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The Dynamic Impact of Inflation on Supply Chain and Competitiveness: Bibliometric and Econometric Analysis

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Abstract

With the intensification of market competition, supply chain management is more critical for business development. Many studies have conducted literature reviews based on supply chain management research. However, less attention has been paid to the impact of the actual economic phenomena on supply chain management research. This paper investigates the dynamic impact of various inflation indicators on supply chain management studies in the context of inflation through bibliometric and econometric analysis. Specifically, this paper first conducts a bibliometric analysis of supply chain management research and determines the literature variables. Secondly, time series data on six inflation indicators are collected as economic variables to reflect trends and fluctuations of inflation. Meanwhile, the Granger causality test investigates the dynamic relationship between inflation and supply chain management research development. Finally, the impact of inflation on supply chain management literature data is quantitatively evaluated by the analyses of impulse response functions and forecast error variance decompositions. The analysis results of this paper show that the influence between inflation and academic research on supply chain management is bidirectional, and the bidirectional impact varies across inflation indicators. The conclusions of this paper can not only provide a reference for enterprises to improve their competitiveness in actual economic activities but also help researchers to grasp the key points in scientific research better and improve the competitiveness of academic research.

Keywords: *supply chain management; inflation; competitiveness, Granger causality test; impulse response functions; forecast error variance decompositions*

JEL Classification: C1, C4, C5

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1. INTRODUCTION

In recent years, market competition has been intensifying, product cycles have been shortening, and operating costs have been gradually rising, making the tests and challenges faced by companies increasingly severe (Law & Gunasekaran, 2012; Wu & Angelis, 2007). In the face of fierce competition, more and more scholars and managers are aware of the importance of supply chain management for business development (Khare et al., 2012; Vokurka et al., 2002). Supply Chain Management was initially introduced in the early 1980s (Oliver & Webber, 1982) when the potential benefits of integrating internal business functions such as purchasing, manufacturing, sales, and distribution were discussed. Since then, some scholars have tried to understand better and explain the activities of supply chain management, including inventory management (Jones & Riley, 1985), supply chain integration (Power, 2005), risk management (Tang, 2006), demand management (Seyedan & Mafakheri, 2020), and information management (Wu et al., 2016). All these studies provide critical value for developing supply chain management research.

With the deepening of the research, some scholars have gradually combined the actual economic phenomenon with supply chain management research. Research on supply chain management has been conducted based on actual economic phenomena such as Brexit (Brooks et al., 2021), the US-China trade war (Blessley & Mudambi, 2022), monetary policy (Hu et al.,

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2020), and business cycles (Durugbo & Al-Balushi, 2022). However, the focuses are primarily on the specific relationship between one aspect of supply chain management and the actual economic phenomena, without careful consideration of the discipline research, which often has a limited impact on the research development and the practice of supply chain management. Therefore, it is necessary to explore further the dynamic relationship between scientific research on supply chain management and the actual economic phenomena.

Current studies exploring the links between scientific research and economic phenomena are mainly based on econometric and bibliometric analysis (Kufenko & Geiger, 2016). Bibliometrics analysis can capture, quantify and visualize the dynamics of scientific research (Wang et al., 2022). Econometrics, the most commonly used quantitative method to analyze economic phenomena, can quantitatively study the relationship between economic variables (Mann, 2012). Therefore, it is more scientific and efficient to combine bibliometrics and econometric analysis to explore the relationship between scientific research and actual economic phenomena (Kufenko & Geiger, 2016). Based on econometrics and bibliometrics analysis, existing studies have investigated the relationship and dynamic impact between the business cycle (Kufenko & Geiger, 2016), poverty cycle (Qin et al., 2021a), and financial cycle (Qin et al., 2021b) and economic literature, which provide the reference for this paper. However, it can be seen that most of the current studies are focused on economics-related areas, and no research about supply chain management research has been conducted.

Additionally, compared with the typical economic phenomenon of the business cycle, inflation is more closely related to the actual supply chain management (di Giovanni et al., 2022). On the one hand, the increase in supply chain costs during the period of inflation will affect the aspects of supply chain management and increase the risk of supply chain management (Meyer et al., 2022). On the other hand, poor supply chain circulation or disruptions will also cause inflationary pressures (Ramani et al., 2022). Moreover, supply chain management research may contribute to developing policies to mitigate inflationary pressures (di Giovanni et al., 2022). Therefore, it is of greater practical value to analyze the relationship between the economic phenomenon of inflation and supply chain management research.

This paper explores the links and interactions between inflation and supply chain management research. Specifically, this paper examines the connections and dynamic impacts between actual inflation and the academic literature on supply chain management for various types of inflation, including energy, food, and production. Firstly, literature variables are determined using bibliometric analysis for the academic literature on supply chain management. Secondly, the econometric analysis is carried out for the economic variables of inflation and supply chain management literature variables. Finally, by constructing the vector autoregression (VAR) model, this paper conducts three analyses, namely the Granger causality test, impulse response functions, and forecast error variance decompositions, to quantitatively illustrate the connection and interaction between actual inflation and supply chain management research.

This paper is organized as follows: Section 2 reviews the relevant literature. Section 3 explains the methods of bibliometric analysis and econometric analysis in this paper. Section 4 describes the bibliometric and econometric analysis results in detail and discusses the link between inflation and the academic literature on supply chain management. Finally, section 5 presents the conclusions of this paper.

2. THEORETICAL BACKGROUND

Supply chain management was first proposed in the 1980s when discussing the potential benefits of conducting supply chain management by integrating internal business functions such as purchasing, manufacturing, sales, and distribution (Oliver & Webber, 1982). Subsequently, some scholars have further studied supply chain management, paying attention to many topics,

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such as logistics, physical distribution, integration, inventory, and demand management (Alfalla-Luque & Medina-López, 2009; Parente et al., 2008; Pournader et al., 2020). Meanwhile, the rapid increase in published articles on supply chain management since the 1990s has prompted scholars to understand the state of the art in this field through literature reviews (Ellram & Ueltschy Murfield, 2019; Lambert & Cooper, 2000).

Some scholars have conducted literature reviews on the characteristics of different types of supply chains, such as green supply chain management (Srivastava, 2007), circular supply chain management (Choi & Chen, 2021), sustainable supply chain management (Brandenburg et al., 2014) and smart supply chain management (Zhang et al., 2022). Some studies have attempted to summarize supply chain management from a theoretical and methodological perspective. Other studies have attempted to summarize supply chain management from a theoretical and methodological perspective, with (Clifford Defee et al., 2010) detailing the types of theory commonly used in supply chain management research. However, it is worth noting that more literature reviews are currently being conducted on specific topics in supply chain management (Swanson et al., 2018). All of these literature reviews provide significant value to the development of supply chain management research. Still, the research perspectives of these studies are mainly based on one aspect of the supply chain.

