffusion of solar photovoltaic panels. Wolske et al. (2020) reviewed the available empirical evidence on peer effects on household energy behaviours and presented a social influence framework for understanding how and when peer effects occur. Gillingham and Bollinger (2021) investigated a large-scale behavioral intervention designed to actively leverage social learning and peer interactions to encourage the adoption of residential solar photovoltaic systems. Therefore, public concern has a major role in promoting social influence (social learning and peer effects) in the field of SC, as shown in Table 1.

3 New energy vehicle purchase motivations and hypotheses

Referring to Chen et al., (2019a, 2019b), we choose new energy vehicles as a representative product of sustainable products for our research. The specific reasons are as follows: First, automobiles have long been considered as a major cause of air pollution and climate change. Therefore, the public concerns about climate change may have a significant impact on the automotive market. Second, new energy vehicles are a clear and effective sustainable alternative to conventional vehicles. Third, compared to conventional vehicles, new energy vehicles are sold at a higher price premium, leading to a significant attitude-behaviour gap in their purchase by the general public.

Different theoretical models have been proposed to explain consumer purchase behaviour, such as the EBM model (Hsu et al., 2012), the Howard-Sheth model (Farley & Ring, 1970) and the Kotler behaviour choice model (Kotler & Armstrong, 2010). These models all address the drivers of consumer purchase behaviour. We will develop our research framework based on the Kotler behaviour choice model, which views consumer behaviour as a "stimulus–response" process, as illustrated in Fig. 1. The model consists of three components: input factors, consumer black box and output factors. After receiving external stimuli, consumers are processed by the consumer black box and eventually produce the corresponding purchase behaviour. The drivers of purchase behaviour consist of marketing stimuli, external stimuli and consumer characteristics. At present, many scholars have studied the purchase motivation of new energy vehicles. Combining the Kotler behavior choice model, we classify new energy vehicle purchase motivations into three categories: marketing stimulus motivation,
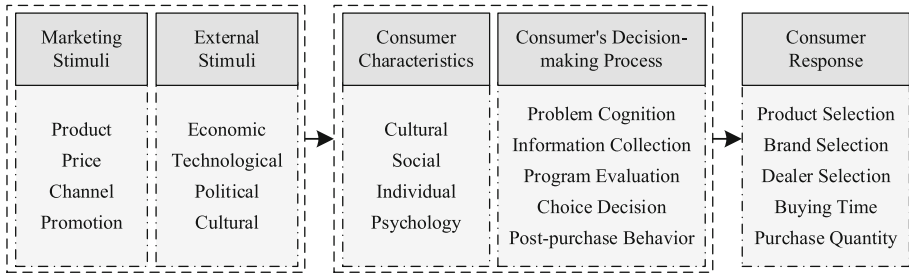
Marketing Stimuli	External Stimuli		Consumer Characteristics	Consumer's Decision-making Process		Consumer Response
Product Price Channel Promotion	Economic Technological Political Cultural		Cultural Social Individual Psychology	Problem Cognition Information Collection Program Evaluation Choice Decision Post-purchase Behavior		Product Selection Brand Selection Dealer Selection Buying Time Purchase Quantity

Fig. 1 Kotler behavior choice model

external stimuli motivation and consumer characteristics motivation. (1) Marketing stimulus motivation. Existing research has focused on both product economy and product technology. Product economy involves vehicle price, usage cost, fuel economy and resale value (Danielis et al., 2018; Zhang & Zhao, 2021; Zhang et al., 2013). Product technology includes acceleration performance, anti-theft system, energy consumption, decorative appearance and usage comfort (Chen et al., 2019a, 2019b; Schlüter & Weyer, 2019). (2) External stimuli motivation. Many scholars have studied it from three perspectives: economic, technological and political. The economic motivation concerns the gasoline price (Danielis et al., 2018). The technological motivation relates to the number of charging stations (Schlüter & Weyer, 2019). The political motivation can be broadly divided into two parts: (1) economic incentives, such as subsidies (Chen & Fan, 2020; Münzel et al., 2019), fee discounts (Ma et al., 2019) and taxes (Tscharaktschiew, 2015); (2) indirect influences through other means, such as licensing controls (Ma et al., 2017) and public procurement (Egner & Trosvik, 2018). (3) Consumer characteristics motivation. The existing literature has focused on both personal and social aspects. Personal drivers include consumer confidence (Hu et al., 2014), consumer experience (Hinz et al., 2015; Homburg et al., 2017) and personal norms (Nordlund & Garvill, 2003). Social drivers mainly include pro-social behaviour and environmental protection. Pro-social behaviour drivers include social status, intrinsic responsibility and social norms (Peters et al., 2015), and environmental protection includes environmental attitudes, environmental values, environmental sensitivity and environmental responsibility (He et al., 2021).

Our research extends the social drivers of consumer characteristics by proposing two new social drivers: public climate change concern and public new energy vehicle concern.

