Journal of Institutional Economics (2025), **21**, e42, 1–19
doi:10.1017/S1744137425100283

CAMBRIDGE UNIVERSITY PRESS

RESEARCH ARTICLE

Banking on research: Who leads? Who follows? Who cares?

Carolina Vasconcelos[1], Bruno Damásio[1] and Sandro Mendonça[2]

[1]NOVA Information Management School, Lisboa, Portugal and [2]Iscte Business School, Lisboa, Portugal
Corresponding author: Carolina Vasconcelos; Email: cvasconcelos@novaims.unl.pt

(Received 30 December 2024; revised 18 September 2025; accepted 19 September 2025)

Abstract
This study sheds light on the diffusion of knowledge production as an institutional norm among central, development, and investment banks. It builds on an original database of 24,435 peer-reviewed scientific items published by a pool of 237 central banks, development banks, and investment banks from 1966 to 2023. The focus is on their interactive dynamics, analysed through a two-fold approach: Granger-Causality analysis for linear relationships and a multivariate Markov chain approach for non-linear interactions. Central banks emerge as leaders in scientific production, influencing development and investment banks. Results lead to further questions about inter-institutional agenda-setting, such as how central banks shape research priorities, the extent to which their intellectual leadership impacts others' priorities, and the mechanisms through which institutional norms are diffused and reinforced within the global financial and policymaking landscape.

Keywords: institutions; norms; organizational behavior; science

Introduction

The importance of Research and Development (R&D) is well-established in the literature, having a positive impact on growth, productivity, and innovation, both at the firm and the country levels (Boeing et al., 2022; Horvath, 2011; Kleis et al., 2012; Orlando et al., 2022; Park et al., 2019; Zhu,et al., 2022). R&D is the activity undertaken to increase the stock of knowledge and create new applications from the available knowledge base. Public institutions and state-based agencies are not top-of-mind in terms of research and innovation, but they are no strangers to practices involving the development of new knowledge. Central and development banks have been noted to significantly invest in the pursuit of useful knowledge (Fernández-Arias et al., 2020; Malovaná et al., 2024; Zapp, 2017; Zapp, 2022). Investment banks, which tend to be privately owned, also allocate resources to research, displaying their peer-reviewed articles and working papers on their public websites (Goldman Sachs, 2024; JPMorgan Chase & Co., 2024; Morgan Stanley, 2024). This investment in new knowledge is not accidental; it is, in fact, the reflection of institutional norms (Drori and Meyer, 2006). Such norms are disseminated through the interaction of organizational fields, which are characterized by shared roles, rules, and goals (DiMaggio and Powell, 1983). In this context, R&D applies across all institutional types and represents a concrete manifestation of the broader process by which these institutional norms spread across fields. Central, development, and investment banks, as distinct yet interconnected entities, operate within these defined fields, adhering to institutionalized patterns of behaviour. While previous studies have explored the adoption of knowledge production as an institutional norm within

these organizations (Marcussen, 2009; Rotolo et al., 2022; Zapp, 2017), the dynamics of interaction between these fields remain underexplored. The goal of this work is to assess the interactions and diffusion of knowledge across these three organizational fields. Studying these relationships is important because research production functions as both a form of cultural authority and a strategic tool, reflecting institutional power (Drori and Meyer, 2006; Kallo, 2006).

The institutionalization of scientific knowledge production into an organization's operations, known as scientization, legitimizes institutional activities by embedding them in research and expertise (Drori, 2003; Marcussen, 2009; Zapp, 2017). This process has been studied and recognized in central, development, and investment banks. As technocratic institutions, central banks rely on scientific tools and methodologies to justify their actions, thereby reinforcing and advancing their scientization process (Dyson and Marcussen, 2009). Through this, central banks have established greater authority and influence, positioning themselves as an epistemic community among wider academic audience (Haas, 1992; Kapstein, 1992), by having a network of professionals with expertise in a specific domain (Claveau and Dion, 2018; Malovaná et al., 2024) and authoritative claim over that domain (Castiglionesi, 2007; Epstein, 2007; Goodhart, 2011; Herger, 2019; Padoa-Schioppa, 2002). Ibrocevic (2025) demonstrated that while central banks' research production has become a global organizational norm, the content of their work remains localized, dependent on specific policy contexts. Development banks followed a similar path, led by the World Bank, which has positioned itself as the 'knowledge bank' (King, 2002; Stone, 2003). Investment banks, on the other hand, operate within an embedded knowledge network structure. This structure refers to trade journals, professional associations, and research departments of investment banks, which offer scientific or expert knowledge (Sinclair, 2000). Thus, similarly to central and development banks, investment banks engage in the production of scientific knowledge through this network.

