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POLICY MIX UNDER STRESS: REVIEW OF ECONOMIC REACTIONS TO FISCAL AND MONETARY POLICIES USING DSGE

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Abstract. The paper aims to review the studies with a particular emphasis on the response of selected economies to the central bank's monetary policy and the government's fiscal policy during various economic shocks developed using DSGE models. Countries generally have different financial structures, institutional frameworks, and macroeconomic policy transmission mechanisms. The authors better explain why some economies respond more effectively to central bank and government actions than others. The article uses a bibliometric analysis of the policy mix and DSGE, and presents a case study of theoretical policy mix modelling using DSGE. The central bank's monetary policy and the government's fiscal policy play a key role in stabilising the economy. Analysing their impact in different economic conditions allows for identifying optimal strategies depending on the nature of shocks. The study shows that the response of economies to various shocks (e.g., financial crises, pandemics, supply shocks) allows us to assess the effectiveness of stabilisation policies and their long-term consequences. DSGE models, extended with fiscal reaction functions and considering household financial constraints, help us understand how monetary and fiscal policy interactions affect economic fluctuations and inflation. A properly selected combination of monetary and fiscal policy can stabilise the economy. Still, its effectiveness depends on the type of economic shocks and the degree of activity of both policies.

Keywords: policy mix; DSGE models; monetary policy; fiscal policy; financial crisis; COVID-19; equilibrium

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1. Introduction

The ongoing progress in globalisation, economic integration, and information technology continues to impact national economies significantly. Firstly, contemporary economies are distinguished by unparalleled openness regarding international trade and capital movements. While this facilitates efficient resource allocation, it also increases the susceptibility of national economies to external shocks. Secondly, economic and market-related news is disseminated more rapidly and frequently than ever, with economic activities occurring almost continuously (Bergstrom & Nowman, 2007).

The real business cycle (RBC) approach and its offshoot, the dynamic stochastic general equilibrium (DSGE) modelling, have shaped mainly contemporary macroeconomic theory for the last fifty years. RBC models typically depict markets as Walrasian, free from real, nominal, or informational obstacles. In these models, as exemplified by Prescott and Kydland's (1982) seminal work, prices, wages, and economic agent interactions are

characterised by perfect elasticity, with no friction impeding market operations. Dynamic Stochastic General Equilibrium (DSGE) models provide a special framework for analysing monetary and fiscal policy interactions, particularly in response to economic shocks. These models highlight how different policy mixes can stabilise economies under various conditions. The macroeconomic analysis employs dynamic stochastic general equilibrium (DSGE) modelling, a technique frequently utilised by monetary and fiscal authorities for several purposes, such as policy evaluation, historical data interpretation, and future predictions. Monetary-fiscal interactions constitute an essential element of the economy, and the direction and strength of their impacts should be considered in policy modelling. Therefore, DSGE models are macroeconomic frameworks designed to study the interactions of economic variables over time. These models are employed to interpret and forecast economic activities and to assist in shaping policy decisions. DSGE models integrate contemporary macroeconomic theories with microeconomic foundations and include random disturbances to account for economic variability (Beetsma & Jensen, 2002; Muscatelli, Tirelli & Trecroci, 2004; Ferroni, Fisher & Melosi, 2024).

Considering the limited number of publications on policy mix issues, this article will focus on these relevant topics. Examining the literature on policy mix and DSGE models is crucial for modern macroeconomic analysis. This examination enhances our comprehension of how monetary and fiscal policies interact under various economic circumstances. Within the framework of DSGE models, which dynamically simulate these interactions, the literature survey helps determine the impact of different factors, such as interest rates, government expenditure, or taxation, on the economy throughout various stages of the business cycle. DSGE models are among the most frequently utilised tools for analysing monetary and fiscal policies. Reviewing the literature helps identify their strengths and weaknesses, particularly in actual economic crises, like the global financial crisis or the COVID-19 pandemic. DSGE models facilitate analysing how monetary and fiscal policies influence the economy through various channels, including investment, consumption, employment, or inflation. The literature review provides a more profound understanding of these transmission mechanisms and enables better prediction of policy mix effects in different scenarios.

Hence, the study will aim to review the studies with a particular emphasis on the response of selected economies to the monetary policy of the central bank and the fiscal policy of the government during various economic shocks developed using DSGE models.

The structure of the paper is as follows. Section 1 introduces the study, and Section 2 reviews the impact of fiscal and monetary policies on economies under various economic shocks. Section 3 performs a bibliometric analysis in the context of policy mix and DSGE models. In section 4 the significant importance of DSGE models in policy mix research is presented; section 5 details the modelling of the policy mix considering the DSGE framework. Section 6 contains conclusions.

2. Policy mix and the economy

Due to the appearance of various economic shocks in economies, i.e., financial crisis, debt crisis, COVID-19 pandemic, inflation shock, energy crisis, and others, the forecasting process of macroeconomic variables has become extremely important, especially from the point of view of players making important decisions regarding the economy, such as the central bank and government. Therefore, these decisions should be supported with appropriate tools. Among these tools, literature (Leeper, 1991; Smets & Wouters, 2003; Woodford, 2003; Christiano, Eichenbaum & Evans, 2005; Gali & Monacelli, 2005) has introduced dynamic stochastic general equilibrium models (DSGE), which are currently a monetary policy tool that can describe the monetary transmission mechanism, starting from the monetary impulse to the reaction of the main macroeconomic variables (namely fiscal variables).

Indeed, in examining and forecasting the impact of monetary and fiscal impulses on the economy, it is crucial to thoroughly understand the relationships and interactions that occur between the decisions of central banks and governments in the context of their policies (Tetik, Ceylan, Ulucan & Bari, 2021; Tetik & Ceylan, 2021; Stawska & Reis Mourao, 2023). These players make decisions with differentiated levels of coordination, and

each result significantly impacts the economy. Sargent and Wallace (1981) signed the seminal "Theory of Unpleasant Monetarist Arithmetic" based on the idea that at the time of fiscal dominance, the monetary authorities can no longer keep inflation under control, regardless of the used strategy. Hence, the conclusion is that the central bank's decisions regarding the conduct of monetary policy are affected by fiscal policy. In the short term, stabilisation of the economy is difficult due to the differences in goals or preferences of the central bank and fiscal authorities. The optimal solution for both authorities is to coordinate their actions and decisions (Sargent & Wallace, 1981).

Another influential model related to monetary and fiscal policy interactions comes from the Fiscal Theory of the Level Price (FTPL), initially developed by Woodford (1994). Its author assumed that the price level was determined by public debt and fiscal policy. Although FTPL has been criticised (Buiter, 2000, 2002; McCallum, 2001, 2003), the existence of this approach is important in interpreting the development of many economic issues. What is worth mentioning Samuelson-Balassa hypothesis (Samuelson, 1964; Balassa, 1964), which also underlines the importance of interactions between monetary and fiscal authorities in the context of price differences in various countries. According to the authors of this hypothesis, the faster productivity growth in catching-up (converging) countries, compared to developed economies, is attributed to a higher level of inflation or appreciation of the nominal exchange rate (Samuelson, 1964; Balassa, 1964). Hoffmann and Schnabl (2008, 2011), Jorda, Schularick and Taylor (2015), and Brunnermeier and Schnabel (2015) based their analyses on Taylor's rule (Taylor (2007)). These studies noticed that too expansionary monetary policy was the cause of excessive financial boom, which contributed to the financial crisis of 2007-2009.