(1) Public climate change concern

Social influence has been widely studied in different fields, such as retail (Argo & Dah, 2020), environment (Xu et al., 2022) and marketing (Lee & Hong, 2016). Social influence can be defined as the change in an individual's attitude or behaviour that results from interaction with other individuals or social group (Salazar et al., 2013). In the consumption area, social influence has also been widely used. Naeem and Ozuem (2021) explored how social practices and social influence generated through social media created panic buying behavior among customers using social practice theory and social influence theory. Salazar et al. (2013) studied the social influence that peer groups like colleagues, family and friends may exert in the decision to choose environmentally friendly products rather than conventional ones. Social learning and peer effects are two important types of social influence. Social learning posits that new patterns of behavior can be acquired by people through either direct experience with or observation of others' behaviors, attitudes, and outcomes of the behaviors (Bandura & Walters, 1977). Peer effect refers to the fact that an individual's behavior is influenced by his

or her peer group (He et al., 2023). A small body of literature has explored the role of social learning or peer effects in promoting sustainable consumer behaviour. Shen et al. (2023) revealed that social learning plays a vital part in identifying pro-environmental actions as an effect of social networking sites. Gillingham and Bollinger (2021) leveraged social learning and peer interactions to encourage the adoption of residential solar photovoltaic systems. Bollinger and Gillingham (2012), Wolske et al. (2020) investigated the impact of peer effects on the diffusion of solar photovoltaic panels and on household energy behaviours. In contrast to these research problems, our study will focus on the field of sustainable consumption, we will explore a new driver of sustainable consumption—public climate change concern. Public climate change concern, as a type of environmental concern, can be seen as a strong positive attitude towards preserving the environment in the marketing field (Newman et al., 2012). At present, some of the literature has explored the impact of environmental concerns on SC (Adnan et al., 2017; Cui et al., 2021; Mainieri et al., 1997; Mohamed et al., 2016; Zhang et al., 2011). However, the unreliability of data sources and the lack of theoretical support led to apparent contradictions in the research results. Considering that the role of public concern in the field of sustainable consumption is to promote social influence (social learning and peer effects) and that social influence is effective in promoting sustainable consumption, we propose the following hypothesis:

H1 Public climate change concern has a positive impact on consumers' new energy vehicle consumption behaviour.

(2) Public new energy vehicle concern

The explosion of social media is prompting companies to pay more attention to social media brand marketing to build a positive image of their products and stimulate consumer consumption (Mathur, 2020). At present, as the star of sustainable products, new energy vehicles have been widely publicised in the world media for their positive impact. In such an environment, consumers verbally indicate a preference for new energy vehicles. However, this preference is limited to words only, and there is a general attitude-behaviour gap in the purchase of new energy vehicles (Park & Lin, 2020; Pristl et al., 2021). This is mainly since there are significant technical and quality problems with new energy vehicles at present, resulting in consumers' subjective perceptions being negative, especially as advanced social media contribute to the rapid spread of such negative subjective perceptions, which can seriously affect the brand image of new energy vehicles (Mathur, 2020). Currently, some literature has been published on the impact of word-of-mouth on consumer purchase behaviour. Zahid et al. (2018), in their study of the relationship between social media publicity on the purchase of green products, suggested that social media publicity can enhance the word-of-mouth of green products. Huang et al. (2019) examined how implementing a word-of-mouth system (through social media integration) on an e-commerce website affects customer conversion in the two stages of the consumer purchase funnel, namely, adding a product to the cart and placing an order. In the process of word-of-mouth influence on consumer purchase behaviour, social influence plays a crucial role. Zahid et al. (2018) confirmed the influence of social appeal on green purchase behaviour considering that consumer behaviour regarding product choice and use is largely influenced by others' opinions. Petrescu et al. (2020) showed the effect that informational social influence has on the development of negative social media firestorms and consumer interest in a brand. Huang et al. (2019) suggested that social learning is an important mechanism through which a word-of-mouth system affects customer behavior. Chia et al. (2021) employed the social learning theory to quantify the impact of word-of-mouth on customers' attitudes and purchase intentions. Furthermore, regarding research on word-of-mouth and public concern, Petrescu et al. (2020) showed that word-of-mouth has

great potential to capture consumer attention, and that negative word-of-mouth campaigns in particular can significantly increase consumer interest in product brands. We will focus on a new sustainable consumption motivation—public new energy vehicle concern. Negative word-of-mouth about new energy vehicles in social networks can contribute significantly to negative consumer concern. Therefore, further considering the key role of social influence in the process of word-of-mouth influence on consumer purchase behaviour and the role of public concern in promoting social influence in the area of sustainable consumption, we propose the following hypothesis:

H2 Public new energy vehicle concern has a negative impact on consumers' new energy vehicle consumption behaviour.