More importantly, supply chain management can be affected not only by changes within the supply chain but also by changes in the external environment, such as economic phenomena, policies, and technological iterations (Samson, 2020). For example, (Hendry et al., 2019) studied the impact of Brexit on the resilience of the local food supply chain and analyzed the potential opportunities and challenges. (Samson, 2020) pointed out that changing fiscal and monetary policies can also impact supply chain management. (Heng et al., 2005) examined the linkages between inventory investment and business cycle fluctuation. Although these studies explored the influence of economic phenomena on supply chain management, they primarily focused on a particular aspect of supply chain management without exploring the connection between economic phenomena and supply chain management from the perspective of research development.

Indeed, economic phenomena, particularly inflation and supply chain management research, are closely linked (di Giovanni et al., 2022). For example, in the economic phenomena of inflation, academia and industry will increase their discussions on supply chain management to counteract supply chain management risks (Meyer et al., 2022; Peck, 2005). At the same time, disruptions or stoppages in supply chains can further contribute to inflationary pressures (Ramani et al., 2022). Therefore, supply chain management research may, in some ways, contribute to developing policies to combat inflationary pressures (di Giovanni et al., 2022). Therefore, exploring the link between supply chain management research and inflation is valuable.

Studies have been conducted to explore the links between scientific research and economic phenomena, typically by Kufenko & Geiger (2016). They investigated the relationship between the actual business cycle and the economics literature based on bibliometric and econometric analyses. Qin et al. (2021a) explored the impact of poverty cycles on economics research by taking the United States as an example. Using China as a case study, Qin et al. (2021b) revealed the relationship between the economics literature and the financial cycle. All the above research explored the connection between scientific research and economic phenomena, which provided a good background for the investigation of this paper.

Considering that the economic phenomenon of inflation is more closely related to supply chain management than the typical business cycles, this paper focuses on the economic phenomenon of inflation. Meanwhile, although the previous research provides a valuable reference for this paper, there are still aspects worthy of further exploration. First, when Kufenko & Geiger (2016) performed a bibliometric analysis, search terms were counted

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whenever they appeared in the article, but this statistical method was not accurate enough. The presence of a critical term in an article does not mean that the article revolves around a topic related to the key term. Therefore, keywords are used in this paper for bibliometric analysis. Second, two directions can be further explored in the bibliometrics based on the work of Qin et al. (2021a) and Qin et al. (2021b).

On the one hand, although these two articles both carried out Granger causality and impulse response functions, they did not consider the influence of variable order on impulse response functions when the model was established. On the other hand, the analysis of forecast error variance decompositions in the quantitative analysis was not performed in the quantitative analysis. Although the study of impulse response functions can observe the response of each variable in the model to shocks, the analysis of forecast error variance decompositions is required to further evaluate the contribution of the variables to the forecast error variance.

3. METHODOLOGY

This paper will mainly conduct two parts of the analysis to study the relationship between actual inflation and supply chain management research. Firstly, this paper performs a bibliometric analysis of supply chain management-related research to determine the research trends of supply chain management. Secondly, the paper describes actual economic inflation indicators and applies econometric analysis to examine the link between real inflation and the academic literature on supply chain management.

3.1 Bibliometric analysis

Bibliometric analysis is the quantitative analysis of academic literature by statistical methods (Roy, 1983). At present, many studies have conducted bibliometric analysis through the Web of Science (Fosso Wamba, 2020), EBSCO (Xu et al., 2018), JSTOR (Kufenko & Geiger, 2016), and other databases. JSTOR, as a database of more than 12 million journal articles and a tool for constructing time series of literature terms, also provides the "Data for Research (DFR, http://dfr.jstor.org/)." In this paper, the JSTOR database is used to collect the data of relevant terms in supply chain management research and determine the time series data of literature variables.

Since this paper studies the research trends of the whole research field of supply chain management, this paper focuses on the key terms of supply chain management research through bibliometric analysis. By reading previous literature reviews related to supply chain management, this paper finally identifies the following 12 key terms, namely "Purchasing," "Logistic," "Transportation," "Supplier," "Distribution," "Inventory," "Demand," "Retailing," "Pricing," "Manufacturer," "Integration," and "Outsourcing." It is worth mentioning that different terms may evolve their specific meanings over time. However, as this paper focuses on the changes in the research field, the particular meanings of terms appearing in each article are not analyzed semantically. This is an issue that deserves further research.

Tab 1. – Literature variables and references. Source: own research

No.	Literature variables	References
1	purchasing	Wisner & Tan (2000)
2	logistic	Abdirad & Krishnan (2021)
3	transportation	Crainic & Laporte (2016)
4	supplier	Minner (2003)
5	distribution	Alvim & Oliveira (2020)
6	inventory	Jones & Riley (1985)
7	demand	Babai et al., (2022)
8	retailing	Tan & Sidhu (2022)
9	pricing	Ziari et al., (2022)

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10	manufacturer	Du et al., (2021)
11	integration	Alfalla-Luque et al., (2013)
12	outsourcing	Akbari (2018)

When collecting research data from JSTOR, this paper follows three principles: First, this paper chooses the journal article as the literature type and English as the literature language. This setting is because journal articles in English are more representative and relevant. Second, as this paper focuses on the relationship between supply chain management and inflation in real economic activities, the category "Business and Economics" is selected for statistics. Finally, different from previous studies, which took whether the key terms appeared in the article as the statistical criterion, this paper takes whether key terms are the article's keywords as the statistical criterion. The statistical criteria selected in this paper further ensure that the bibliometric data collected are focused on supply chain management research rather than just mentioning a particular term. Based on the above three principles, this paper searches for 12 key terms in supply chain management research.

According to previous literature research, the concept of supply chain management is first proposed in the 1980s (Alfalla-Luque & Medina-López, 2009), so the time range of bibliometric statistics is from 1980 to 2021. Meanwhile, considering that the amount of supply chain management literature fluctuates to different degrees in different years, this paper uses relative frequencies to characterize the change of key terms. The relative frequencies of key terms are measured as the proportion of journal articles with a key term as the keyword in all journal articles in the category "Business and Economics" in the same year. In other words, if the relative frequency of the term "Logistics" in 2010 is 5%, this means that 5% of journal articles in the category "Business and Economics" in 2010 used the term "Logistics" as the keyword.

3.2 Econometric analysis

3.2.1 Economic variables

To investigate the relationship between actual inflation and supply chain management research, this paper needs to collect relevant indicators of actual inflation as economic variables. Since the bibliometric analysis in this paper does not define a specific local country or region, the economic indicators used are based on global statistics. This paper refers to the database provided by (Ha et al., 2021), which provides the comprehensive inflation data of 196 countries from 1970 to 2022 and an aggregate annual average inflation data weighted by GDP. This paper uses six specific economic indicators as economic variables, i.e., headline consumer price inflation (HCPI), energy price inflation (ECPI), food price inflation (FCPI), official core consumer price inflation (CCPI), producer price inflation (PPI) and GDP deflator growth rate (DEF). Given the period of the literature variables, the statistical range of the economic variables is also from 1980 to 2021. Tab.2 shows a detailed description of the six economic variables.