The financial crisis of 2007-2009 and the sequent debt crisis changed the approach to monetary and fiscal policy. As a result of this financial crisis, the debate on the effectiveness of monetary and fiscal policy in economic activity was resumed. Guerguil, Mandon and Tapsoba (2017) and Özer and Karagöl (2018) emphasised that, as a consequence of the financial crisis, the monetary policy of the autonomous central banks had a limited impact on economic activity in many countries (mainly during the zero lower bound phenomenon). In turn, fiscal instruments were considered countercyclical tools of macroeconomic policy. However, according to Pečarić, Slišković and Kusanović (2018), the impact of fiscal policy on economic growth increased during these times, which was particularly due to the activation of automatic fiscal policy stabilisers during the crisis. In response to the crisis, economic authorities tried to stimulate demand in economies through increased public spending and tax reforms. However, with expansionary fiscal policy, public deficits and debt tend to increase (Ettmeier & Kriwoluzky, 2024). This was observed in several EU countries when, due to an expansive fiscal policy during the financial crisis of 2008-2009, public deficits and debts of individual countries increased significantly, which additionally created inflationary pressure (van Riet, 2010).

The central bank and the government, using the available monetary and fiscal policy instruments, respectively, are assumed to affect the economy. The rationale for this phenomenon can be summarised as follows. The impact of monetary policy on the economy takes a special dimension through transmitting monetary policy impulses to the real economy (Rotemberg & Woodford, 1997; Clarida, Gali & Gertler, 1999). According to the IS-LM paradigm, a reduction in the money supply leads to higher interest rates and, consequently, to a decrease in investment activity (Gerdesmeier, 2009). The central bank influences other interest rates by controlling short-term money market interest rates (Tobin, 1978). Bernanke and Blinder (1990) recognised that the interest rate is one of the most frequently mentioned monetary policy instruments influencing economic growth in the literature. According to Boivin, Kiley and Mishkin (2010), neoclassical channels consider the direct impact of interest rates on investment spending, wealth and intertemporal substitution on consumption and the effect on foreign trade through exchange rates. Talpos, Avram and Hetes (2013), focusing on the research on the impact of monetary and fiscal policy on economic growth in European Union (EU) countries, noted a substantial effect of interest rates on GDP. Altavilla and Ciccarelli (2007) emphasised that stabilising inflation is vital for the entire economy, including the level of investment. Borio and Lowe (2002) noted earlier that low and stable inflation determines financial stability. However, unexpected fluctuations in inflation tend to increase the economy's susceptibility to crises. Changes in the level of interest rates also have a significant impact on household savings and consumption.

Since the 2008-2009 financial crisis and the subsequent recession, negative nominal interest rates have become an additional policy tool for central banks in many developed countries (Bernoth & Haas, 2018). As Coeure (2016) argued, negative interest rates strengthen other monetary policy instruments. Many central banks adopted unconventional monetary policies (UMP) (Tillmann, 2016). Michael (1998) pointed out that the ultimate consequence of such policies was the loss of the ability to stimulate savings in a low-interest-rate scenario. When real interest rates (in both developed and emerging economies) are negative, a cap on deposit interest rates encourages savers to hold government bonds (Reinhart, Kirkegaard & Sbrancia, 2011). An interest rate at or close to zero also supports fiscal stimulus because it creates conditions for the government to achieve a significant budget deficit by lowering debt service costs. Low economic growth usually leads to problems related to the deepening deficit of the general government sector, most often during or after financial crises or, more broadly, economic crises. In most cases, an interest rate of zero or close to zero contributes to a larger deficit because it prevents the central bank from stimulating overall demand.

Some studies have noted the dominance of fiscal policy during the crisis, especially in combination with accommodative monetary policy (maintaining low interest rates) (Spilimbergo, Symansky, Blanchard, & Cottarelli, 2009). The authors of these studies emphasised that fiscal policy instruments are easier to use and stimulate the economy in a shorter period than monetary policy measures (Summers, 2008). In the wake of the 2007-2009 financial crisis, numerous governments implemented discretionary fiscal policies that increased deficits and debt in the general government sector. These fiscal packages, driven by discretionary fiscal policy, were designed to stabilise financial systems and boost aggregate demand in affected economies (Spilimbergo, Symansky, Blanchard, & Cottarelli, 2009). Macroeconomic policy significantly influences sustainable economic growth, encompassing monetary and fiscal policies as its key components (Sen & Kaya, 2015). Authorities in EU countries have prioritised fiscal stability to mitigate the impact of fiscal shocks on national budgets (Voda, Dobrotă, Dobrotă & Dumitrașcu, 2002). Suescun (2020) argues that fiscal policy should be considered a long-term financial strategy rather than a single-period shock, as it involves the government's implementation of socio-economic measures to prevent fiscal unpredictability that could lead to economic instability and hinder sustainable development. Chugunov, Pasichnyi, Koroviy, Kaneva and Nikitishin (2021) suggest that fiscal policy should foster economic growth by managing revenues, expenditures, and budget deficits, while monetary policy should aim to maintain price stability. Corsetti, Dedola, Jarociński, Maćkowiak and Schmidt (2016) propose that coordinated monetary and fiscal policies are essential for economic stabilisation, particularly during severe recessions. Furthermore, Corsetti, Higgins and Pesenti (2016) emphasise that monetary policy cannot achieve its intended objectives without substantial support from fiscal policymakers.

While there is no universal agreement in academic literature or practical application regarding the ideal monetary or fiscal policy, a significant body of research supports inflation targeting as the preferred approach. This view is reflected in the increasing number of countries adopting this strategy (Ball & Sheridan, 2004). Numerous scholars have contributed to this discourse, including Leiderman and Svensson (1995), Bernanke and Mishkin (1997), Svensson (2000), Mishkin and Schmidt-Hebbel (2001), Amato and Gerlach (2002), Truman (2003), Gonçalves and Salles (2008). Concurrently, fiscal rules are gaining traction in theoretical discussions and real-world applications. This trend is evidenced by the work of researchers such as Alesina and Bayoumi (1996), Fatas and Mihov (2006), Hallerberg, Strauch & Hagen (2007), Krogstrup and Waelti (2008), Caceras, Corbacho and Medina (2010), de Jesus, Besarria and Maia (2020).

3. A bibliometric analysis of DSGE

In the last decade, scientific studies on bibliometric analyses have "exploded" in numbers, citations and interest. In 1969, the SCOPUS referencing database identified one work using the terms 'bibliometrics/bibliometric'; in 2023, the same database identified more than 44 thousand works with the same criteria.