We develop our conceptual framework based on the Kotler behaviour choice model. Our study focuses on two new social drivers—public climate change concern and public new energy vehicle concern, which are both consumer characteristic drivers. In conjunction with the categorisation of the studied drivers in this subsection, we will select marketing stimulus drivers, external stimulus drivers and other consumer characteristic drivers as control variables. The marketing stimulus driver is the fuel economy in product drivers; the external stimulus driver is the petrol price in the economic drivers, the number of charging stations in the technology drivers and the policy subsidies in the political drivers; and the other consumer characteristic driver is the consumer confidence in the personal drivers. A conceptual framework summarizing the two proposed hypotheses and control variables is shown in Fig. 2.
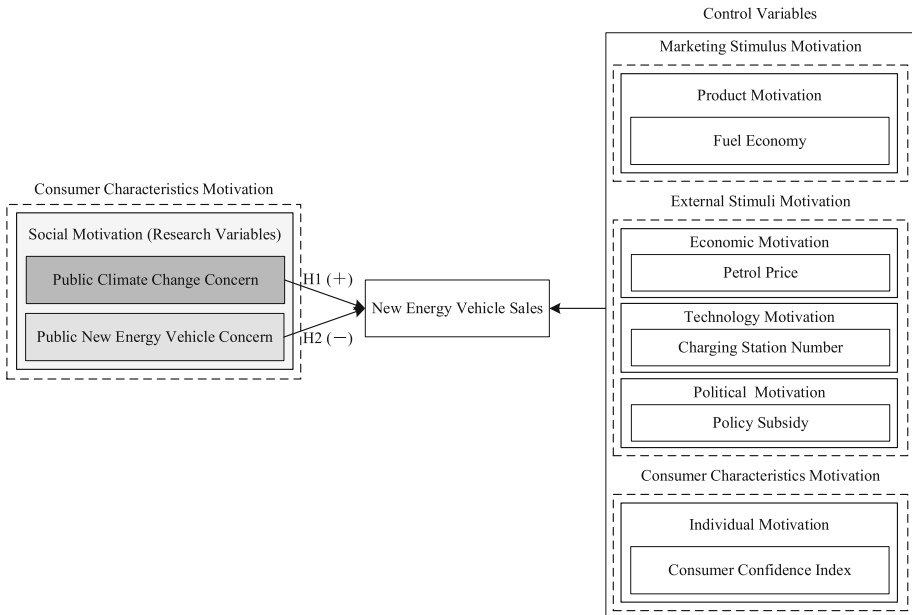

Fig. 2 Conceptual framework

4 Data sources and model construction

4.1 Data sources

In conjunction with the conceptual framework developed, three types of data will be collected: the dependent variable (new energy vehicle sales), the key research variables (public climate change concern and public new energy vehicle concern) and the control variables (fuel economy, petrol price, number of charging stations, policy subsidies and consumer confidence index).

4.1.1 New energy vehicle sales

In this paper, we select new energy vehicle sales as a measure of actual new energy vehicle consumption behaviour. The research on new energy vehicle sales can be divided into different granularities, such as country, brand and model. Considering the wide variation in the level of new energy vehicle development at the country level and the rapid and uneven iteration of data at the model level, we select data at the brand level to research. The monthly sales data of new energy vehicles is obtained from Passenger Vehicle Market Information Joint Committee (CMC). The time span is from January 2016 to December 2019. And we mainly select vehicle brands that are representative and meet the sales volume requirements as research subjects, as demonstrated by their entry into the new energy vehicle industry for more than five years and their monthly sales volume generally exceeding 100 units. The final vehicle brands that enter the scope of the research include BYD, Geely, Jianghuai, Jiangling, Chery and Chang'an.
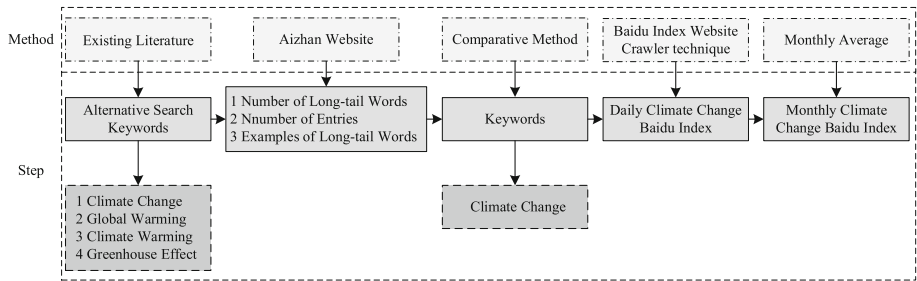
4.1.2 Baidu search index

Search index, such as Google trends and Baidu search index, is an index constructed based on the search volume of keywords on search engines by netizens. At present, search indices have been applied extensively in behavioral research (Ginsberg et al., 2009; Li et al., 2022; Xu et al., 2022). Due to the rapid development and popularity of the Internet, when an individual is concerned about a phenomenon or commodity, he or she will search on search engines as a way to obtain more relevant information. Therefore, search indices can be used as authoritative secondary data to measure public concern. Some of the literature has applied search indices to the measurement of concerns (Li et al., 2022; Xu et al., 2022), such as air pollution Baidu index, air quality Baidu index, PM2.5 Baidu index, PM10 Baidu index.

(1) Climate change Baidu search index

Public climate change concern can be expressed in the marketing field as a strong positive attitude towards preserving the environment. Existing studies mainly use experiments, interviews and questionnaires to measure it (Aasen, 2017; Newman et al., 2012), which is highly subjective. Following Xu et al. (2022) and Li et al. (2022) who measured public concern about air pollution based on Baidu search index, we will use climate change Baidu search index to measure public climate change concern. We use existing artificial intelligence systems and a coded crawler program to obtain climate change Baidu index data in the following steps, as shown in Fig. 3.

First, we identify four alternative search keywords by summarising the existing literature: climate change, global warming, climate warming and greenhouse effect. Second, the four alternative keywords are searched separately through the keyword mining function provided by aizhan website (https://ci.aizhan.com/) to obtain the number of long-tail words, the number of entries and the examples of long-tail words, and the results are shown in Table 2.