Tab 2. – Economic variables and description. Source: Ha et al., (2021)

Variable Name	Indicator Type	Time frames	Description
HCPI	inflation rates	1980-2021	Headline consumer price inflation, annual
ECPI	inflation rates	1980-2021	Energy price inflation, annual

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FCPI	inflation rates	1980-2021	Food price inflation, annual
CCPI	inflation rates	1980-2021	Official core consumer price inflation, annual
PPI	inflation rates	1980-2021	Producer price inflation, annual
DEF	inflation rates	1980-2021	GDP deflator growth rate, annual

3.2.2 Econometric methods

After the bibliometric analysis and the collection of economic indicators, the relevant data of literature variables and economic variables are determined. This section will detail the econometric analysis based on literature and economic variables. Firstly, unit root tests should be performed on the time series data of literature variables and economic variables to test whether they are stationary. Common methods for unit root tests include DF (Dickey-Fuller) test (Dickey & Fuller, 1979), ADF (Augmented Dickey-Fuller) test (Dickey & Fuller, 1981), and DF-GLS (Dickey-Fuller with Generalised Least Squares) test (Elliott et al., 1996). Considering that the performance of the DF-GLS test is better than the DF test and ADF test (Elliott et al., 1996), this paper uses the DF-GLS test to detect the stationarity of literature variables and economic variables. If the variable passes the DF-GLS test, it indicates that it is stable and can be directly used in the subsequent VAR model construction. If it fails to pass the test, it is necessary to conduct the cointegration test to determine whether there is a cointegration relationship between variables (Johansen, 1988). Subsequently, the first difference can be made for the non-stationary variables, and the DF-GLS test can be conducted again for the first difference variables. Only when all variables are stationary variables can the VAR models be constructed. The optimal lag length should be determined first in building the VAR models. Then the constructed VAR models should be tested, including the stability test of the VAR models and the Portmanteau Q test for the white noise test of residuals (Ljung & Box, 1978). After passing the above tests, this paper conducts three kinds of analysis based on the VAR model: the Granger causality test, impulse response functions, and forecast error variance decompositions. Fig.1 shows the specific steps of econometric analysis.

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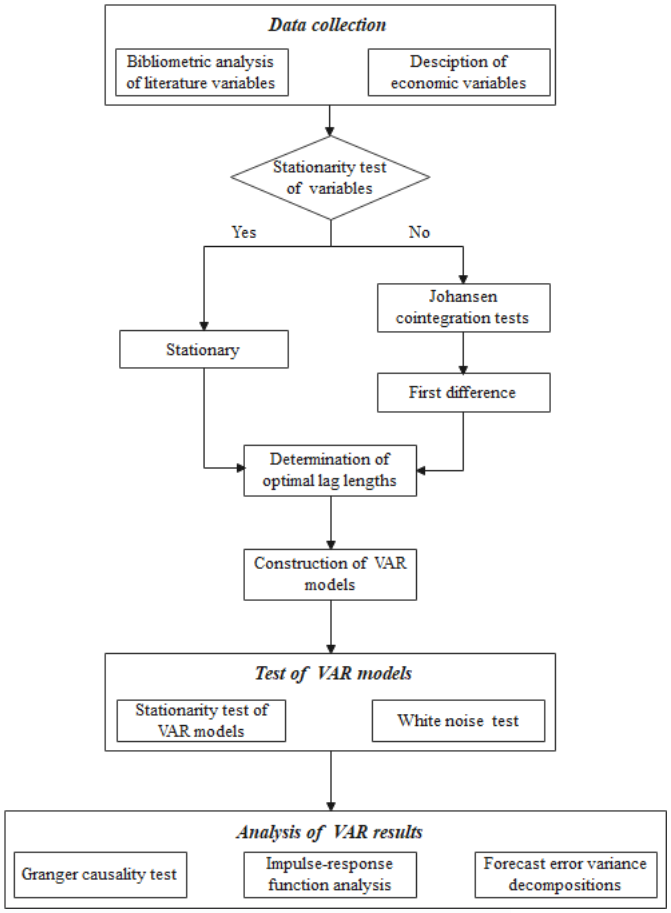

Fig. 1 –The specific steps of econometric analysis. Source: own research

Each step is explained in detail below:
The mathematical formula of the VAR model in this paper is shown in Eq. 1.

$$y_t = \beta_1 + \sum_{j=1}^{m} a_j y_{t-j} + \sum_{j=1}^{m} b_j x_{t-j} + \varepsilon_{1t}$$
$$x_t = \beta_2 + \sum_{j=1}^{m} c_j y_{t-i} + \sum_{j=1}^{m} d_j x_{t-j} + \varepsilon_{2t} \quad (1)$$

where y_t denotes the time series of economic variables; x_t represents the time series of literature variables. β_1 and β_2 denote the constants; a_j, b_j, c_j and d_j represent the different coefficients for the variables; $t-j$ denotes the lag operator; ε_{1t} and ε_{2t} denote the error terms. The optimal lag lengths of the VAR models are determined by the parsimony principle of Likelihood Ratio (LR) (Vuong, 1989), Akaike Info Criterion (AIC) (Akaike, 1992), Bayesian (BIC) (Schwarz, 1978), Schwarz Criterion (SC) (Schwarz, 1978) and Hannan-Quinn (HQ) (Hannan & Quinn, 1979) information criteria.

After the VAR models are built, the fitting results of the VAR models will be tested, including the stability test of VAR systems and the white noise test of residuals. The stability of VAR systems is a necessary condition for subsequent analysis. The white noise test of the residuals determines whether the models' residuals are random data that cannot be captured. If the residuals are white noise, the model is well-fitted. If the residual is not white noise, the model needs to be further optimized.

After determining the reliability of the VAR models, this paper will carry out three kinds of analyses: the Granger causality test, impulse response functions analysis, and forecast error variance decompositions. Granger causality is not causality in the usual sense but a particular

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case of causal reasoning, representing a statistical test of the significance of VAR coefficients (Kufenko & Geiger, 2016). Granger causality in this paper means that some variables help predict the future values of other variables (Granger, 1969). In this paper, the original hypothesis of Granger causality is that economic variables do not generate Granger causality for literature variables. However, suppose Granger causality exists between economic and literature variables in a certain period. In that case, it indicates that inflation in this period can predict the trend of future supply chain management-related research. In addition, the impulse response functions describe the dynamic impact of the impulse of one variable on other variables in the VAR models (Stock & Watson, 2001). Finally, forecast error variance decompositions mean decomposing the variance of a variable into various disturbance items of the VAR system and determining the influence relationship between various variables by showing the relative influence degree of each disturbance item on other variables (Stock & Watson, 2001).