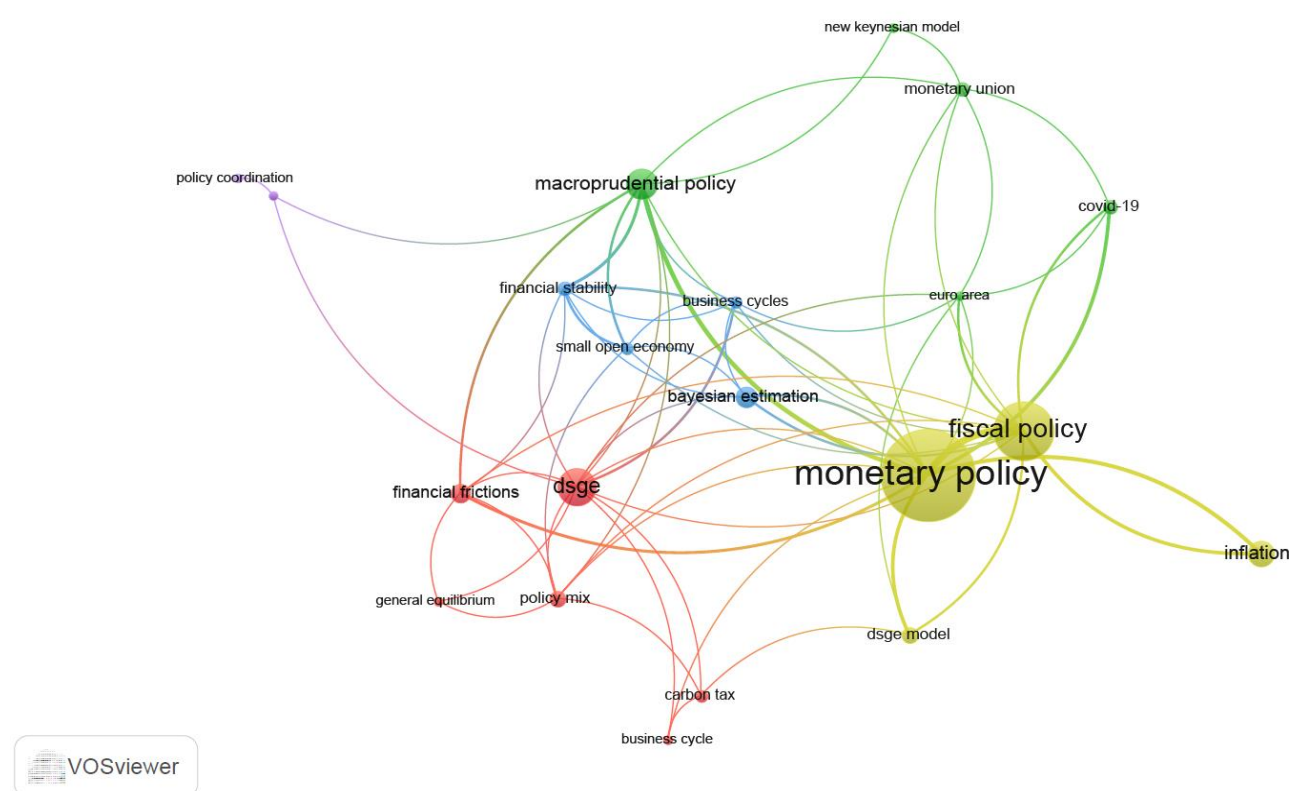
Generally speaking, a bibliometric analysis is a response based on methodological procedures to a simple question: what is there in the published knowledge on a given topic? In a simplified image, bibliometric analysis resembles the response of a bookseller or librarian when we ask them what books there are in the bookstore or the library (respectively) on a given topic.

In addition, bibliometric analysis identifies a set of complementary fields and makes a series of alternative observations. Using the image of a visit to a bookstore or library, bibliometric analysis points out the oldest books, derivative publications, or the most verbose authors.

The methodology for researching policy mix and DSGE models using VOSviewer software involved the following steps (Gorzeń-Mitka, Bilśka, Tomaszewska & Kołozyn-Krajewska, 2020; van Eck & Waltman, 2019):

1. Locating publications in the chosen scientific database (SCOPUS) using specific search criteria (specifically, "policy mix" AND "DSGE models" yielding 190 publications in the years 2009 - 2024).
2. Generating and extracting the bibliographic information for the identified publications from SCOPUS in .csv format.
3. Selecting the VOSviewer option that enables map creation based on bibliographic data, adhering to the software's guidelines (specifically, importing SCOPUS-downloaded data and choosing the keyword occurrence research option).
4. Reviewing and refining the software-selected terms by eliminating "noise" such as the repeated word "new - Keynesian policy", and eliminating the keywords "e52" and "renewable energy" - the latter is not related to the research topic - other than that, it did not show any relationship with the different keywords.
5. Producing a keyword relationship map and examining it using the "items" and "analysis" features.

In the articles examined from the Scopus (which were extracted by entering the phrases "policy mix" and "DSGE model"), 190 articles appeared, and in them, 576 keywords of which, after making some restrictions, it was noted that a given keyword should appear at least four times, which allowed for a reduction to 24 keywords. Three keywords were excluded from these, as mentioned above, which either repeated, were irrelevant to the studied area, or had no connection with other keywords. Thus, 21 keywords remained, grouped into five clusters (see Scheme 1 and Table 2).



Scheme 1. Keywords occurrences based on literature related to "policy mix" and "DSGE"
Source: Own collaboration in VOSviewer based on SCOPUS data

Analysing the information contained in Table 1, we can see that the most frequently appearing keyword was "monetary policy" (39 times), followed by "fiscal policy" (25 times) from cluster 4 and DSGE (16 times) from the first cluster, and adding "DSGE model" (7 times) from cluster 4, it can be suggested that DSGE also appeared frequently in the examined articles. In Table 1, the Occurrence Ratio (OR) quantifies the frequency of keyword pairs appearing together in publication titles, abstracts, or keyword lists; the Links (L) means the number of keywords that the keyword we are examining is connected to; the Total Link Strength (TLS) means the number of all occurrences of a given keyword with other keywords. TLS of the keywords such as "monetary policy" (45), "fiscal policy" (33) and "DSGE" (14) and "DSGE model" (8) show that in the examined area, these keywords can be considered the central ones.

Table 1. Keywords and their occurrences in the bibliometric analysis related to policy mix and DSGE models conducted in VOSviewer

Cluster	Colour	Keywords	Occurrences	Links	Total link strength
Cluster 1 (six items)	red	Business cycle	4	3	3
		Carbon tax	5	4	4
		DSGE	16	13	14
		Financial frictions	8	7	10
		General equilibrium	4	3	3
		Policy mix	7	8	8
Cluster 2 (five items)	green	Covid-19	6	4	8
		Euro area	4	7	8
		Macropprudential policy	13	11	20
		Monetary union	6	6	6
		New Keynesian model	4	2	2
Cluster 3 (four items)	blue	Bayesian estimation	9	6	8
		Business cycles	5	7	8
		Financial stability	6	7	11
		Small open economy	5	6	8
Cluster 4 (four items)	yellow	Dsge model	7	4	8
		Fiscal policy	25	13	33
		Inflation	11	2	9
		Monetary policy	39	13	45
Cluster 5 (two items)	purple	Policy coordination	4	1	1
		Welfare analysis	4	3	3

Source: Own presentation based on VOSviewer.