Fig. 3 Climate change baidu search index acquisition process

Table 2 Alternative keyword search

Alternative keyword	No. of long-tail words	No. of entries	Examples of long-tail words
Climate change	16	1.00×10^9	UN framework convention on climate change; advances in climate change research
Global warming	11	8.23×10^8	Causes of global warming; dangers of global warming
Climate warming	13	8.21×10^8	Global warming; the dangers of global warming
Greenhouse effect	6	4.59×10^8	What is the greenhouse effect; gases that contribute to the greenhouse effect

Third, Table 2 shows that the number of long-tail words for the keyword climate change reaches 16, and the number of entries exceeds 100 million, which is significantly better than other alternative keywords. Therefore, climate change is adopted as the core keyword in this paper. Forth, we search for the keyword climate change on the Baidu index website (https://index.baidu.com) and use a Python toolkit to crawl the daily climate change Baidu index from 2016 to 2019. Fifth, the daily data obtained are monthly averaged.

(2) New energy vehicle Baidu search index

For new energy vehicles as high value products, consumers often search online for appropriate product information as a reference for their purchase decision, so the new energy vehicle Baidu search index can be the measure of public new energy vehicle concern. In the same way as the climate change Baidu search index, three alternative keywords are obtained: new energy vehicles, electric vehicles and non-fuel vehicles. Using the aizhan website, the keyword new energy vehicles is found to be significantly better than the other alternative keywords, so we use new energy vehicles as the search keyword. By crawling the data of new energy vehicles on the Baidu index website through Python and averaging the daily data, we obtain the monthly new energy vehicle Baidu search index data from January 2016 to December 2019.

4.1.3 Data on control variables

We obtain petrol prices in China from the data centre at data.eastmoney.com. Unlike other countries and regions, petrol prices in China are strictly regulated by the government and do not fluctuate in line with international oil prices. Petrol prices also remain broadly consistent across provinces and regions in China. Second, we introduce a new indicator, new energy vehicle credit, which can represent the results of new energy vehicle brands in terms of fuel economy. The Chinese Ministry of Industry and Information Technology (MIIT) discloses the new energy credits of each new energy vehicle brand for the previous year in July. Third, we obtain charging station number data from the China Electric Vehicle Charging Infrastructure Promotion Alliance (EVCIPA), which publishes monthly data on the total number of charging stations. Fourth, consumer confidence index data is obtained from the National Bureau of Statistics of China (NBSC). NBSC conducts an annual questionnaire survey on urban consumer confidence, which is published monthly. Finally, the policy subsidy data is derived from the "New Energy Vehicle Promotion Subsidy Scheme and Product Technical Requirements", which is published annually by the Chinese national government.

The variable description and source in this paper, including the dependent, independent, and control variables, are summarized in Table 3 with more details.

4.2 Model construction

Table 4 presents the descriptive statistics and correlations for the main variables. The data period is mainly from January 2016 to December 2019. The Hausman test indicates that the data in this paper is suitable for constructing a fixed effects model. Thus, we model the overall sales for new energy vehicles as a function of climate change Baidu search index, new energy vehicle Baidu search index, petrol price, consumer confidence index, charging station number, new energy vehicle credit, policy subsidy and season. The model specification is as follows:

$$
\begin{aligned}
\text{Sales}_{it} =& \beta_1 \, \text{ClimateBI}_t + \beta_2 \, \text{NEVBI}_t + \beta_3 \, \text{GasPrice}_t + \beta_4 \, \text{NEVCredit}_{it} \\
& + \beta_5 \, \text{PileNum}_t + \beta_6 \, \text{CCI}_t + \beta_7 \, \text{Subsidy}_t + \beta_8 \, \text{Season}_t + \varepsilon_{it}
\end{aligned}
\tag{1}
$$

Sales_{it} denotes the sales of new energy vehicle brand i in month t; ClimateBI_t denotes climate change Baidu search index in month t; NEVBI_t denotes new energy vehicle Baidu search index in month t; GasPrice_t denotes petrol price in month t; NEVCredit_{it} denotes the new energy vehicle credit of new energy vehicle brand i in month t; PileNum_t denotes the number of charging stations in month t; CCI_t denotes consumer confidence index in month t; Subsidy_t denotes government subsidy in month t; Season_t denotes quarter in each year, controlling for quarterly changes in new energy vehicle sales.

The fixed effects model describes the impact of different factors on new energy vehicle sales. However, in order to correctly identify these effect relationships, endogeneity needs to be further considered. The first type of endogeneity is concerned with reverse causality between the dependent and independent variables. In this paper, the concern is whether the relationship between public climate change concern and new energy vehicle sales can be bidirectional. The dependent variable in this paper is the sales of brand-specific new energy vehicles per month, while the independent variable is the Baidu search index which evaluates climate change searching. It is virtually impossible that the sales of a particular brand of new energy vehicles influence the public search for climate change, so we can ignore this reverse causality.

Table 3 Variable description and source

Variables	Variable description	Data source
New energy vehicle sale	Monthly new energy vehicle sales at brand level are used as an indicator of new energy vehicle consumption behaviour	CMC
Climate change Baidu search index	Monthly climate change Baidu search index is used as a measure of public climate change concern and is obtained by means of a crawler	Baidu index website (index.baidu.com)
New energy vehicles Baidu search index	The monthly new energy vehicles Baidu search index is used as a measure of public new energy vehicles concern and is obtained by means of a crawler	Baidu index website (index.baidu.com)
Petrol price	Petrol price measures the monthly petrol price situation in China and is measured in yuan per ton	data.eastmoney.com
New energy vehicle credit	New energy vehicle credit, as a measure of fuel economy, can represent the result of new energy vehicle brands in terms of fuel economy	MIIT
Charging station number	Monthly charging station number represents the level of technological support for new energy vehicle charging	EVCIPA
Consumer confidence index	Consumer confidence index measures the strength of consumer confidence in the macro environment	NBSC
Policy subsidy	Policy subsidy is an important government policy to promote the development of new energy vehicles. China's new energy vehicle policy subsidies are constantly changing every year	Policy documents issued by the government