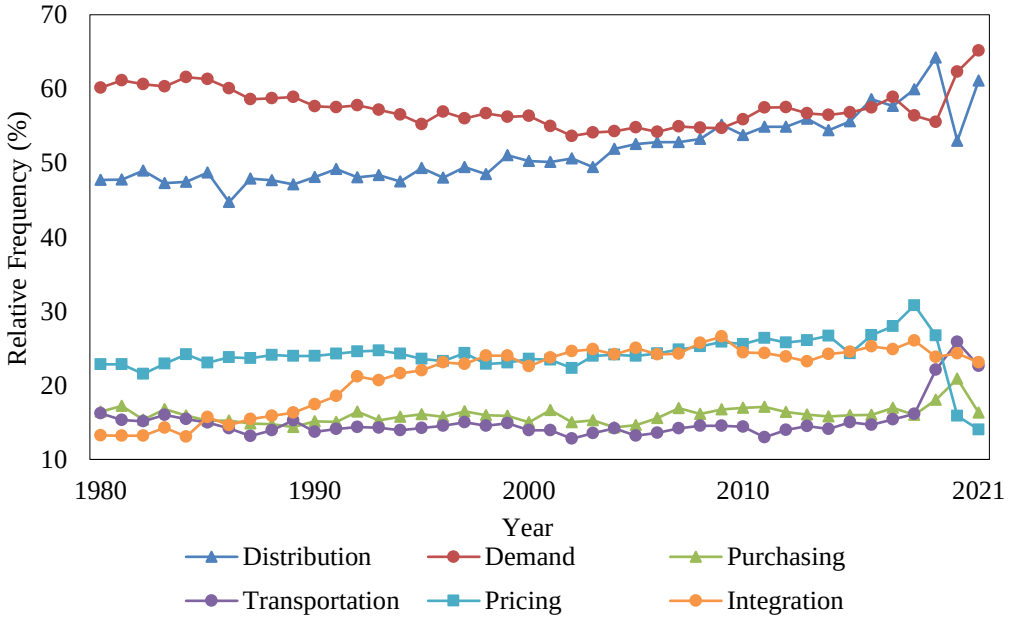
It is worth noting that both impulse response functions and forecast error variance decompositions depend on the orders of variables, so the order of variables should be determined first, which has not been carried out in previous studies exploring the relationship between scientific literature and economic activities. This paper uses the cross-correlation coefficients to determine the orders of variables in the VAR models.

4. RESULTS AND DISCUSSION

This section will show the results of the empirical analysis from two aspects. Firstly, the descriptive analysis of bibliometric results is presented. Secondly, the results of the econometric analysis are presented to support the study of the links and interactions between inflation and supply chain management research.

4.1 Descriptive analysis of bibliometric results

This paper investigates the relative frequencies of keywords relevant to supply chain management research. Fig.2 presents the statistical results for literature variables from 1980 to 2021.



(a) More than 10%.

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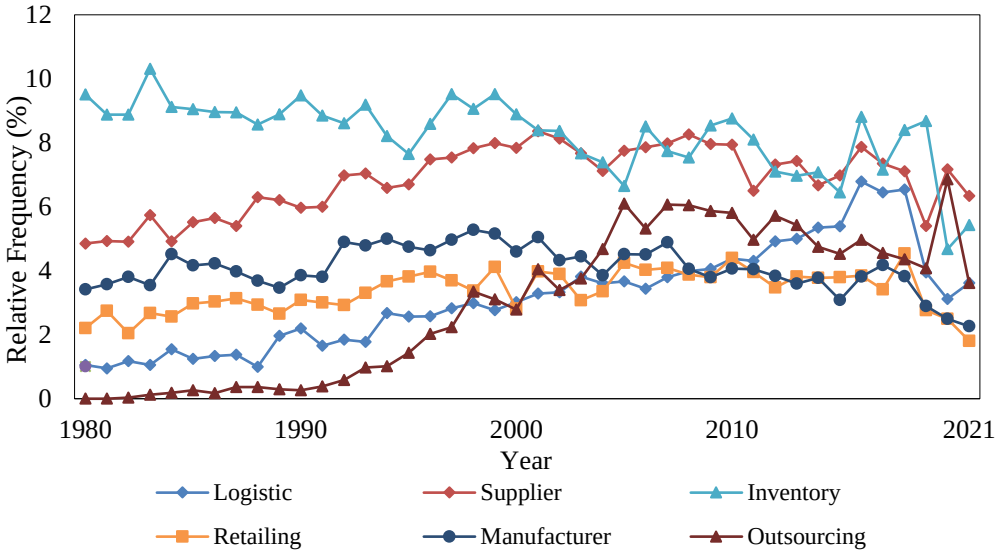

(b) Less than 10%.

Fig. 2 –Relative frequencies of literature variables. Source: own research

Through preliminary statistics on the relative frequencies of the literature variables, this paper finds that the 12 can be divided into two groups based on their relative frequencies, i.e., relative frequencies fluctuating above 10% and below 10%. To analyze the relevant trends more intuitively, Fig.2(a) and Fig.2(b) present the relative frequencies of the two literature variables.

Fig.2(a) illustrates the six literature variables with high relative frequencies, namely "Distribution," "Demand," "Purchasing," "Transportation," "Pricing," and "Integration." Among them, the two highest literature variables are "distribution," and "demand." It can be seen from Fig.2(a) that the two variables have fluctuated by more than 40% in the past 40 years, and their change trends are the opposite. The literature variable "distribution" shows a fluctuating upward trend until 2020, while the overall trend for the literature variable "demand" shows a fluctuating downward trend. Meanwhile, it can be seen that the relative frequencies of the four literature variables "Purchasing," "Transportation," "Pricing," and "Integration" fluctuate in the range of 10% to 30%. The relative frequencies of these four variables are relatively stable except for the literature variable "Integration," which has shown an upward trend since 1990. In addition, the relative frequency of the literature variable "Pricing" decreased year by year in 2018, which may be due to the financial crisis in 2018. The relative frequencies of the remaining three literature variables all showed a downward trend in 2021, which may be due to the impact of the pandemic on supply chains.

Fig.2(b) illustrates six literature variables with relative frequencies lower than 10%, namely "Logistic," "Supplier," "Inventory," "Retailing," "Manufacturer," and "Outsourcing." The highest relative frequency of the six literature variables is the variable "Inventory," which shows an overall downward fluctuating trend until 2015. However, the relative frequency of the variable "Logistic" shows the opposite trend, with a trend of rising fluctuation before 2016. In addition, except for the literature variables "Inventory" and "Logistic," the relative frequencies of the other four literature variables all showed an upward trend before 2008, while the overall trend showed a downward trend to varying degrees after 2008. This phenomenon may be due to the impact of the 2008 financial crisis on supply chain management research.