Other conclusions can be drawn from the above bibliometric analysis performed in VOSviewer. First of all, the topic of policy mix and DGSE model is still worth exploring. We noticed that some keywords are connected with the subject studied. The highlighted keywords that appeared at least four times in the studied group of publications were grouped into five clusters. Each cluster also indicates specific leading research trends in DSGE models used for policy mix research.

Complimentary steps of a bibliometric analysis

The steps of a bibliometric analysis will depend on the main objectives of the research team. When we consult the literature, we find many steps or methodological stages. However, for operational purposes, we can identify the following as the main steps:

- definition of terms and keywords that are effective in identifying and filtering the works that we want to analyse within the phenomenon;
- identification of the appropriate search engines for this purpose;
- recognition of the most important languages of the texts of the publications;
- identification of the period we want to cover in relation to the date of the publications, as well as the period in which the bibliometric survey was carried out.

Within the list obtained, it is then worth noting the following:

- removal of homonymous publications (due to being associated with different versions of the articles or works);
- analysis of the existence or lack thereof in all publications and of all the fields that are expected to be studied (for example, names and academic affiliations of authors, abstracts, keywords, etc.).

After these preliminary stages, bibliometric research moves on to an initially descriptive dimension. This dimension analyses the work identified by type (articles, books, conference proceedings, etc.) and its temporal evolution. Although there is a tendency for the most recent years to be those in which there have been more publications identified, both cumulatively and on an annual average (there are several reasons – from the growth in the number of journals included in the consulted databases to the increase in the number of researchers at a global level), this temporal analysis may, among other reasons, indicate 'peaks' or decreases in the number of publications, generally around a specific academic (and also media) prominence on the phenomenon.

The principal authors of the works are then identified, with attention paid to the years of publication, as well as the associated universities and their respective nationalities. Although scientific research does not have to be dependent on the binomial “observation of the phenomenon in a location/researchers from that location,” the identification of the main authors and universities shows where the phenomenon has localised discussion focuses, which helps to identify more specialised work and research groups for the respective debate. A similar analysis concerns the discussion of the language of the publications, identifying phenomena reported for a more globalised discussion (generally published in English) or for a more localised discussion (published mainly in languages spoken around the world).

We analysed the main journals published on the topic and where the identified works were most concentrated. It is interesting to observe the impact indexes of these journals, generally positively associated with the number of citations expected of an article published in each journal. In this regard, it may be stimulating to compare the impact index of each of these journals with the number of citations of each of the articles under analysis, showing whether, depending on the year of publication of the article, it performed better than expected. Content analysis may also prove relevant and associated with elements such as the title, abstract, or keywords. This analysis will highlight the most used terms/words, identifying them as the core of the discussions developed, the most used methodological resources or the concepts of a broad debate. For this purpose, software such as Atlas.ti or Iramuteq can be referenced.

We consider it relevant to differentiate the values by publication language (English, French, German, Italian, and Spanish). As will be presented, different lines of observation were found. Thus, on 27th November 2024, we began by surveying the works that mention “DGSE” in the Scopus and WoS databases. It is worth noting that Scopus and WoS identified 53 documents containing "DGSE" in the title, abstract or keywords. As expected, a concentration of work has been identified over the most recent years (particularly since 2006).

Figure 1 shows the evolution of the number of publications regarding DGSE in the observed period. Notably, there is no clear trend in the number of publications, which shows that this topic is still an emerging field in economics, with a limited number of identified publications over the years.

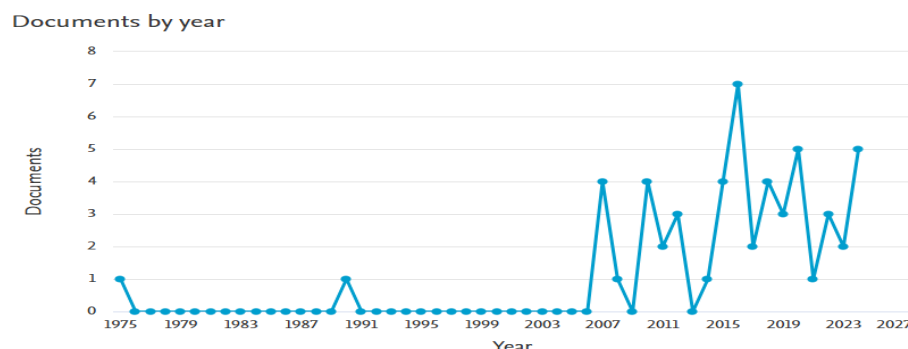


Figure 1. Evolution of the number of documents referenced with the DGSE term

Source: Own study based on SCOPUS and Web of Science

Bharadwaj, Choudhuri and Roy are the authors with the highest number of publications (4). They are followed by a group of seven authors with two publications on DGSE: Ali, Ghosh, Gartner, Hertel, Reuner, Schaferling and Vetter. The universities affiliated with the authors who have published the most on the topic are the Indian Institute of Technology and the Indian Institute of Science. Eight countries with universities that have published the most on the subject are the United States, China, France, Italy, Germany, India, South Korea, and the Netherlands.

The areas that contributed most to this number were Economics, Econometrics and Finance (21.7%), Social Sciences (12.1%), and Business, Management and Accounting (8.7%). The dominant types of documents are articles (77.4%), Books and Book chapters (1.9%), and Conference papers (9.4%). The predominant language is English.

Recurring to VosViewer, the most frequent keywords are ‘DGSE models’, ‘forecasting’, ‘inflation’, ‘DGSE models’, ‘VAR models’, ‘indirect inference’, and ‘expectations’. The most notorious co-occurrences of these keywords are signalled as yellow clouds in Figure 2, associating ‘inflation’ to ‘DGSE models’, ‘forecasting’ to ‘expectations’ and ‘density forecast’, or ‘expectations’ to ‘Bayesian econometrics’.