The second type of endogeneity is the omitted variable problem. In order to minimise the impact of omitted variables, we consider different motivations for purchasing new energy vehicles from existing research, including marketing stimulus motivation, external stimuli motivation and consumer characteristics motivation. For each type of motivation, we select control variables to minimise the omitted variable problem. Omitted variables may also include unobserved social trends or cultural changes (Chen et al., 2019a, 2019b) that may influence consumers' decisions to purchase new energy vehicles. Unobserved social trends or cultural changes can develop over time, and quarterly control variables can to some extent eliminate the impact of these omitted variables.

Table 4 Descriptive statistics and correlations among key variables

Variable	Mean	Std.Dev	1	2	3	4	5	6	7	8
1. Sales	4621.35	5524.96	–							
2. ClimateBI	275.86	45.13	0.150	–						
3. NEVBI	5839.66	2834.59	0.065	0.326	–					
4. NEVPoint	192,393.90	217,281.80	0.798	0.088	0.096	–				
5. PileNum	241,187.70	130,792.40	0.207	0.322	– 0.017	0.308	–			
6. GasPrice	7351.00	758.63	0.269	0.327	0.399	0.322	0.676	–		
7. CCI	117.73	9.07	0.250	0.386	0.443	0.313	0.803	0.817	–	
8. Subsidy	31,705.25	11,621.75	– 0.166	– 0.299	0.041	– 0.288	– 0.957	– 0.644	– 0.754	–

5 Estimation results

5.1 Impact of public climate change concern on new energy vehicle sales

The final estimation results are given in Table 5. Table 5 shows that public climate change concern has a significant positive impact on new energy vehicle sales ($r = 10.4077$, $p < 0.05$), suggesting H1 is supported. The above results can be explained using social influence theory. When public climate change concern is elevated, it will promote social influence (learning and peer effects) in consumer groups, both of which further positively influence consumers' SC behaviour.

In addition, Table 5 shows that public new energy vehicle concern has a significant negative impact on new energy vehicle sales ($r = -0.3313$, $p < 0.01$), suggesting H2 is supported. The above findings can be explained by social influence theory (social learning and peer effects). As a sustainable product under development, new energy vehicles generally suffer from immature technology and inadequate supporting facilities, resulting in negative word-of-mouth. This negative word-of-mouth can contribute significantly to negative consumer concerns, which will further promote social learning and peer effects of negative word-of-mouth in the consumer group, which in turn can lead to consumers abandoning the purchase of new energy vehicles.

In terms of control variables, fuel economy, petrol price, consumer confidence index and policy subsidy all have a positive impact on new energy vehicle sales, which is in line with expectations and previous research findings.

Table 5 Impact of public climate change concerns on new energy vehicle sales

Variables	(1)	(2)	(3)
	Pooled regression	Fixed Effects	Fixed effects
ClimateBI	10.6672** (5.3568)	10.4077** (4.8832)	10.4077** (4.8832)
NEVBI	− 0.3364*** (0.1114)	− 0.3313*** (0.1015)	− 0.3313*** (0.1015)
NEVPoint	0.0207*** (0.0009)	0.0138*** (0.0016)	0.0138*** (0.0016)
PileNum	− 0.0032 (0.0061)	0.0004 (0.0056)	0.0004 (0.0056)
GasPrice	0.4755 (0.4410)	0.8672** (0.4098)	0.8672** (0.4098)
CCI	131.5430** (58.5843)	134.4139** (53.4050)	134.4139** (53.4050)
Subsidy	0.1169** (0.0586)	0.1348** (0.0535)	0.1348** (0.0535)
Season	431.9121** (202.9367)	320.6068* (186.3530)	320.6068* (186.3530)
Constant	− 23,327.7702*** (6226.4752)	− 26,330.1958*** (5708.1487)	− 26,330.1958*** (5708.1487)
Brand fixed effects	No	No	Yes
N	288	288	288
R-sq	0.677	0.389	0.389

Standard errors in parentheses
*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$

5.2 Robustness check

Although we construct the model with full consideration of endogeneity, endogeneity is an unavoidable problem whose existence may lead to unreliable results. Therefore, in order to further circumvent and address this situation, we further supplement the original model by applying the lagged dependent variable of new energy vehicle sales and the time decay effect of public concern to further validate the findings and check the robustness of findings.