Among these dynamics, a critical question arises: Are there an institution(s) influencing scientific production within the banking field? The diffusion of practices between organizational fields can reflect reciprocal or hierarchical relationships (Fligstein and McAdam, 2012). This study seeks to understand the dynamics of influence among these key players, distinguishing leaders from followers. Thus, we address two core questions: Do central, development, and investment banks influence each other's scientific production and impact through patterns of publication and citation? If so, what are the directionality and structure of these epistemic relationships? A massive dataset of peer-reviewed scientific items churned by these banks will serve as a proxy for their cognitive activity (in-house research output) and the corresponding citations (attention devoted by external research) as a proxy for the impact of their work (Garfield and Merton, 1979). We adopt a two-fold approach. We begin by assessing linear causal relationships through Granger-Causality analysis. Subsequently, we employ a multivariate Markov chain model to capture non-linear inter-connections. These methodologies will allow us to uncover linear and non-linear relationships and identify leader/follower institutions. We focus specifically on the diffusion of knowledge production as an institutional norm, rather than on the content of that knowledge. In addition, we assume that central, development, and investment banks are not fully unitary actors but categories embedded in field-level structures subject to similar institutional logic. Thus, we do not assume coordination or unified strategies within each group, and interpret the results as field-level trends, not as evidence of synchronized behaviour.

Results reveal that central banks lead in research output and impact, influencing both development and investment banks. Specifically in terms of research impact (citations per article), central and development banks exhibit a reciprocal relationship, impacting each other. This symbiotic relationship between central and development banks is mostly driven by the World Bank (WB) and the European Central Bank (ECB). In addition, investment banks' citations are influenced by those of central banks. Given that central banks lead in research production, the relevance of their articles is, in part, shaped by their followers. Overall, these findings suggest that central banks play a key role in shaping institutional norms among development and investment banks.

Central, development, and investment banks hold significant roles in shaping society. In particular, central and development banks, as policymaking entities, have substantial influence on social and

economic dynamics. These findings reveal the need for a more critical examination of the societal impact of these institutions. The scientific discourse emerging from financial research is shaped not only by institutional priorities but also by the epistemic leadership of central banks. This raises concerns about the objectivity and plurality of knowledge, as the research produced may reflect the strategic interests and normative preferences of a set of powerful institutions, rather than representing an unbiased or ideologically neutral view. Ultimately, the credibility and impartiality of the research conducted by these organizations come into question, emphasizing the importance of scrutinizing their influence on knowledge production.

This paper is organized as follows: Section *Introduction* presents the introduction, followed by a contextual background in the *Scientization and Institutional Dynamics* section. *Data and Methods* section describes the data and methodology used. *Results* section provides the results. Finally, *Discussion and Conclusion* sections present the discussion and main conclusions of these findings, respectively.

Scientization and institutional dynamics

Organizational fields in global finance

Organizational fields refer to 'those organizations that, in the aggregate, constitute a recognized area of institutional life' (DiMaggio and Powell, 1983: 2). Fields are not defined merely by shared function but by structured patterns of interaction, interdependence, and mutual recognition among actors. They emerge when organizations share common sources of legitimacy, engage with similar rules and norms, and observe one another as relevant peers or competitors. This concept enables the analysis of both horizontal relationships (e.g. between similar institutions) and vertical or hierarchical dynamics (e.g. between dominant and subordinate actors). Building on this foundation, Fligstein and McAdam's theory of fields further emphasizes that fields are social arenas of contestation and coordination, where actors of unequal power engage in struggles over resources, legitimacy, and rule-setting (Fligstein and McAdam, 2012). These fields are stabilized through shared understandings, but remain open to disruption through innovation, shifting alliances, or legitimacy challenges. Importantly, they are often nested within broader field structures, such as those governed by professional, epistemic, or regulatory norms.

This field-based perspective is particularly useful for understanding how scientized practices, such as knowledge production, academic publishing, and the formation of research departments, diffuse across institution types, not necessarily through direct imitation but via pressures, dependencies, and legitimacy-seeking behaviours. It also allows us to observe how institutions operating under different mandates may nonetheless become part of a shared epistemic environment, subject to similar standards.

In what follows, we apply this framework to central, development, and investment banks, each treated as a distinct organizational field, but embedded within the wider global finance arena. This conceptualization allows us to explore how knowledge production as a scientized practice is shaped by institutional position, professionalization, and the pursuit of legitimacy within and across fields.

Central, development, and investment banks: dynamics in the global finance field

Central, development, and investment banks can be seen as organizational fields since each represents a recognized area of institutional life (Marcussen, 2006; Mazzucato and Penna, 2016; Vit, 2007), such as key suppliers, resource or product consumers, regulatory agencies, among others. Generally, this refers to organizations that have a specific role that is acknowledged by other organizations and individuals in society. Central banks' roles in particular can be segmented into three main categories: (1) price stability, typically depending on the monetary regime, that is, gold standard, pegged exchange rate or inflation target; (2) financial stability, by acting as lenders of last resort for the banking sector; and (3) supporting activities, that is, acting as bankers for the government, issuing banknotes, supervising