4.2 The connection between inflation and supply chain management research

This paper uses the DF-GLS test to examine the stationarity of variables, and the results show that all variables are not stationary. Subsequently, all variables are first-order differenced, while the differenced variables are examined again, and all variables pass the DF-GLS test.

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Therefore, this paper uses the first-order difference variable, a stationary variable, for subsequent analysis. To further explore whether there is a cointegration relationship between variables, this paper conducts the Johansen cointegration test. Tab.3 shows the Johansen cointegration test results, which show no cointegration relationship between literature variables and economic variables.

Tab 3. – Johansen tests for cointegration. Source: own research

Economic Variables	
Cointegration rank	
HCPI	0
ECPI	0
FCPI	0
CCPI	0
PPI	0
DEF	0

Subsequently, the stationary variables obtained by the first difference are applied to the VAR models. Meanwhile, the stability of the VAR models is tested after determining the optimal lag length. The results show that all the VAR models are stable. To ensure the reliability of the subsequent Granger causality test results, this paper conducts the Portmanteau Q test on the residuals of the VAR models. Tab.4 shows the Portmanteau Q test results of all VAR model residuals. It can be seen that only one VAR model fails the test on the benchmark of 5% (dDemand and dCCPI), but it has no impact (the variables in this VAR model do not have Granger causality).

Tab 4. – Portmanteau Q test of the residuals. Source: own research

	dHCPI	dECPI	dFCPI	dCCPI	dPPI	dDEF
dPurchasing	0.70207	0.1262	0.86372	0.3322	0.1849	0.6560
dLogistic	0.72999	0.9253	0.62952	0.23294	0.12844	0.61600
dTransportation	0.65018	0.6021	0.99555	0.64014	0.09766	0.63567
dSupplier	0.34226	0.37812	0.65434	0.45113	0.10388	0.4001
dDistribution	0.68915	0.6683	0.39335	0.51624	0.6074	0.86144
dInventory	0.63783	0.3330	0.3927	0.63497	0.41367	0.38661
dDemand	0.15596	0.2395	0.28281	**0.01395**	0.2860	0.2241
dRetailing	0.76849	0.66953	0.82153	0.79298	0.3893	0.4067
dPricing	0.58987	0.41451	0.67740	0.47552	0.2937	0.6329
dManufacturer	0.7476	0.51228	0.5502	0.4375	0.25658	0.6206
dIntegration	0.6718	0.70398	0.8107	0.19535	0.38407	0.46815
dOutsourcing	0.86844	0.75060	0.5843	0.63828	0.1894	0.5464

In this paper, three Granger causality tests are carried out, namely, Granger causality from the economic variables to literature variables, instantaneous Granger causality, and reverse Granger causality (Granger, 1980). Tab.5 shows the results of the three Granger causality tests. The two columns of data under each economic variable in the table respectively show the Grange causality test from economic variables to literature variables (Column 1) and the Grange causality test from literature variables to economic variables (Column 2). In this paper, the results of Granger causality are determined on the benchmark of 5% and 10%.

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Tab 5. – The results of Granger causality. Source: own research

Variables	dHCPI		dECPI		dFCPI	
Direction of Granger causality	To bibliometric	To economic	To literature	To economic	To literature	To economic
dPurchasing	0.818	**0.059***	**0.014****	0.115	0.880	0.535
dLogistic	0.670	0.158	**0.042****	0.217	0.914	0.493
dTransportation	0.554	0.583	**0.003****	0.545	0.876	0.642
dSupplier	0.248	0.712	0.308	0.150	0.263	0.573
dDistribution	0.575	0.494	**0.029****	0.039	0.943	0.628
dInventory	0.281	0.459	0.829	**0.006****	**0.002****	**0.040****
dDemand	0.259	0.278	0.965	**0.024****	0.774	0.180
dRetailing	0.608	0.820	0.150	0.274	0.489	0.440
dPricing	0.522	0.443	0.369	0.483	0.501	0.587
dManufacturer	**0.056***	0.537	0.849	0.512	**0.007****	0.847
dIntegration	0.229	**0.079***	0.570	0.929	**0.073***	**0.060***
dOutsourcing	0.583	0.280	0.963	0.170	0.598	**0.014****
Variables	dCCPI		dPPI		dDEF	
Direction of Granger causality	To literature	To economic	To literature	To economic	To literature	To economic
dPurchasing	0.877	**0.006****	0.962	**0.042****	**0.048****	**0.028****
dLogistic	0.999	0.841	0.162	0.113	0.513	0.217
dTransportation	0.661	0.923	0.193	0.111	0.230	0.328
dSupplier	0.693	0.777	0.165	0.103	**0.070****	0.285
dDistribution	0.285	0.719	**0.074***	**0.073***	0.227	0.260
dInventory	0.670	0.875	0.863	0.173	0.230	0.321
dDemand	0.530	0.324	0.389	**0.003****	0.171	**0.087***
dRetailing	0.210	0.150	0.954	**0.089***	0.928	**0.062***
dPricing	0.688	0.285	0.450	**0.005****	0.153	**0.080***
dManufacturer	0.717	**0.077***	0.328	0.211	0.283	**0.024****
dIntegration	0.572	0.572	0.278	0.807	0.387	0.326
dOutsourcing	0.721	0.817	0.981	**0.045***	0.471	**0.067***

Note: significant results are marked. **, * represent 5% and 10% benchmark respectively.

Firstly, the Granger causality relationships between economic variables and literature variables are analyzed to reveal whether inflation impacts supply chain management research. As can be seen in Tab.5, at the 5% level, energy price inflation is the Granger cause of most literature variables, namely "Purchasing," "Logistic," "Transportation," and "Distribution." Food price inflation is the Granger cause of the bibliometric data "Manufacturer." GDP deflator growth rate is Granger-cause for the bibliometric data "Supplier." At the 10% level, the headline consumer price inflation is the Granger cause of the bibliometric data "Manufacturer."

In addition, instantaneous Granger causality can be determined. It is worth mentioning that instantaneous Granger causality is uncommon compared to unidirectional Granger causality between economic variables and literature variables. According to the results of the Granger causality test shown in Tab.5, it can be seen that instantaneous Granger causality exists in three economic variables. There are two pairs of instantaneous Granger causality for food price inflation, i.e., the literature variables "Inventory" and "Integration." Producer price inflation

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and GDP deflator growth rate have an instantaneous Granger causality, namely "Distribution" and "Purchasing."