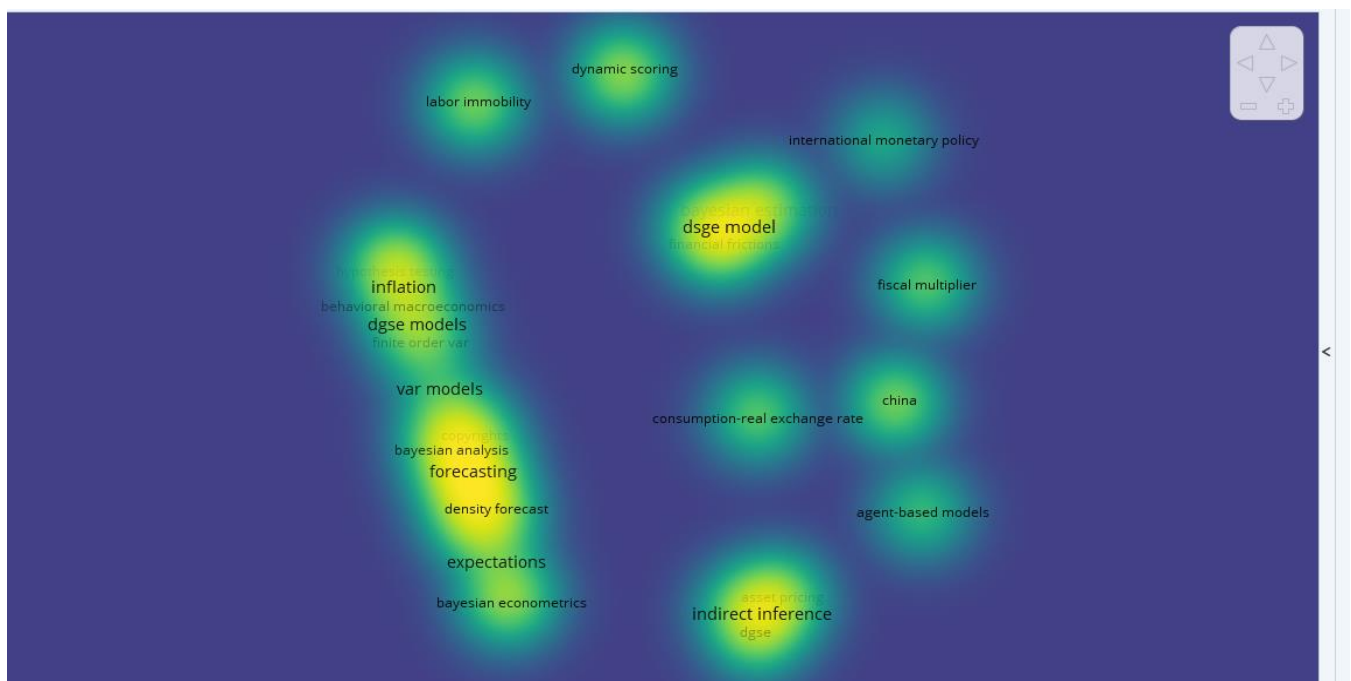


Figure 2. Keywords’ frequencies regarding the documents about DGSE
Source: Own collaboration in VOSviewer based on SCOPUS and Web of Science

49 journals have published the identified articles containing DSGE. Among these titles, we find some established titles in the field of Economics like Economics Letters (2 published works), Studies in Economics and Finance (1), Public Choice (1), Journal of Strategic Studies (1), Journal of Money Credit and Banking (1), Journal Of Monetary Economics (1), Journal Of Forecasting (1), Journal of Economics And Business (1), Journal of Economic Dynamics And Control (1), Journal Of Economic Behavior And Organization (1), or Journal of Econometrics (1).

4. DSGE models and policy mix

Interdependence of Policies and Impact of Government Debt

DSGE models have been applicable to illustrate the interdependence between monetary and fiscal policies, especially during financial crises (Csápai, 2022). DSGE models have gained prominence in macroeconomic and economic policy literature and have been extensively implemented in real-world scenarios. Numerous central banks, such as those of the United States (Federal Reserve System), England, Switzerland, Canada, the

Czech Republic, New Zealand, and France, rely on DSGE models for policy analysis and forecasting (Coenen Motto, Rostagno, Schmidt & Smets, 2017; Hlédik, Madjoska, Miteski & Vlcek, 2024).

The most commonly employed methods for estimating DSGE models are Bayesian techniques, whose properties have been highlighted in multiple studies, including Schorfheide (2000), Smets and Wouters (2003), Rabanal, Rubio-Ramirez (2005), Lubik and Schorfheide (2007), An and Schorfheide (2007), Edge, Kiley and Laforge (2010). DSGE models employ contemporary macroeconomic theory to elucidate and forecast the synchronised movements of aggregate time series throughout the business cycle. The DSGE model classification encompasses various macroeconomic frameworks, ranging from the conventional neoclassical growth model outlined by King, Plosser and Rebelo (1988) to advanced New Keynesian monetary models. These latter models incorporate numerous real and nominal frictions and are founded on the research of Christiano, Eichenbaum, and Evans (2005) and Smets and Wouters (2003). A unifying characteristic of these models is the derivation of economic agents' decision rules from assumptions regarding preferences, technologies, and the current fiscal and monetary policy environment. This is achieved by resolving intertemporal optimisation challenges. Consequently, the DSGE model framework yields empirical models with a robust theoretical foundation, making them valuable tools for conducting policy experiments.

Central banks have also increasingly used sophisticated macroeconomic models for policy analysis and forecasting. Dynamic Stochastic General Equilibrium models have become standard tools in developed and emerging economies. Consequently, more central banks in developing markets are adopting DSGE models. Due to structural changes in these economies, it is essential to incorporate specific technological trends and wedges alongside total factor productivity to align models with real-world data. The DSGE approach is now a predominant technique for examining macroeconomic policy issues and is widely used by practitioners and academics (Hlédik, Madjoska, Miteski & Vlcek, 2024). The level of government debt significantly influences the effectiveness of fiscal policy: higher debt ratios can increase vulnerability to economic shocks (Bobaşu & Muraraşu, 2021). Mixed monetary-fiscal policies can yield different stabilisation effects depending on the nature of the economic shock, emphasising the need for tailored approaches (Wang, Li & Zhang, 2022). We must point out that while DSGE models provide valuable insights into policy interactions, they may oversimplify real-world complexities, such as political constraints and market imperfections, which can affect policy effectiveness and economic outcomes.

Table 2 presents an overview of research results on the impact of the policy mix on economies using DSGE models. The focus is on results indicating how monetary and fiscal policy affects selected economic variables, emphasising what information DSGE models can provide.

Table 2. Literature review on policy mix research results using DSGE models

Literature in chronological order	Countries, research time and methodology	Policy mix research findings using DSGE models
Ratto, Roeger, and Veld (2008)	- The study outlined the assessment of a DSGE model for an open economy in the euro area. While most evaluated DSGE models have primarily focused on monetary policy examination, this model was enhanced by including fiscal reaction functions, enabling its use for fiscal policy analysis.	The model demonstrates the effectiveness of fiscal policy by incorporating financial market constraints that compel some households to spend their current wages and transfer income. This research distinguishes itself from other evaluated DSGE models by treating the euro area as an open economy and utilising non-detrended data for estimation, allowing for examining non-stationary productivity shock impacts.
Kirsanova and Wren-Lewis (2012)	-This DSGE model incorporates nominal rigidities (e.g., price and wage rigidities) and other classical economic mechanisms (such as responses to demand and supply shocks).	The paper investigated how varying levels of fiscal feedback affect debt when monetary policy is optimally determined rather than following a simple rule. When fiscal responsiveness grows, the optimal monetary policy becomes less active, as fiscal measures tend to counteract inflationary pressures. If fiscal responsiveness drops below a certain threshold, monetary policy shifts to a highly passive approach, significantly declining economic well-being.