5.2.1 Lagged dependent variable

Social trends or cultural changes evolve over time, and the inclusion of lagged dependent variables can effectively deal with the endogeneity caused by this part of the omitted variable (Germann et al., 2015). Furthermore, it is patently illogical to suggest that new energy vehicle sales have led to an increase in public climate change concern. However, this counter-logical reverse causality may become a problem. The endogeneity problem caused by this reverse causality can be effectively mitigated when a lagged dependent variable is added to the right-hand side of the equation. The model with the addition of the lagged dependent variable is shown as follows:

$$\text{Sales}_{it} = \beta_1 \, \text{ClimateBI}_t + \beta_2 \, \text{NEVBI}_t + \beta_3 \, \text{GasPrice}_t + \beta_4 \, \text{NEVCredit}_{it}$$
$$+ \beta_5 \, \text{PileNum}_t + \beta_6 \text{CCI}_t + \beta_7 \, \text{Subsidy}_t + \beta_8 \, \text{Season}_t + \text{Sales}_{i(t-1)} + \varepsilon_{it} \quad (2)$$

After adding the lagged dependent variable, the results of fixed effects model estimation are shown in Table 6. Table 6 shows that there is a significant positive relationship between

Table 6 Estimation with lagged sales

Variables	(1) Pooled regression	(2) Fixed effects	(3) Fixed effects
L.Sales	0.6636*** (0.0466)	0.5809*** (0.0502)	0.5809*** (0.0502)
ClimateBI	12.9532*** (4.2035)	12.5472*** (4.1178)	12.5472*** (4.1178)
NEVBI	− 0.1471* (0.0868)	− 0.1682** (0.0852)	− 0.1682** (0.0852)
NEVPoint	0.0068*** (0.0012)	0.0049*** (0.0016)	0.0049*** (0.0016)
PileNum	− 0.0003 (0.0047)	0.0012 (0.0047)	0.0012 (0.0047)
GasPrice	0.5463 (0.3402)	0.7409** (0.3399)	0.7409** (0.3399)
CCI	18.4776 (45.6378)	34.1013 (44.8581)	34.1013 (44.8581)
Subsidy	0.0724 (0.0450)	0.0873** (0.0442)	0.0873** (0.0442)
Season	102.9942 (160.6995)	85.4979 (158.0637)	85.4979 (158.0637)
Constant	− 11,101.7404** (4845.9009)	− 14,187.8872*** (4813.7788)	− 14,187.8872*** (4813.7788)
Brand fixed effects	No	No	Yes
N	282	282	282
R-sq	0.814	0.587	0.587

Standard errors in parentheses
*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$

lagged sales of new energy vehicles and current monthly sales (r = 0.5809, $p < 0.01$). This is in line with research expectations and suggests that lagged sales do mitigate some omitted variable problems. More importantly, the results still show that public climate change concern has a significant positive impact on new energy vehicle sales (r = 12.5472, $p < 0.01$) and public new energy vehicle concern has a significant negative impact on new energy vehicle sales (r = − 0.1682, $p < 0.05$), suggesting H1 and H2 are supported respectively.

5.2.2 Time decay effect of public concern

As a high-value product, consumers tend to take a longer time to make comparisons before finally deciding whether to purchase a new energy vehicle. In addition, there is a significant time decay effect of public concern. Therefore, we further set two public concern variables (public climate change concern and public new energy vehicle concern) as cumulative variables over time, specifically by backdating the Baidu search index for three months and using them as new concern proxy variables. Thus, the data is processed using exponential and inverse functions to obtain the cumulative climate change Baidu search index in exponential function form (AddCMBI_E), the cumulative climate change Baidu search index in inverse function form (AddCMBI_I), the cumulative new energy vehicle Baidu search index in exponential function form (AddNEVBI_E) and the cumulative new energy vehicle Baidu search index in inverse function form (AddNEVBI_I).

The estimation results are shown in Table 7. Table 7 shows that AddCMBI_E has a significantly positive relationship with new energy vehicle sales (r = 30.6813, $p < 0.01$) and AddCMBI_I has a significantly positive relationship with new energy vehicle sales (r = 9.7062, $p < 0.05$). In addition, Table 7 also shows that AddNEVBI_E has a significantly negative relationship with new energy vehicle sales (r = − 1.0686, $p < 0.01$) and AddNEVBI_I has a significantly negative relationship with new energy vehicle sales (r = − 0.3750, $p < 0.01$). Therefore, the new estimation results under the exponential time decay function and the inverse time decay function remain broadly consistent with the estimation results of the original model. It indicates that public climate change concern indeed positively affects the sales of new energy vehicles and public new energy vehicle concern indeed negatively affects the sales of new energy vehicles, suggesting H1 and H2 are supported.

5.3 Predictive analysis

Estimation results show that there is a significant positive (negative) effect of public climate change concern (public new energy vehicle concern) on consumers' purchase of new energy vehicles. We will further verify the validity and accuracy of the estimation results from the perspective of new energy vehicle sales forecasting. Specifically, we select the random forest algorithm (Breiman, 2001) and the lasso algorithm (Tibshirani, 1996) from machine learning algorithms as forecasting algorithms. In terms of prediction data, the predicted variable is new energy vehicle sales, and the data are selected from the CMC for each month from 2016 to 2019, and the data source is shown in Table 3. The prediction factors are climate change Baidu search index, new energy vehicle Baidu search index, petrol price, charging station number, consumer confidence index, policy subsidy and season for each month from 2016 to 2019, and the data sources are shown in Table 3. The specific prediction steps are as follows: First, prediction experiment identification and prediction factor selection. Four prediction experiments are identified, which are prediction experiment 1 (PD_EX_1, baseline prediction experiment), prediction experiment 2 (PD_EX_2), prediction experiment