The reverse Granger causality test (from literature to economic variables) also provides some research values. At the 5% level, "Inventory," "Demand" and energy price inflation; "Outsourcing" and food price inflation; "Purchasing" and official core consumer price inflation; "Purchasing," "Demand" and "Pricing" and producer price inflation; "Manufacturer" and GDP deflator growth rate. At the 10% level, "Purchasing," "Integration" and headline consumer price inflation; "Manufacturer" and official core consumer price inflation; "Retailing," "Outsourcing" and producer price inflation; "Demand," "Retailing," "Pricing" and "Outsourcing" and GDP deflator growth rate.

To quantitatively measure the relationship between economic variables and literature variables, impulse response functions and FEVD are also simulated. However, the results of impulse response functions and FEVD depend on the orders of variables. Therefore, the cross-correlation coefficients between variables are considered in this paper. By analyzing the cross-correlation coefficients between variables, only the orders of variables in the VAR models can be determined.

This paper takes the economic variable "dFCPI" and the literature variable "Manufacturer" as examples, and Tab.6 shows the cross-correlation coefficients. As seen from Tab.6, the literature variable "dManufacturer" is most relevant to the economic variable "dFCPI" one year in advance. Therefore, "dFCPI" should precede "dManufacturer" in the orders of variables in this VAR model. In this paper, the cross-correlation coefficients of 12 literature variables and six economic variables are calculated to determine the variable orders of all VAR models.

Tab 6. – The cross-correlation coefficients of the two variables (dmanufacturer and dfcpi). Source: own research

Lag	Corr	-1 0 1 [Cross-correlation]	Lag	Corr	-1 0 1 [Cross-correlation]
-17	0.0148	|	1	0.1078	|
-16	0.0630	|	2	0.0851	|
-15	-0.1662	--|	3	0.0736	|
-14	-0.0877	|	4	-0.1052	|
-13	0.0931	|	5	-0.0663	|
-12	-0.0720	|	6	-0.0467	|
-11	-0.0735	|	7	-0.0251	|
-10	0.0312	|	8	-0.1112	|
-9	0.1119	|	9	0.1793	|--
-8	-0.2266	--|	10	0.2181	|--
-7	-0.1104	|	11	-0.1320	--|
-6	0.1842	|--	12	-0.0583	|-
-5	0.0572	|	13	0.0184	|
-4	0.0270	|	14	0.1233	|
-3	0.2385	|--	15	-0.0701	|
-2	-0.1987	--|	16	0.0290	|
-1	-0.2884	----|	17	-0.0427	|
0	-0.0688	|			

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After determining the orders of variables, this paper analyzes the dynamic impact of inflation on supply chain management through IRFs. Due to space constraints, Fig.3 shows several selected impulse response functions based on Granger causality.

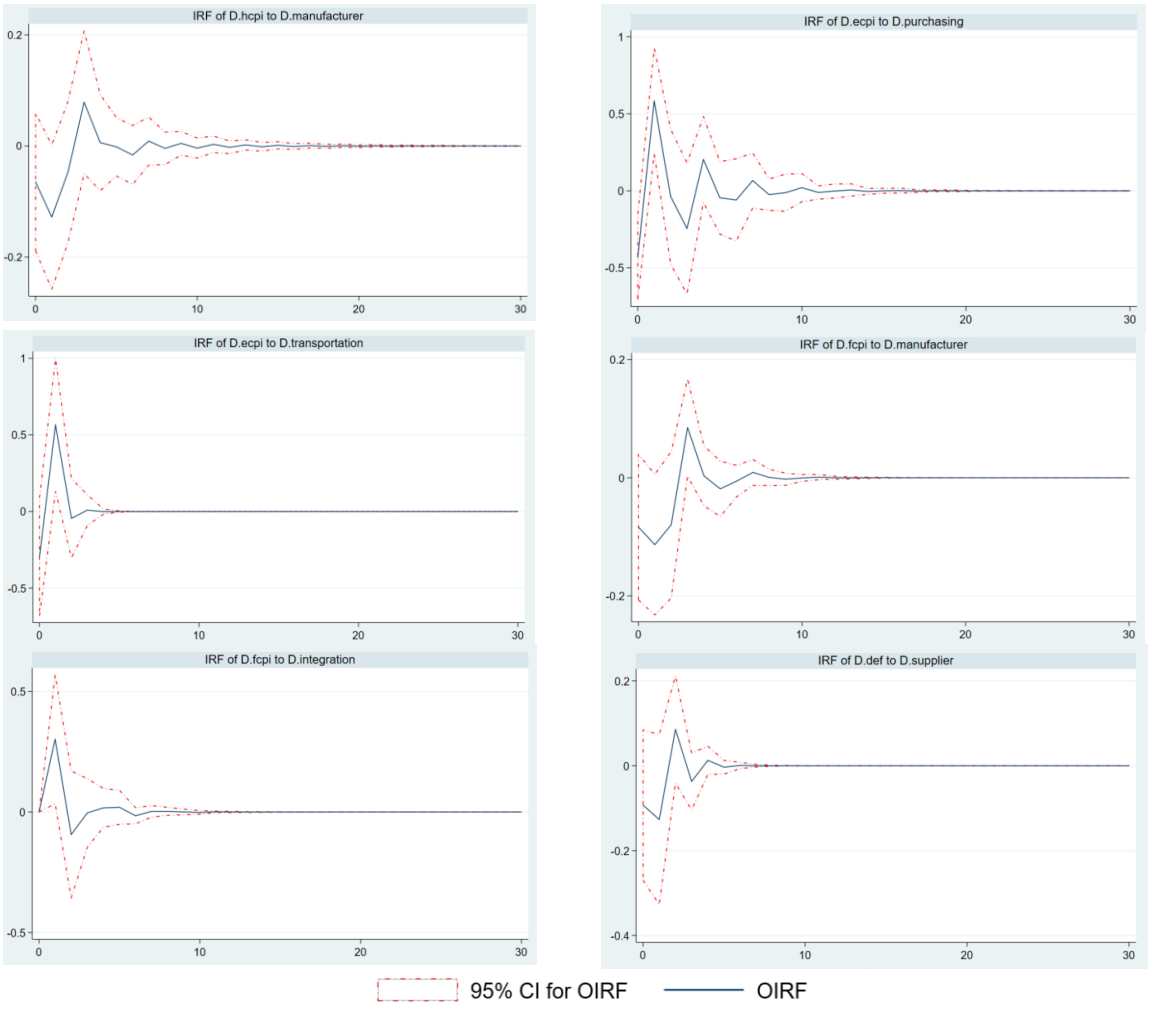

Fig. 3 –Selected impulse-response functions based on Granger causality. (Impulse variables: economic variables) Source: own research

As seen from Fig.3, the economic variables of inflation impact literature variables related to supply chain management within a specific range. Although the final convergence steps are different, they all tend to converge eventually. For example, the influence of energy price inflation on the bibliometric data "Transportation" and the influence of GDP deflator growth rate on the bibliometric data "Supplier" will converge within ten steps. Likewise, the impact of headline consumer price inflation on the bibliometric data "Manufacturer" and energy price inflation on the bibliometric data "Purchasing" will converge in about 15 steps. Finally, the influence of food price inflation on the bibliometric data "Manufacturer" and "Integration" will converge in about 20 steps.