Hayo and Niehof (2014)	-Open-economy DSGE model with monetary and fiscal policy. -Stochastic differential equations for continuous-time framework. -Theoretical model for two open economies	An adjusted Taylor rule mitigates the effects of financial market turmoil on the actual economy. Implementing a mix of loose monetary policy and restrictive fiscal policy helps to bring stability to economies. Within a monetary union, it becomes more challenging to stabilise output in the nation where the financial disruption begins. Additionally, regarding prices, the country experiencing the crisis faces deflation, while the other nation sees a rise in inflation rates.
Bianchi and Ilut (2014)	-The phenomena described in this study were evident during the early 1980s and can be explained by the shift in the policy approach itself. -A micro-founded Dynamic Stochastic General Equilibrium model is employed to reevaluate the described occurrences. This framework incorporates regime changes in the interaction between monetary and fiscal policies and the volatility of structural shocks.	This study demonstrates that fluctuations in US inflation can be attributed to shifts in the power dynamics between monetary and fiscal authorities. When fiscal authorities take the lead, fiscal imbalances result in sustained and enduring inflation increases, diminishing the monetary authority's capacity to regulate inflation. These shock effects persist as long as the public anticipates the fiscal authority's continued dominance in the future. When the monetary authority attempts to reduce inflation without support from the fiscal authority, inflation remains largely unchanged. However, as soon as the fiscal authority aligns with the central bank's actions, inflation rapidly decreases, the economy experiences a downturn, and the debt-to-GDP ratio rises.
Kliem, Kriwoluzky and Sarferaz (2016)	-An estimated Dynamic Stochastic General Equilibrium model was employed to provide a structural interpretation of the low-frequency measure and to demonstrate how fiscal policies influence inflation over extended periods. -The cross-country data from 1965 to 1999 for Germany, the US, and Italy.	The interplay between monetary and fiscal policies influences fiscal-driven inflation. The effects of these policy interactions on inflation rates vary across different nations. Results from the DSGE model indicate that modifications in monetary-fiscal policy interactions, in conjunction with corresponding alterations in the transmission of structural shocks, can effectively elucidate shifts in the low-frequency relationship between fiscal stance and inflation.
Cavalli, Naimzada and Pecora (2019)	-The paper uses rigorous analytical tools combined with numerical simulations. -The stability conditions of the unique steady state and the emergence of different endogenous dynamics are investigated.	The study examines the complex interactions between fiscal and monetary policies, emphasising their impact on output fluctuations and their ability to generate endogenous fluctuations within a real economy model. Appropriate fiscal and monetary measures can help achieve desired employment levels. Additionally, policy mix tools can potentially create endogenous variations in economic performance.
Drygalla, Holtemöller and Kiesel (2020).	- A standard medium-scale dynamic stochastic general equilibrium model was extended to include non-optimising households and the fiscal sector. -Feedback rules to model spending and revenue variables were used.	Based on the conducted research, it was noted that fiscal policy, mainly public consumption, investments, transfers and changes in labour tax rates, including social security contributions, counteracted a more substantial and long-term decline in production in Germany at the beginning of the Great Recession - which indicated a timely response of fiscal policy. The article assessed the effects of fiscal stimulus packages within the estimated DSGE model. The study indicated the overall positive effects of fiscal policy on German production in 2009 and 2010.
Wang, Li and Zhang (2022)	-This study examines how monetary and fiscal policies interact within China's Dynamic Stochastic General Equilibrium model. -It focuses on determining the optimal combination of these policies to mitigate macroeconomic volatility when faced with various economic disturbances.	The most effective combination of economic policies changes depending on the nature of economic disruptions. When faced with shocks related to government expenditure, a proactive fiscal approach coupled with a passive monetary strategy is recommended.
Adrian, Gaspar and Vitek (2022)	-This research thoroughly examines the most effective ways to implement various	To achieve optimal inflation control and economic stability, it is advisable to modify all available policies in response to

	economic policies. These include monetary strategies, interventions in foreign exchange markets, fiscal measures, macroprudential regulations, and management of capital flows. -This policy analysis utilises a dynamic stochastic general equilibrium (DSGE) model of the global economy. This model incorporates various nominal and real rigidities, comprehensive macro financial connections with endogenous risk, and multiple spillover transmission mechanisms. The model's scope is estimated to be medium-scale, encompassing the complexities of worldwide economic interactions.	fluctuations in both domestic and global financial cycles when possible. This includes implementing foreign exchange interventions and managing capital flows under certain circumstances. The extent of these adjustments can vary significantly based on the specific structural framework of the economy. This framework incorporates various distortions linked to nominal rigidities and financial frictions while accounting for the extensive interplay between the policies under examination. Monetary policy assumes primary responsibility for stabilising consumption price inflation and economic output without constraints. Foreign exchange intervention serves a complementary function by enhancing monetary autonomy, specifically in its capacity to facilitate the stabilisation of consumption price inflation. However, any potentially destabilising effects on economic output that may arise from foreign exchange intervention under these circumstances are mitigated by fiscal policy measures.
Hlédik, Madjoska, Miteski and Vlcek (2024).	- The National Bank of the Republic of North Macedonia (NBRNM) developed a new calibrated New Keynesian DSGE model to reflect the unique traits of North Macedonia's small open economy with a fixed exchange rate. This research outlines the model's structure, calibration, and empirical validation. It includes features typical of DSGE models like monopolistic competition, Calvo sticky prices and wages, habit formation, and multilayer goods production, which are crucial for capturing business cycle dynamics. Additionally, it features sector-specific technology and trends to align with Macedonian economic narratives.	The compact DSGE model for an open economy is a supplementary analytical instrument for policy evaluation, offering a more consistent, theoretically grounded framework for structural examination and policy recommendations at the NBRNM. This model is built on microeconomic foundations, considering the interrelated actions of consumers and firms, technological aspects, and the institutional structure (including budget limitations, market clearing, and monetary policy rules). Consequently, it facilitates the examination of monetary policy's impact on economic agents' decisions by assessing the effects of various economic shocks. As a result, this model provides a valuable new resource and benchmark for comprehensive research on numerous policy-relevant issues.