commercial banks, overseeing the financial-market infrastructure, and providing consumer protection regarding monetary and financial issues (Goodhart, 2011; Herger, 2019). Moreover, development banks follow a set of shared practices and norms related to development finance, targeting sustainable development, poverty alleviation, climate change adaptation, and growth in developing countries. The first development bank, the International Bank for Reconstruction and Development (currently, World Bank), was created in 1944, upon the Bretton Woods monetary agreements. This bank aimed to promote financial access through funding activities, in order to prevent the negative effects of the pro-cyclical private financial sector (Mazzucato and Penna, 2016). Following the Bretton Woods agreements, additional development banks were established (Mazzucato and Penna, 2016; Schröder et al., 2011; Torres Filho and Costa, 2012). In the subsequent decades, these institutions progressively diversified their operations: from providing finance for small and medium-sized enterprises (SMEs), targeting innovation development (Mazzucato and Penna, 2016), investing in regional economic development, and supporting and nurturing new ventures and innovation development (Sanderson and Forsythe, 2013). Finally, investment banks are private organizations that arrange financing for corporations and/or governments, advice on merges and acquisitions transactions, and provide services related to trading and asset management business (Stowell, 2017). Investment banking is a global industry, providing wide-ranging financial services within a financial conglomerate organizational structure (Liaw, 2011; Soulard, 2021). Thus, central, development, and investment banks can each be viewed as distinct organizational fields, as they represent recognized areas of institutional life: central banks regulate and supervise the financial system, through price and financial stability; development banks provide services targeting economic, social, and financial development; and investment banks provide a wide range of financial services to corporations/governments.

Organizational fields do not exist in isolation; in fact, smaller organizational fields are embedded within larger fields (Fligstein and McAdam, 2012). For instance, central, development, and investment banks are contained within the global finance field (Gorton and Winton, 2003). Within this larger organizational field, organizations could be connected by various factors, and these links can be unconnected, hierarchical, or interdependent.

Within the global finance field, central banks function as both dominant actors and governance structures (Fligstein and McAdam, 2012). They define macroeconomic rules that shape the strategic behaviour of other financial institutions. They also act as enforcers of institutional practices, prescribing the dominant norms and practices of monetary policy, and serve as arbiters of power, particularly through their role as lenders of last resort (Goodhart, 2011; Herger, 2019). In essence, central banks regulate the boundaries of what is possible in finance, establishing the normative and operational limits within which other institutions must operate (Castiglionesi, 2007; Epstein, 2007; Padoa-Schioppa, 2002). This positions central banks at the top of a hierarchical relationship among key financial institutions. While development and investment banks play crucial roles in capital allocation and financial intermediation, they do so within the constraints defined by central banks (Castiglionesi, 2007; Epstein, 2007; Padoa-Schioppa, 2002). As such, central banks not only dominate strategic action within the financial field but also help constitute the very structure of the field itself. Following Fligstein and McAdam (2012), development and investment banks act as institutional entrepreneurs by introducing new practices. Development banks are mission-oriented institutions whose operations are largely diversified, with some development banks focusing on climate and innovation and others on industrial policy (Mazzucato and Penna, 2016). Investment banking also acts as institutional entrepreneurs by driving financial innovation and expanding their scope through mergers, deregulation, and the rise of universal banking structures. Their diversification into conglomerate financial services, combining underwriting, proprietary trading, mergers and acquisitions advisory, and asset management, culminated in their central role in both the globalization of capital markets and the structural responses to crises like 2008, prompting new waves of regulation and reconfiguration (Fohlin, 2014). Institutional entrepreneurs, also called 'challengers', seek to improve their chances of survival by either reducing their dependence on the dominant field or strategically aligning with more powerful actors (Fligstein and McAdam, 2012). Essentially, institutional entrepreneurs are actors that

aim to gain legitimacy and mobilize others to support field transformation (Fligstein and McAdam, 2012).

Legitimacy, defined as 'the perceived appropriateness of an organization to a social system in terms of rules, values, norms, and definitions' (Deephouse et al., 2017: 7), is the key factor we will be focusing on this work. Specifically, we focus on knowledge production as a key tool for organizational legitimation. While governance structures like central banks help confer legitimacy on the financial field as a whole, these structures must also legitimate themselves. One key strategy for doing so is through the production of scientific knowledge, particularly peer-reviewed research, which serves to frame institutional authority as objective, evidence-based, and rational. In this context, science becomes both a resource and a performative tool for sustaining institutional legitimacy within the field of global finance, increasingly adopted by central, development, and investment banks. This study explores the dynamics of the diffusion of knowledge production among these institutions.

Scientization and knowledge production

Scientization has become a worldwide institutionalized practice across different fields (Drori, 2003; Drori et al., 2006). This phenomenon refers to the process by which knowledge serves as a framework for action and activities are legitimized through science (Drori and Meyer, 2006).

Central banks' scientization began in the 1990s (Marcussen, 2009). Blinder (1997) identified the link between academia and central bankers and encouraged the deepening of this relationship. Since then, the research in central banks has increased. Specifically, central banks' brain power (i.e. research personnel) has grown significantly in the last decades, publishing an increasing share of articles in specialized scholarly journals and yielding an impact higher than that produced outside central banks (Claveau and Dion, 2018; Malovaná et al., 2024). Similar to central banks, development banks have been producing increasingly more intellectual contributions and are among the top international government organizations in scientific production (Zapp, 2017). In particular, the World Bank has established itself as the 'knowledge bank', focusing on knowledge production and sharing (King, 2002). Moreover, since the 1980s and 1990s, the process of scientization has increasingly permeated private firms, leading to greater investment in R&D and a rise in research output (Campbell and Guttel, 2005), while also becoming embedded in formal organizational structures (Drori and Meyer, 2006). Consequently, investment banks have evolved into knowledge-based organizations (Hicks, 1995), with a substantial volume of their research now featured in standard scientometric databases.