Table 7 Estimation with time decay effect of public concern

Variables	(1) PR	(2) FE	(3) FE	(4) PR	(5) FE	(6) FE
AddCMBI_E	31.5345** (12.6283)	30.6813*** (11.5067)	30.6813*** (11.5067)			
AddNEVBI_E	− 1.1212*** (0.2579)	− 1.0686*** (0.2352)	− 1.0686*** (0.2352)			
AddCMBI_I				10.0259** (4.2350)	9.7062** (3.8618)	9.7062** (3.8618)
AddNEVBI_I				− 0.3982*** (0.0851)	− 0.3750*** (0.0777)	− 0.3750*** (0.0777)
NEVPoint	0.0208*** (0.0009)	0.0141*** (0.0016)	0.0141*** (0.0016)	0.0208*** (0.0009)	0.0142*** (0.0016)	0.0142*** (0.0016)
PileNum	− 0.0092 (0.0063)	− 0.0052 (0.0058)	− 0.0052 (0.0058)	− 0.0119* (0.0064)	− 0.0077 (0.0059)	− 0.0077 (0.0059)
GasPrice	0.8026* (0.4460)	1.1598*** (0.4130)	1.1598*** (0.4130)	0.9599** (0.4522)	1.2949*** (0.4182)	1.2949*** (0.4182)
CCI	204.7679*** (61.8936)	200.0013*** (56.3984)	200.0013*** (56.3984)	231.7805*** (62.9793)	223.1581*** (57.4481)	223.1581*** (57.4481)
Subsidy	0.1120* (0.0573)	0.1290** (0.0523)	0.1290** (0.0523)	0.1024* (0.0569)	0.1193** (0.0520)	0.1193** (0.0520)
Season	276.5920 (202.7179)	177.6283 (185.8162)	177.6283 (185.8162)	238.0343 (200.9860)	147.8215 (184.2174)	147.8215 (184.2174)
Constant	− 32,586.6069*** (6813.8848)	− 34,652.8625*** (6222.5878)	− 34,652.8625*** (6222.5878)	− 35,485.3262*** (7020.4269)	− 37,071.6359*** (6409.3190)	− 37,071.6359*** (6409.3190)
Brand fixed effects	No	No	Yes	No	No	Yes
N	288	288	288	288	288	288

PR pooled regression, *FE* fixed effects; Standard errors in parentheses

$*p < 0.10$, $**p < 0.05$, $***p < 0.01$

Table 8 Prediction experiments and prediction factors selection

Prediction experiment	Prediction factors
PD_EX_1	Petrol price, number of charging stations, consumer confidence index, subsidy, season
PD_EX_2	New energy vehicle baidu search index, petrol price, number of charging stations, consumer confidence index, subsidy, season
PD_EX_3	Climate change baidu search index, petrol price, number of charging stations, consumer confidence index, subsidy, season
PD_EX_4	Climate change baidu search index, new energy vehicle baidu search index, petrol price, number of charging stations, consumer confidence index, subsidy, season

3 (PD_EX_3) and prediction experiment 4 (PD_EX_4). The prediction factors for the four prediction experiments are selected as shown in Table 8. Second, prediction index selection, we select three assessment indexes, namely the mean absolute error (MAE), the root mean squared error (RMSE) and the mean absolute percentage error (MAPE). Third, prediction execution. The prediction algorithms are the random forest algorithm and the lasso algorithm. The ratio of the training set to the test set is 8:2, i.e., the first 38 months of data are selected as the training set and the last 10 months of data are used as the test set to test. Fourth, comparative experiments. The other prediction experiments are compared with the baseline prediction experiments to obtain the percentage decrease (PD) of each prediction indicator to verify the validity and accuracy of the estimation results. The final comparison of predictions is shown in Table 9.

Table 9 shows that when forecasting using the random forest algorithm and the Lasso algorithm, relative to the baseline forecasting experiment, prediction experiment 3 and prediction experiment 4 show substantial decreases in all evaluation indexes (MAE, RMSE, MAPE), and prediction experiment 2 shows substantial decreases in both MAE and RMSE and a small increase in MAPE. Therefore, the results of prediction experiments 3 and 4 compared with prediction experiment 1 show that taking into account the public climate change concern in

Table 9 Comparison of final forecasting results

Random forest	PD_EX_1	PD_EX_2		PD_EX_3		PD_EX_4	
	Value	Value	PD (%)	Value	PD (%)	Value	PD (%)
MAE	29,635.87	27,398.85	− 7.55	25,690.69	− 13.31	26,001.86	− 12.26
RMSE	35,411.42	34,285.13	− 3.18	30,402.06	− 14.15	30,961.55	− 12.57
MAPE	0.3059	0.3072	0.39	0.2677	− 12.49	0.2715	− 11.27
Lasso	Value	Value	PAMR (%)	Value	PAMR (%)	Value	PAMR (%)
MAE	71,975.04	68,781.59	− 4.44	65,571.36	− 8.90	65,521.11	− 8.97
RMSE	81,703.88	77,810.34	− 4.77	74,462.81	− 8.86	74,212.38	− 9.16
MAPE	0.4386	0.4571	4.21	0.4084	− 6.87	0.4135	− 5.72

the prediction of new energy vehicle sales can effectively improve the accuracy of the prediction, thus demonstrating the validity and accuracy of our empirical results (public climate change concern has an impact on consumers' purchase of new energy vehicles). In addition, although the comparison between prediction experiment 2 and prediction experiment 1 shows a small increase in MAPE, the overall comparison between prediction experiments 2, 4 and prediction experiment 1 shows that taking into account the public new energy vehicle concern in the process of predicting new energy vehicle sales can effectively improve the accuracy of the prediction, thus demonstrating the validity and accuracy of our empirical results (public new energy vehicle concern has an impact on consumers' purchase of new energy vehicles).