As can be seen from Fig.3, a 1 % increase in the headline consumer price inflation in the previous year leads to the 0.0648% points decrease in the papers using "Manufacturer" in the current year; a 1 % increase in the energy price inflation in the previous year resulted in a reduction of 0.4325% and 0.2961% in the papers using "Purchasing" and "Transportation" respectively; a 1 % increase in the food price inflation in the previous year resulted in a decrease of 0.0835% in the papers using "Manufacturer;" a 1 % increase in the GDP deflator growth rate in the last year leads to the 0.0925% decrease in the papers using "Supplier" in the current year.

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To explain the impulse process of the inflation on the bibliometric data more clearly, this paper takes the impact response of the economic variable "dFCPI" on the literature variable "dIntegration" as an example to carry out a detailed analysis. After the impulse economic variable "dFCPI" has imposed an impulse on the literature variable "dIntegration," it obviously has a positive effect in the first year, and the effect rapidly declines in the second year and slowly increases from the third year to the fifth year. These performances are reflected in specific values. When the economic variable "dFCPI" increases by 1%, the literature variable "dIntegration" will rapidly increase by 0.3020% in the first year and rapidly decrease to -0.9365% in the second year. Then it slowly rises to 0.1971% by the fifth year, and the effect fluctuates in a small range until it tends to zero in about 15 years. This shows that the impact of the economic variable "dFCPI" on the literature variable "dIntegration" fluctuates in the first 15 years, and the fluctuation range becomes smaller and smaller. With the extension of time series, the literature variable "dIntegration" growth rate tends to be stable.

Following impulse response functions analysis of the dynamic impact between the economic variables related to inflation and literature variables from the supply chain management research, this paper uses the forecast error variance decompositions to determine the size and magnitude of this impact. It can be seen from the above analysis of impulse response functions in Fig.3 that the effects of most economic variables on literature variables tend to converge within 20 periods.

This section takes economic variables as impulse variables to show more stable results and simulates the forecast error variance decompositions results of 30 periods. This paper focuses on the results of issue 30 because of the higher explanatory power, and the results are shown in Tab.7.

Tab 7. – The results of forecast error variance decompositions.
(Impulse variables: economic variables) Source: own research

		Impulse Variables					
		HCPI	ECPI	FCPI	CCPI	PPI	DEF
Response Variables	purchasing	0.0140	0.4027	0.0453	0.0881	0.1311	0.2243
	logistic	0.0260	0.1348	0.0048	0.0024	0.1270	0.0602
	transportation	0.0511	0.2081	0.0502	0.0246	0.1160	0.1615
	supplier	0.0280	0.0308	0.0719	0.0554	0.0648	0.0778
	distribution	0.0324	0.2455	0.0362	0.0265	0.0658	0.0325
	inventory	0.0607	0.0121	0.2853	0.0318	0.0112	0.0407
	demand	0.0623	0.0018	0.0122	0.0279	0.0524	0.0951
	retailing	0.0088	0.0703	0.0222	0.0384	0.0261	0.0051
	pricing	0.0210	0.1881	0.1066	0.0096	0.0225	0.0643
	manufacturer	0.1404	0.0012	0.1627	0.0253	0.0888	0.0449
	integration	0.0322	0.0114	0.0012	0.1448	0.0815	0.0203
	outsourcing	0.0075	0.1367	0.0114	0.0689	0.0713	0.0316

As can be seen from Tab.7, the forecast variance decomposition of all supply chain management literature variables is less than 50%, which indicates that literature variables are more influenced by themselves than by economic variables. This, to some extent, shows that supply chain management research is mainly based on previous research.

Meanwhile, the results in Tab.7 also show that economic variables have different effects on the forecast variance of literature variables. In this paper, the benchmark of 10% is used to illustrate which literature variables have a more significant influence than different economic variables. When headline consumer price inflation changes, the bibliometric data "Manufacturer" in supply chain management research is greatly affected; When the energy

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price inflation changes, the bibliometric data "Purchasing" has the most significant impact at 40.27%, followed by the bibliometric data "Distribution" and "Transportation," both of which have more than 20%. Finally, prediction variances of "Pricing," "Outsourcing," and "Logistic" are also significantly affected by energy price inflation; When food price inflation changes, the bibliometric data "Inventory" is affected the most, reaching 28.53%. Meanwhile, the bibliometric data "Manufacturer" and "Pricing" are also significantly affected; When official core consumer price inflation changes, only the bibliometric data "Integration" is significantly affected; When producer price inflation changes, the bibliometric data "Purchasing," "Logistic" and "Transportation" are all affected considerably; When GDP deflator growth rate changes, the bibliometric data "Purchasing" is affected the most, and the bibliometric data "Transportation" is also significantly affected.

4.3 Discussion

This paper aims to analyze whether inflation in the economic phenomenon impacts supply chain management research. Through bibliometric analysis and econometric analysis, the conclusion of this paper that the actual inflation will impact supply chain management research can be confirmed.

From the bibliometric analysis perspective, the results align with the development process of supply chain management research. As a research field of operations management, supply chain management was first proposed in the 1980s, focusing on the benefits of integrating purchasing, manufacturing, sales, and distribution businesses. The bibliometric analysis results in this paper show that the relative frequency of key terms in supply chain management research is relatively high. In addition, combined with the changes in various inflation indicators and the results of bibliometric analysis, it can be further confirmed that the research related to supply chain management is affected by actual inflation.

This paper counts up the changing trend of six inflation indicators, the results are shown in Fig.4.

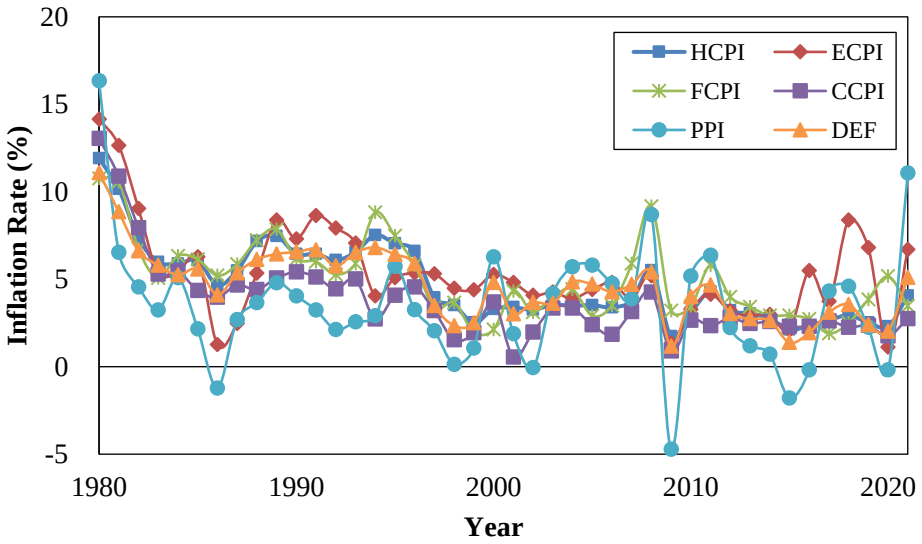

Fig. 4 – The trends of six inflation indicators. Source: Ha et al., (2021)