The global cultural environment influences organizational behaviour, leading to homogenization among organizations, even across diverse local contexts (DiMaggio and Powell, 1983). This cultural homogeneity facilitated the diffusion of key practices, such as central bank independence (Polillo and Guillén, 2005) and inflation targeting policies (Wasserfallen, 2019). A similar process occurred in knowledge production, where central banks developed into an epistemic community, characterized by shared views and organizational practices aimed at implementing those views (Haas, 1992; Kapstein, 1992). In the context of development banks, the diffusion of knowledge and the establishment of an epistemic community were driven largely by the World Bank, primarily through its Global Development Network (Stone, 2003). Within this network, the dissemination of knowledge predominantly occurs through the technical staff. Similarly, investment banks and rating agencies operate within embedded knowledge networks (research departments and trading agencies). These networks utilize technical expertise to carry out ideological functions, empowering the research departments of investment banks to deliver authoritative judgements (Sinclair, 2000). A major factor driving this process has been the increasing presence of highly qualified employees within these institutions, which has shifted them toward a more science-based framework (Zapp, 2021). This phenomenon reflects the broader professionalization of science, which has helped establish cultural norms that dictate how practices should be conducted and provide the tools necessary for their successful diffusion (Drori, 2003).

Scientization reflects a form of cultural authority, specifically a form of soft governance (Kallo, 2006; Maggetti, 2015; Niemann and Martens, 2018). In soft governance, authority is based on recognition from others within an epistemic governance framework. The spread of this cultural norm occurs through isomorphism (Drori and Meyer, 2006), which refers to the adoption of behaviours or institutional norms across organizations within the same field. Furthermore, organizations that adopt institutionalized norms are perceived as more legitimate, successful, and ultimately more likely to survive (Meyer and Rowan, 1977). Thus, international organizations play a relevant role within epistemic communities, diffusing the norms, supported by highly qualified and specialized staff (Zapp, 2017).

While prior work has documented the rise of scientized practices in central banks and, to a lesser extent, in development banks and investment banks, few studies have examined how these practices diffuse across institutional types within the same epistemic field. Existing research tends to focus on institutions in isolation, overlooking the relational dynamics and hierarchical structures that may shape their research output and influence. This study addresses that gap by analysing the inter-dependencies and directional influence in knowledge production among central, development, and investment banks.

Isomorphism and the diffusion of research norms

The mechanisms driving institutional isomorphic change can be categorized into three types: coercive, mimetic, and normative (DiMaggio and Powell, 1983). Coercive isomorphism arises from formal and informal pressures, such as cultural expectations or government mandates. Mimetic pressures occur in response to environmental uncertainty, leading organizations to imitate more successful models. Normative pressures stem from the professionalization of science, influencing organizational behaviour through established standards and practices. In the case of central, development, and investment banks, isomorphic change has been largely driven by both coercive and normative forces. The process of scientization, as outlined in the literature, is closely linked to coercive pressures as organizations seek legitimacy and its linked to the modern structures of power (Drori and Meyer, 2006; Goutsmedt et al., 2023; Rautalin et al., 2021; Zapp, 2021). These pressures incentivize institutions to adopt practices that conform to established scientific norms, such as forming research departments, publishing in peer-reviewed outlets, or collaborating with academia. In addition, the professionalization of these institutions, through the hiring of PhD-trained employees, internalization of academic standards, and participation in expert networks, has facilitated the diffusion of scientization practices (Drori, 2003; Zapp, 2021), making normative pressures equally significant.

Regardless of the mechanisms driving scientization, knowledge production serves as a strategic tool within these organizations and reflects a form of institutional power (Drori, 2003; Kallo, 2006; Maggetti, 2015; Niemann and Martens, 2018). Organizations often model themselves after more legitimate or successful counterparts (DiMaggio and Powell, 1983), and knowledge production serves to legitimize their activities. Within central, development, and investment banks, knowledge production has become an institutional norm (Rotolo et al., 2022; Marcussen, 2009; Zapp, 2017).

While their core mandates differ, these institutions intersect in their contributions to economic and financial governance (Fohlin, 2014; Kapstein, 1992; Mazzucato and Penna, 2016). Despite institutional differences, central, development, and investment banks have all embraced peer-reviewed scientific production as a strategic activity. Their comparability in this arena stems not from a shared role but from shared contributions to economic and financial governance and a convergence in practice: knowledge production.

Previous research on the scientization of economic and financial institutions has largely overlooked the relational dynamics between them. As Cross (2013) argues, epistemic communities vary in their degree of influence, and the greater their influence over other institutions, the more likely they are to shape policy outcomes. Given that central, development, and investment banks constitute a core set of actors in global financial governance, this study aims to conduct a comparative analysis of their relative

influence. Specifically, our research asks: (1) Do central, development, and investment banks influence each other's scientific production and impact through patterns of publications and citation? (2) If so, what are the directionality and structure of these epistemic relationships? In this framework, the institution with the greatest epistemic authority is understood to be the most powerful. Accordingly, our first testable hypothesis in this work is as follows:

Hypothesis 1. *Central banks' research production and citations influence the research production and citations of development and investment banks.*