6 General discussion

6.1 Theoretical implications

Our research has important implications for theory and future research.

First, the attitude-behaviour gap in consumer sustainability behaviour is a serious barrier to the diffusion and adoption of sustainable products in society. Research into the drivers of consumer behaviour for sustainable products can effectively alleviate the attitude-behaviour gap. Environmental concern, as one of the important social drivers of consumer characteristics, has been studied by some scholars. However, the limitation of research data acquisition leads to the research perspective of environmental concern being limited to the individual level. Therefore, we use existing artificial intelligence decision systems to collect authoritative secondary data to measure public concern about climate change at a public level and explore its impact on the consumption of sustainable products. To our best knowledge, it is the first time that a bridge has been built between public concern and sustainable product consumption, and it provides an important direction for exploring the drivers of sustainable consumer behaviour.

Second, one of the keys of marketing business management is to capture the attention of the public (Mukattash et al., 2021). For the first time, we clarify from a theoretical perspective that public concern plays a role in promoting social influence (social learning and peer effects) in the field of sustainable consumption. At present, the explosion of social media has contributed to the rise of social marketing. Social marketing cannot operate without social influence (Hu et al., 2019). Therefore, our explicit role of public concern can provide theoretical support for social marketing management.

Third, sustainable marketing business management has received widespread attention (McDonagh & Prothero, 2014). And it involves the use of marketing processes and their impacts to promote the diffusion and popularity of sustainable products. We explore the relationship between two new social drivers (public climate change concern and public new energy vehicle concern) on the consumption of sustainable products, which provide theoretical support for the social diffusion and adoption of sustainable products and contribute to the development of sustainable marketing business management.

6.2 Managerial implications

Our findings provide several important implications for governments and companies promoting sustainable products and for companies' SBM.

First, Our research has some implications for the next stage of the national promotion of sustainable products. Based on this research, sustainable products can be further promoted in a more economical and subtle way. Nowadays, everyone who lives in society is inseparable from the media. Considering the specificity and authority of state media, news and information about climate change can be promoted through the official media, which can effectively facilitate the purchase of sustainable products. The study case in this paper focuses on the Chinese new energy vehicle market, and the research variables involve three motivation perspectives: marketing stimulus motivation, external stimuli motivation and consumer characteristics motivation. We obtain their impact relationship on consumers' new energy vehicle consumption behaviour. It can provide theoretical support for Chinese policymakers and business managers to make appropriate decisions to promote the adoption and diffusion of new energy vehicles throughout society.

Second, one of the tasks of sustainable marketing business management is to promote and popularise sustainable products. Companies need a better grasp of market demand and orientation in an increasingly competitive sustainable product market. The findings in this paper can, to some extent, help companies address sustainable marketing issues and promoting the CE. According to the results of this research, public climate change concern affects the sales of sustainable products, i.e., consumers who are concerned about climate change are to a certain extent more likely to purchase sustainable products. Therefore, from sustainable marketing business management perspective, companies can connect their sustainable products with improving climate change in their marketing strategies to ensure that their sustainable products are accurately positioned, which will have a significant positive impact on their brand image building and product sales, which in turn will contribute to the sustainable marketing business management of the company. Furthermore, the negative impact of public new energy vehicle concern on sustainable product consumption suggests that word-of-mouth is critical to the promotion and adoption of sustainable products. Therefore, companies need to focus on enhancing the word-of-mouth of sustainable products in their marketing business management of sustainable products as a means of promoting sustainable marketing business management.

Third, we use our existing artificial intelligent system to collect authoritative secondary data (climate change Baidu search index and new energy vehicle Baidu search index) to measure public climate change concern and public new energy vehicle concern. After fully considering the two drivers of sustainable products, we use artificial intelligence algorithms to forecast the demand for sustainable products, thereby improving the accuracy of forecasting, which provides the company with an important decision-making tool for sustainable product demand forecasting.

Fourth, as an important supply chain business management, sales and operations planning is a tool that unites different business plans into one integrated set of plans (Thomé et al., 2012). We identify the impact of two important social drivers on sustainable product consumption (public climate change concern and public new energy vehicle concern) and apply both to demand forecasting for sustainable products. This approach improves the accuracy of demand forecasting on the sales side. Combined with sales and operations planning, the improvement in demand forecasting accuracy can contribute to a balance between supply and demand at the front and back ends of supply chains, and thus to the SBM of supply chain operations.

6.3 Research limitations and future work

Although our research in this paper enhances knowledge in the area of consumer SC behaviour, there are some limitations. First, we focus on the data from the Chinese new energy vehicle industry, which carries strong geographical limitations. Second, new energy vehicles have been in development for a very short period of time, resulting in fewer brands meeting the requirements of this research and creating some uncertainty in the findings. Future work can be undertaken in the following areas. First, in order to gain a deeper understanding of the validity of motivations influencing consumers' SC behaviour, further consideration needs to be given to some potential moderators that may influence the motivations in this research. Second, in order to verify the validity and accuracy of the findings in this paper, future attempts can be made to investigate the relevant motivations using other methods, such as quasi-experimental study, instrumental variable regression, novel artificial intelligence prediction algorithms and parameters analysis. Finally, the results of the impact of public climate change concern and public new energy vehicle concern on consumers' new energy vehicle consumption behaviour can be further researched from a theoretical perspective to investigate the relevant mechanisms.

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