It can be seen that from 1980 to the present, all inflation indicators peaked in 1980, much higher than the current years. Meanwhile, inflation rates were higher in 2008 and 2018, when the global economic crisis erupted. Inflation rates also increased in 2021 due to the COVID-19 pandemic. Combining Fig.2 and Fig.4, it can be seen that the relative frequencies of most supply chain management-related terms increase as the inflation rates decrease, except the literature variables "inventory" and "demand." Specifically, compared with the high inflation rate in the

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1980s, the inflation rate in recent decades has been relatively low, and the overall trend of literature variables "inventory" and "demand" has been gradually decreasing. In 2008, 2018, and 2021, the inflation rate increased to different degrees, and the relative frequency of the literature variable "inventory" decreased. This is consistent with economic activity. Due to the increase of inflation pressure, the supply chain cost will increase, resulting in supply chain obstruction and a backlog of goods, so the attention to inventory will increase.

From the perspective of econometric analysis, the quantitative results also further illustrate the point of view of this paper. The econometric analysis mainly includes the Granger causality test, impulse response functions, and forecast error variance decompositions. It is worth mentioning that Tab.5 shows not only the Granger causality from the economic variables to the literature variables but also the instantaneous Granger causality and reverse Granger causality. From the Granger causality results of economic variables to literature variables, it can be seen that energy price inflation has the most influence on the bibliometric data of supply chain management research. This result could go some way to speculating that higher energy prices will significantly impact the supply chain.

Additionally, the instantaneous Granger causality of economic and literature variables is evidence of the interaction between inflation and supply chain management-related research. It must be acknowledged that this phenomenon may be related to the fact that the data collected in this paper are annual, and more granular data collection methods (monthly and quarterly data) may generate more such phenomena. However, given the review process for journal articles, it is more reasonable to use annual data. From the perspective of real economic activities, not only will inflation affect the development of the supply chain, but also the operation of the supply chain will, in turn, affect the inflationary pressure. For example, the outbreak of COVID-19 in 2020 caused disruptions in key parts of the supply chains, affecting the production and sales of manufacturers worldwide and resulting in supply problems and price pressures that contributed to inflation. Moreover, the existence of reverse Granger causality can be inferred that the progress of scientific research may affect economic variables through policies or some channels. For example, supply chain management research can influence economic activities such as monetary policy by studying strategies related to "Pricing."

Based on Granger causality tests, Fig.3 presents the results of impulse response function analysis to quantify the dynamic impact of the economic variables on the literature variables. The change in fluctuations in Fig.3 shows that the relative frequencies of most of the literature variables related to supply chain management decrease with the increase of various inflation economic variables. In addition, Tab.7 presents the results of the forecast error variance decompositions, which determine the size and extent of the impact between the inflation-related economic variables and the literature variables of supply chain management research. The results in Tab.7 not only show that different inflation indicators have different impacts on the bibliometric data related to supply chain management but also that the bibliometric data of supply chain management are primarily based on previous studies (the forecast error variance of all supply chain management literature variables is less than 50%).

In conclusion, the results of both bibliometric and econometric analysis confirm this paper's findings that inflation impacts supply chain management research. However, regarding the reasonableness of the selected literature variables, this paper needs to clarify that although sufficient investigation and screening were conducted to identify the variables, they may not fully cover the actual research situation. However, the results of the data analysis in this paper also support the conclusion.

5. CONCLUSIONS

This study uses an empirical case study to provide an in-depth analysis of the links and interactions between inflation and supply chain management research, which provides a

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methodological framework for future research on the connections between actual economic activities and the scientific literature. In the case of this paper, bibliometric and econometric analyses are used to investigate this link by examining various inflation indicators, including energy, food, producer, etc. The results show the connection between actual inflation and supply chain management research. The main contributions of this research are as follows:

This paper provides a quantitative framework for examining the links and interactions between inflation and supply chain management research, which not only quantifies the impact of inflation on supply chain management research but also investigates the impact of academic literature on supply chain management on inflation. Specifically, this paper combines bibliometrics and econometric methods for analysis. The conclusions of this paper are intuitively illustrated by the correlation change trend of the bibliometric results of 6 inflation indicators and 12 key terms. The results of econometric analysis mainly include the Granger causality test, impulse response functions, and forecast error variance decompositions.

The Granger causality test shows the relationship between the academic literature on supply chain management and actual inflation. Impulse response functions based on the results of the Granger causality test provide a specific dynamic assessment. The analysis of forecast error variance decompositions further illustrates the degree of impact of inflation on supply chain management-related research. The results of this paper show that there is not only Granger causality from economic variables to literature variables but also instantaneous and reverse Granger causality. It is worth noting that although instantaneous Granger causality and reverse Granger causality are not common, their existences also provide some research values. Instantaneous Granger causality illustrates the possible interaction between economic and literature variables, suggesting a bidirectional influence between academic research on supply chain management and inflation. Reverse Granger causality implies that the academic literature on supply chain management may be able to speculate about inflation in economic activity.

In addition, based on the results of the Granger causality test, dynamic evaluation is also carried out by impulse response functions. The results of impulse response function analysis show that the relative frequencies of most of the bibliometric data related to supply chain management research will decrease with the increase of inflation indicators. More importantly, this paper also carries out forecast error variance decompositions. The results not only show that different inflation indicators have different effects on bibliometric data but also that the bibliometric data of supply chain management is more affected by previous studies than the impact of economic indicators. Finally, it is worth mentioning that, considering that the results of impulse response functions and forecast error variance decompositions depend on the orders of variables in the VAR models, this paper also determines the orders of variables through cross-correlation coefficients of variables, which has not been carried out in previous studies exploring the relationship between scientific literature and economic activities.

Although the quantitative framework and the resulting analysis in this paper provide a good reference for exploring the links and dynamic impacts between economic activities and scientific research, there are still areas for further exploration. Firstly, although this paper looks for key terms in supply chain management by reviewing the rich literature to identify literature variables, there may still be omissions. Considering the evolution of key terms over time, a semantic analysis could also be considered in the future. Secondly, this paper's bibliometric analysis of literature variables is based on the relative frequencies of keywords in journal articles. Perhaps more measurement standards may be considered in the future.

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