This hypothesis builds on both our earlier characterization of each institution and Cross (2013)'s conceptualization, where internal cohesion within an epistemic community is crucial for understanding its influence. The key mechanism underpinning this cohesion is professionalism, which includes shared norms, technical standards, training regimes, and jurisdictional claims over a specific domain of expertise. Among the institutions considered, it is central banks that most clearly embody these characteristics: (1) central banks are technocratic institutions, staffed by highly trained economists and financial specialists (Claveau and Dion, 2018; Malovaná et al., 2024); (2) follow international standards set by the Bank of International Settlements (BIS) (Kapstein, 1992); (3) have jurisdictional primacy over core aspects of financial and economic policy: monetary policy, interest rates, and macroprudential regulation (Castiglionesi, 2007; Epstein, 2007; Goodhart, 2011; Herger, 2019; Padoa-Schioppa, 2002). While the development and investment banks may also exhibit characteristics such as professionalism and adherence to international standards, the degree to which these features are institutionalized falls short of that seen in central banks. The global diffusion of central banking roles is more cohesive and standardized than the more fragmented and heterogeneous roles and activities of development and investment banks. In addition, investment and development banks are subject to the regulations and norms established by central banks. There is a hierarchical relationship between these institutions' roles, which we aim to assess if it is translated to the diffusion of research production as practice.

Moreover, from the Bretton Woods Agreement to the emergence of green bonds and the rise of sustainable finance, development banks also play a significant role in shaping the global financial field. Historically, they have aligned with central banks during key moments of institutional transformation, such as the establishment of post-war financial architecture at Bretton Woods and in the response to major financial crises, helping to define the prevailing norms and frameworks of global economic governance (Dreher and Gassebner, 2012; Park and Vetterlein, 2010). Among financial institutions, development banks stand out as the strongest competitors to central banks in the pursuit of institutional legitimacy. While central banks dominate through their monetary authority, development banks assert legitimacy through their development-oriented financial innovation. Notably, they have been instrumental in defining new financial instruments, such as green bonds and blended finance mechanisms, which have since been adopted or adapted by investment banks (Güngen, 2023; Mendez and Houghton, 2020). In doing so, development banks not only contribute to expanding the boundaries of financial practice but also influence the strategic orientation of private financial institutions, thus reinforcing their relevance within the global finance field. Accordingly, our second hypothesis positions development banks as the secondary actors within the institutional hierarchy, following central banks in terms of epistemic influence and research production, influencing investment banks' research.

Hypothesis 2. *Development banks' research production and citations influence the research production and citations of investment banks.*

The operationalization of this theoretical framework is achieved empirically through the assessment of time series of publication and citations for each institution category. The Granger-causality tests assess whether changes in research output or citation counts in one institution type (e.g. central banks)

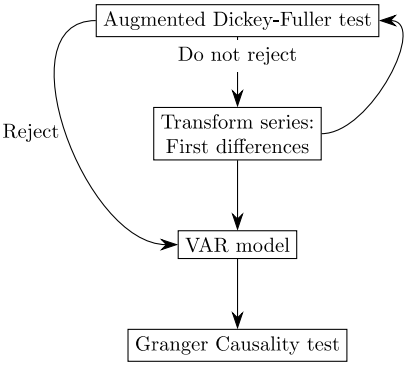

Figure 1. Linear approach.

Granger-cause similar changes in others (e.g. development banks). Such directional relationships suggest the presence of epistemic influence and provide evidence of field-level coercive alignment. In parallel, the Mixture Transition Distribution (MTD) and GenMarkov models (GenMarkov) estimate the relative weight of influence that one institutional group exerts on another over time. These models allow us to explore non-linear and probabilistic dependencies, offering a complementary view on institutional interdependence within the broader process of scientization. This empirical strategy does not test for isomorphism in a strict causal sense. Rather, we interpret patterns of citation and publication dynamics as indicators of normative alignment and hierarchical influence, through which institutional norms surrounding scientific legitimacy and knowledge production are diffused across organizational fields.

Data and methods

Analytical approach

The dataset includes peer-reviewed journal articles and their corresponding citations, where at least one author is affiliated with a central, development, or investment bank. We exclude working papers, policy briefs, and books, as our objective is to analyse formal engagement with the scientific publication system. The data were retrieved through the Web of Science search engine and include the published records from the first record published (1966) until 2023. The multivariate time series includes 188 institutions for central banks, 29 institutions for development banks, and 20 for investment banks.

Several sources were considered to delineate the perimeter of the players to be considered. Central banks were retrieved from a list compiled by the Bank for International Settlements, development banks were retrieved from lists compiled by the OECD, European Commission, and Xu et al. (2019), and investment banks' list considered the work of Stowell (2017).

To determine causal relationships and leader-follower dynamics, we adopted a two-fold approach: (1) assessing possible existing linear relationships through Granger-Causality analysis by estimating a VAR model, (2) assessing possible existing non-linear relationships through a multivariate Markov model.

Figures 1 and 2 contain the methodological approach. The Augmented Dickey-Fuller test indicates whether the time series considered is stationary. In the scenario of non-stationarity, we perform the first-difference transformation. Then, the VAR model accounts for the linear relationship, and the MTD and Generalized Multivariate Markov Chain model account for the non-linear assessment.