Source: Own study based on the subject literature

When discussing the results obtained in policy mix studies using DSGE models, it is worth emphasising several of their results. Ratto, Roeger and Veld (2008) extend the DSGE analysis for the euro area by including fiscal policy responses and the impact of financial constraints on households, which allows for the study of monetary and fiscal policy interactions in an open economy. Kirsanova and Wren-Lewis (2012) employed an expanded model incorporating micro-foundations and price rigidities characteristic of the new Keynesian theory, which includes anticipating agents. Within this framework, they developed optimal and simplified fiscal and monetary rules. They also considered the social utility function, enabling them to evaluate the welfare impacts of various policy combinations. Their findings indicated that the optimal monetary policy rule involved an active approach, specifically increasing the real interest rate when inflation rose. The costs associated with implementing a basic fiscal rule, where expenditures only responded to debt changes, were relatively minor. However, the debt level played a crucial role. An active monetary policy might not be optimal when the accumulated debt is substantial and interest rate fluctuations significantly affect the budget. The more proactive the fiscal policy is, characterised by government expenditures being less sensitive to debt levels, the less active monetary policy should be.

In DSGE models, monetary and fiscal policies are interconnected, jointly affecting economic output and inflation rates. These models often incorporate modified policy rules to enhance economic stability during crises, especially in open-economy scenarios (Hayo & Niehof, 2014). Cavalli, Naimzada and Pecora's (2019) research finds that stability conditions affect economic dynamics and employment targets, and fiscal and monetary policies can induce endogenous fluctuations. The study (Bianchi & Ilut, 2014) shows that inflation volatility in the US was driven by changes in the power relationship between monetary and fiscal policy, particularly in the 1980s. When fiscal policy dominated, it led to persistent increases in inflation and a weakening of the central bank's ability to control it. Attempts by the central bank to curb inflation without fiscal

policy support were ineffective. In contrast, when fiscal policy began to cooperate with monetary policy, inflation fell quickly, but at the cost of an economic slowdown and an increase in public debt. These results underscore the crucial importance of cooperation between monetary and fiscal authorities for stabilising the economy.

Kliem, Kriwoluzky and Sarferaz (2016) examine how monetary and fiscal policies interact within Dynamic Stochastic General Equilibrium (DSGE) models. It explores how these interactions can result in fiscal inflation, specifically analysing the economic frameworks of three distinct nations – Germany, the US, and Italy (Kliem, Kriwoluzky & Sarferaz, 2016). Cavalli, Naimzada and Pecora (2019) show that appropriate coordination of fiscal and monetary policies can effectively stabilise output fluctuations and support achieving desired employment levels. At the same time, policy mix tools can generate endogenous fluctuations in economic outcomes, highlighting the complexity of the interactions between these policies.

DSGE models have incorporated both monetary and fiscal policies. Fiscal policy within DSGE frameworks is typically represented through feedback mechanisms that impact government spending, investment, and transfer payments, thereby influencing the dynamics of economic output during periods of fluctuation (Drygalla, Holtemöller & Kiesel, 2020).

A dynamic stochastic open economy general equilibrium model has also been employed to examine the effects of monetary and fiscal policies on macroeconomic fluctuations in China (Wang, Li & Zhang, 2022). The study utilises an impulse response and welfare analysis to evaluate the stabilising impact of various combinations of these policies. Findings reveal that the ideal mix of monetary and fiscal measures varies depending on the scenario. A proactive fiscal approach coupled with a passive monetary strategy proves most effective in government spending shocks. Conversely, when faced with domestic interest rate shocks, foreign interest rate shocks, or foreign consumption shocks, a passive fiscal stance paired with an aggressive monetary policy yields better results (Wang, Li & Zhang, 2022). Other studies on the selection of fiscal and monetary strategies to optimise fiscal space and fully utilise the effects of proactive fiscal policy in China using NK-DSGE were conducted by Yang and Liu (2024).

Adrian, Gaspar and Vitek's (2022) study shows that optimal stabilisation of inflation and economic growth requires a flexible policy mix, including monetary policy, currency intervention, macroprudential regulation, and capital flow management. The DSGE model considers nominal rigidities, financial constraints, and global transmission mechanisms, which allows for assessing the effects of different policies depending on the economy's structure. In yet another case, we notice that the new DSGE model developed by the National Bank of the Republic of North Macedonia enables a more coherent and theoretically justified analysis of macroeconomic policy in a small, open economy with a fixed exchange rate (Hlédik, Madjoska, Miteski & Vlcek, 2024). The new model for the National Bank of the Republic of North Macedonia (NBRNM), taking into account microeconomic foundations and key market mechanisms, allows for assessing the impact of monetary policy on economic agents' economic decisions. As a result, it is a valuable tool for analysing the effects of various economic shocks and formulating policy recommendations for the NBRNM. DSGE models are widely used in economics to assess the impact of different monetary policies.

5. Influential models in DGSE

Hayo and Niehof (2014) integrated and expanded upon the frameworks developed by Smets and Wouters (2002) and Bekaert, Cho and Moreno (2010) to create a New Keynesian model incorporating fiscal and monetary policy, as well as a financial market component. Their research examined various fiscal and monetary policy responses to domestic and foreign financial market disruptions. Hayo and Niehof (2014) constructed a New Keynesian DSGE model for two open economies using stochastic differential equations. They investigated the interconnected effects between financial markets and the transmission of financial market disturbances to the real economy, both within individual economies and across borders. The study then explored different policy stabilisation scenarios, including (1) a conventional open economy with the Taylor (1993) rule aimed at stabilising output, inflation, and exchange rates; (2) an enhanced the Taylor rule that also considers financial market stabilisation; (3) an expansionary fiscal policy based on increased expenditure; and (4) an austere fiscal

approach. In their analysis, Hayo and Niehof (2014) distinguished between market participants indifferent to high government debt levels and those who are averse to such debt. Below, we present the equations for building DSGE models that incorporate monetary and fiscal policy into a dynamic stochastic general equilibrium model.

Households

Households receive income through various sources: wages from employment, rental income, and dividends from company ownership. Additionally, the government provides some household payments based on previously issued risk-free government bonds. The typical household aims to maximise the following utility function (Hlédik, Madjoska, Miteski and Vlcek, 2024):

$$\max_{C_t, L_t, B_t, J_t, K_t} E_t = \left\{ \sum_{t=0}^{\infty} \beta^t \left(\frac{(C_t - \chi \bar{C}_{t-1})^{1-\sigma}}{1-\sigma} - \frac{L_t^{1+\psi}}{1+\psi} \right) \right\}$$

Where: C_t – consumption of goods; $\bar{C}_{t-1}$ – previous total consumption adjusted to account for technological advancements; L_t – the number of hours worked; β – the intertemporal discount factor; σ – the relative risk aversion coefficient; ψ – the marginal disutility of labour; χ – the habit persistence parameter.