Granger causality analysis is based on a VAR model, which describes the first-moment (conditional mean) of each variable as a linear function of its own lagged values and the lagged values of other variables in the system (Granger, 1969). This approach captures linear dependencies within a multivariate setting. A multivariate Markov model describes how the probability distribution of a set of

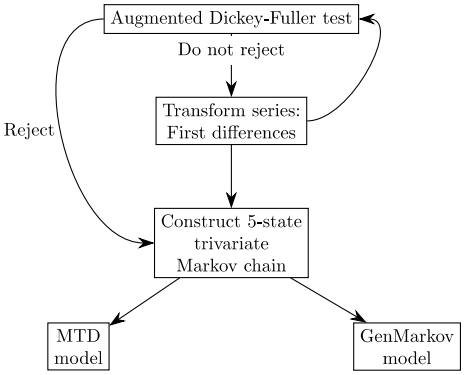

Figure 2. Non-linear approach.

time series evolves over time, based on their own past values and their inter-dependencies (Berchtold and Raftery, 2002). Unlike a VAR model, which primarily captures linear relationships and models the conditional mean, a Markov model describes non-linear dynamics beyond the first-order moments, allowing for a more comprehensive understanding of the time series' behaviour (Damásio and Nicolau, 2014, 2024). We considered two multivariate Markov models: the MTD model (Raftery, 1985) and the GenMarkov model (Vasconcelos and Damásio, 2025). The main advantage of the latter over the former is the incorporation of exogenous variables. Specifically, instead of considering solely the previously observed values of a given time series, it includes additional covariates as explanatory variables in the model. Thus, the GenMarkov model controls for other variables in the analysis without requiring the discretization of continuous values and the incorporation of an additional parameter.

The combination of Markov chain models and Granger-causality tests is familiar in the literature. Psaradakis et al. (2005) considered a VAR model with time-varying parameters governed by a Markov chain to establish a causal link between monetary variables. In addition, Droumaguet et al. (2017) compared a linear VAR model with a Markov Switching VAR model. The results of this work showed that the Markov Switching VAR model uncovered a causality relationship, which the linear VAR model did not. Moreover, Comte and Lieberman (2000) develop two definitions of second-order non-causality in a multivariate setting by considering a Multivariate GARCH Process. In the context of this work, the role of the Multivariate Markov chain models is to capture non-linear causality by considering a model that describes the probabilistic distribution of the set of time series.

Granger-causality applications range from neuroscience (Ding et al., 2006) to the environment (Smirnov and Mokhov, 2009) and economics (Bollen et al., 2011; Kónya, 2006; Narayan and Smyth, 2005). Previous information science studies considered the Granger-causality inference method. Specifically, Hu et al. (2021) studied the relationship between download and citation counts using this approach. Multivariate Markov chain models also have a wide range of applications such as modelling credit ratings (Fung and Siu, 2012; Siu et al., 2005) or stock markets (Maskawa, 2003), demand predictions (Ching et al., 2002), technological competition (Damásio and Mendonça, 2019, 2023), and citation networks (Yeo et al., 2014).

Results

Causality analysis

The present section contains the main results from the approaches depicted in Figures 1 and 2, where the details of this methodological approach are available in the supplementary materials. Considering research production (Figure 3), Granger-causality tests revealed no significant linear relationships among the three institutional categories. However, the MTD model uncovered a non-linear, dynamic relationship, suggesting that institutional publication patterns are mutually influential. Rather than a

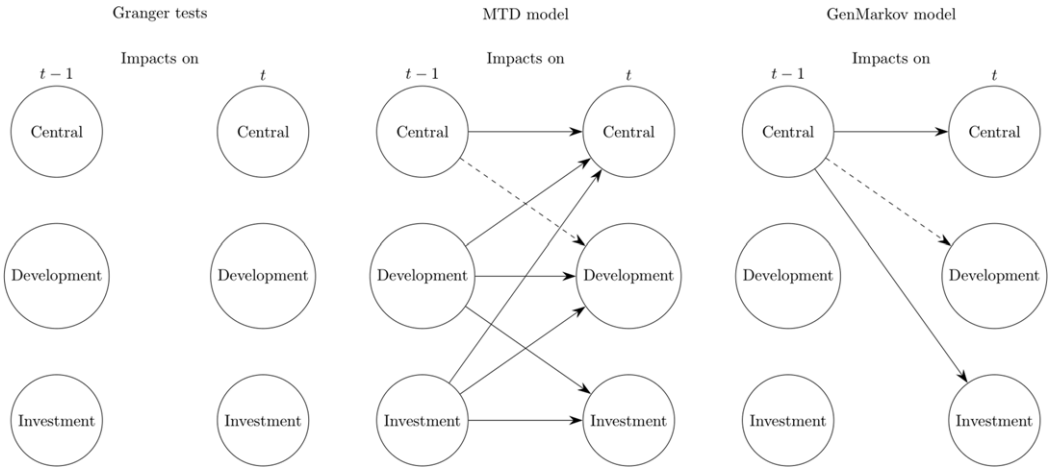

Figure 3. Publication's time series results.
Notes: **solid lines: 5% significance level, dashed lines: 10% significance level.**

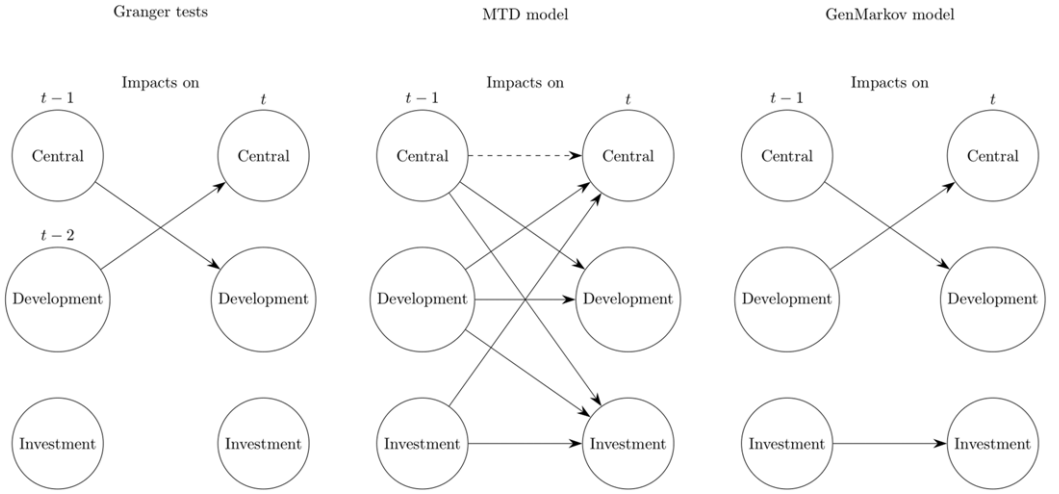

Figure 4. Citations' time series results.
Notes: **solid lines: 5% significance level, dashed lines: 10% significance level.**

single dominant trajectory, the MTD results point to a more interdependent field structure. However, the MTD model does not account for the number of authors, which can influence publication and citation counts (Abramo et al., 2017; Guan et al., 2017; Hsu and Huang, 2011; Lee and Bozeman, 2005; Tahamtan et al., 2016). To address this, the GenMarkov model incorporated the average number of authors per publication/year. The results from this model revealed that central banks influence the research production of both development and investment banks, providing support for the first hypothesis. Leadership, in this context, emerges only when non-linear dependencies are taken into account. Turning to scientific impact (Figure 4), a linear reciprocal relationship was found between central and development banks. Both the MTD and GenMarkov models confirm this co-dependency.

The main analysis treated central, development, and investment banks as aggregated institutional categories. However, research contributions are not uniformly distributed within these groups: each category contains a clear leading institution. To account for this internal heterogeneity, we conducted a robustness check by replicating the analysis while excluding the top contributor from each group. This

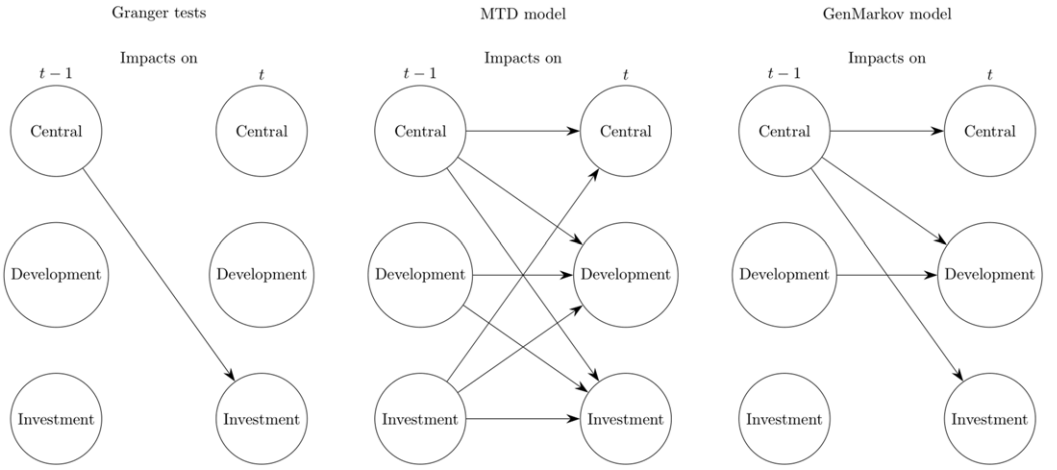

Figure 5. Publication's time series results (excluding ECB, WB, and Deutsch Bank).
Notes: **solid lines: 5% significance level, dashed lines: 10% significance level.**