Production sector

The production of intermediate goods is produced under monopolistic competition using the Cobb-Douglas production function:

$$Y_t(i) = A_t K_t(i)^\alpha N_t(i)^{1-\alpha}$$

where: Y_t – production; A_t – technological efficiency; K_t – capital; N_t – labour; α – the share of capital.

$$K_t = K_{t-1}(1 - \delta) + \left(1 - V \left(\frac{I_t}{I_{t-1}} \right) \right) I_t$$

where δ is the depreciation rate; V is an adjustment cost function

In the manufacturing process, intermediate goods serve as inputs for creating various final products, including consumer items (Y_t^C), capital (investment) goods (Y_t^I), exports (Y_t^X), and public goods (Y_t^G) (Hlédik, Madjoska, Miteski & Vlcek, 2024):

$$Y_t = Y_t^C + Y_t^I + Y_t^X + Y_t^G$$

The government and the central bank

In the research by Hayo and Niehof (2014), it was assumed that the government's fiscal policy aims to achieve two goals: stabilising output and managing debt. A smoothed fiscal spending rule based on debt evolution is implemented. The degree of budgetary smoothing affects how spending and taxes respond to debt and income, with the latter serving as a proxy for the output gap. Higher fiscal smoothing reduces government spending and taxation sensitivity to income and debt levels. These budgetary rules are considered ad-hoc and assume governments face no short-term borrowing restrictions. This approach aligns with Leith and Von Thadden (2008), who developed a workable New Keynesian model where a budget does not constrain government debt.

$$G_t = G_{t-1}^{\varsigma_G} (Y_{t-1}^{\varsigma_Y} V_{t,t+m}^{\varsigma_b} \epsilon_t^G)^{1-\varsigma_G}$$

$$T_t = T_{t-1}^{\varsigma_T} (Y_{t-1}^{\varsigma_Y} V_{t,t+m}^{\varsigma_b} \epsilon_t^T)^{1-\varsigma_T}$$

Where: G_t – government consumption; T_t – tax revenues; $V_{t,t+m}^B$ – government issues m -period nominal bonds; ς_G and ς_T – degree of fiscal smoothing; ς_Y ; ς_T ; ς_b ; ς_{b_z} – the reaction of the government to the last period's income and bonds; ϵ_t^G ; ϵ_t^T – shocks that cause the deviations between planned and actual government spending and revenue.

The central bank implements monetary policy through two mechanisms: issuing bonds for the banking sector B_t^{CB} and establishing the cost of money via the bank interest rate (R_t^{CB}). The central bank employs the Taylor rule, which takes the following:

$$\log(R_t^{CB}) = \phi_R + \nu_R * \log(R_{t-1}^{CB}) + (1 - \nu_R) * ((\varrho_\pi * \log(\pi_t) + \varrho_y * \log(GDP_t)))$$

ϕ_R - through its control over the interest rate, it determines the steady-state level of inflation. A fluctuation in this variable is recognised as a monetary shock, representing the central bank's deviation from the Taylor rule's steady-state form (the discretionary aspect of monetary policy); ν_R - determines the relative weight that the central bank attaches to deviations of current inflation and current GDP from their stationary values, at the rule level; ϱ_π and ϱ_y - the relative role of both deviations within the rule.

Following the conventional Taylor rule, Hayo & Niehof (2014) developed an alternative monetary policy response model incorporating financial market conditions alongside traditional factors.

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_R} \left[\left(\frac{\pi_t}{\pi_{t-1}}\right)^{\psi_{\pi}} \left(\frac{S_t}{S_{t-1}}\right)^{\psi_S} \left(\frac{R_t^E}{R_{t-1}^E}\right)^{\psi_E} \right]^{1-\rho_E} \eta_{mp,t}$$

Where: $\eta_{mp,t}$ – monetary policy shock; R_t – the domestic interest rate; π_t - inflation

The exchange rate S_t is determined by the proportion between the overall price levels in the domestic and foreign markets.

$$S_t = \frac{P_t^f}{P_t^d}$$

Where: P_t^f - foreign currency price index; P_t^d – domestic currency price index.

Conclusions

Studying the response of economies to various shocks (e.g., financial crises, pandemics, supply shocks) allows us to conclude the effectiveness of multiple stabilisation policies and their consequences for the economy in the short and long term. The combination of accommodative monetary policy and restrictive fiscal policy can effectively stabilise the economy, especially in conditions of financial turmoil, but within a monetary union, stabilising the economy of a country affected by the crisis becomes more difficult. DSGE models show that monetary and fiscal policy can lead to endogenous economic fluctuations, which means that their inappropriate implementation can generate instability in output and prices.

Interactions between fiscal and monetary policy significantly impact inflation, and their effects may vary depending on the country and the specifics of the economy. The DSGE model shows that changes in how fiscal and monetary policy interact and the transmission of structural shocks can explain the long-term relationship between fiscal policy and inflation.

Monetary policy remains a key tool for stabilising inflation and output, and currency interventions can increase monetary autonomy, although fiscal measures must balance their adverse effects on production. The DSGE model indicates that the more active fiscal policy is in responding to economic shocks, the less aggressive monetary policy must be because fiscal measures can effectively stabilise inflation and public debt. If the fiscal policy response is insufficient, monetary policy switches to a passive mode, which can lead to a deterioration in economic welfare and more substantial declines in economic activity. A properly selected policy mix can not only help to achieve the optimal level of employment but also affect the dynamics of the economy in the long run, changing the equilibrium conditions and potentially creating new economic cycles.

The study notes that effective inflation control in the US depended on cooperation between monetary and fiscal policy, and its absence led to long-term increases in inflation and the weakening of central bank actions. The optimal combination of fiscal and monetary policy depends on the type of economic shocks – for example, when government spending increases, an approach with active fiscal policy and passive monetary policy is more effective.

In summary, this study expands theoretical knowledge and provides practical guidelines for economic policy in changing macroeconomic conditions. A literature review will allow us to identify their strengths and weaknesses and indicate potential directions for their improvement, e.g., by including new variables or adjustment mechanisms. Keyword analysis will enable us to determine which aspects of policy mix and DSGE models are most frequently studied, e.g., the impact of fiscal policy on macroeconomic stability or the interaction of monetary policy with economic shocks. Bibliometric analysis contributes to the systematisation of knowledge and can become a starting point for further research in policy mix and DSGE models.

This study may have several limitations, as follows: a) The selection of literature and interpretation of bibliometric analysis results may be subject to subjective decisions of the researcher, which may affect the conclusions; b) Bibliometric analysis is based on databases (e.g. SCOPUS, Web of Science), which may not include all relevant publications, especially newer studies or those published in less accessible sources; c) Bibliometric analysis takes into account the number of citations and keywords, but does not always reflect the quality of the content or the contribution of a given publication to the development of policy mix theory and DSGE; d) DSGE models are based on assumptions that may not fully reflect reality (e.g. rational expectations, linear structure), which may lead to simplifications in the policy mix analysis.

This study may enhance further research as follows. The selection of literature and interpretation of bibliometric analysis results may be expanded by including other sub-topics. Bibliometric analysis is based on databases (e.g., SCOPUS, Web of Science), which may complement other relevant publications, especially the latest studies or those published in less accessible sources. Our bibliometric analysis can also consider the number of citations and keywords. Finally, DSGE models are based on assumptions that may not fully reflect reality (e.g., rational expectations, linear structure), which may lead to simplifications in the policy mix analysis. Therefore, we can highlight and detail, in further studies, the empirical achievements published in the literature.

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