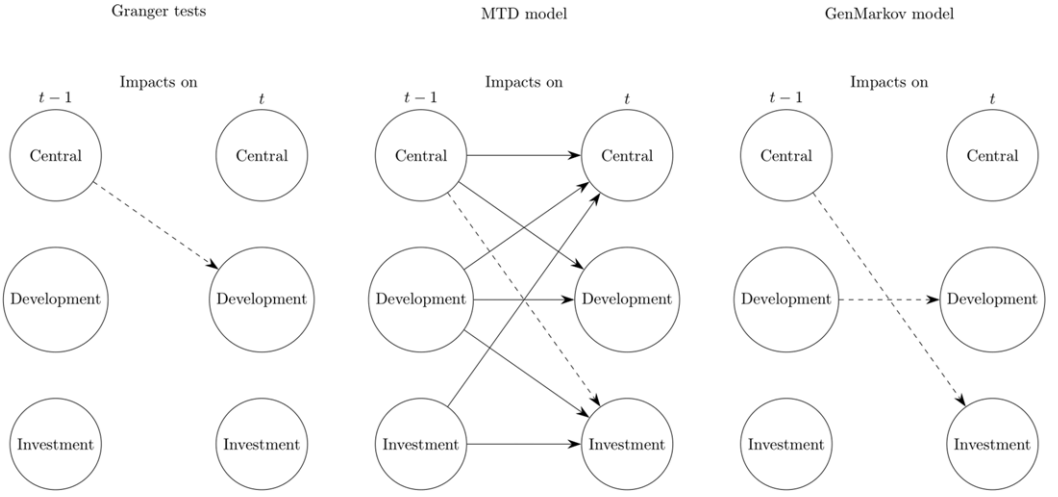

Figure 6. Citations' time series results (excluding ECB, WB, and Deutsch Bank).
Notes: **solid lines: 5% significance level, dashed lines: 10% significance level.**

approach helps to mitigate the risk of ecological fallacies, that is, drawing conclusions about an entire group based on the behaviour of a single dominant entity. Specifically, we excluded the ECB, the WB, and Deutsche Bank from the analysis.

When the leading institutions (ECB, WB, and Deutsche Bank) are removed (Figures 5 and 6), the results on research production are robust; however, the bidirectional citation link weakens, suggesting that this relationship was largely driven by the close collaboration between the ECB and the World Bank. Thus, in addition to this analysis, we examined collaboration networks, considering the co-authorship, to obtain further understanding of the citation dynamics among institutions.

Network analysis

Citation behaviour is shaped not only by research quality but also by self-citation practices, journal open-access policies, disciplinary culture, or authors' collaboration (Bornmann and Daniel, 2008;

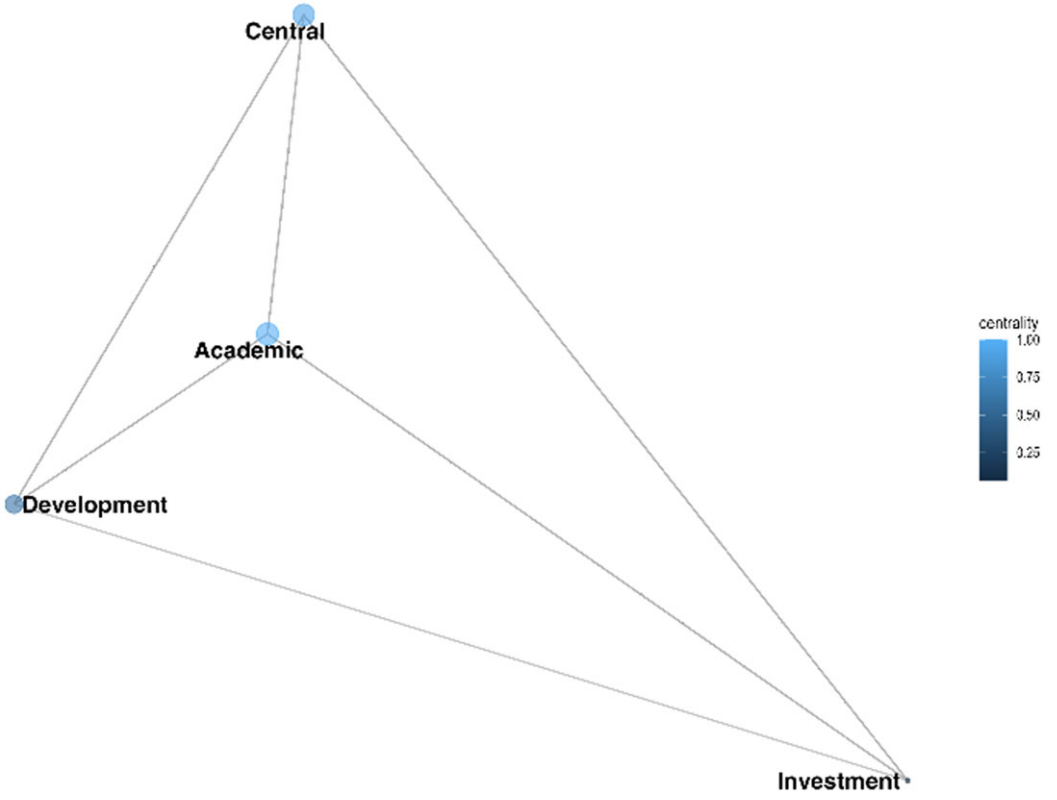

Figure 7. Collaboration Network, including all institutions.

Tahamtan et al., 2016). The structure of these collaboration patterns is related to citation behaviour, given that institutions that collaborate more frequently tend to cite one another more often (Mensah et al., 2025).

When analysing the full sample's collaboration network, central banks and development banks exhibit the highest standardized degree centrality scores (1.0 and 0.6, respectively). As shown in Figure 7 (created through the bibliometrix R package (Aria and Cuccurullo, 2017)), these two institutions emerge as key nodes within the network, with two possible paths: connected directly or through an intermediary academic node. This suggests a reciprocal relationship between central and development banks that is also mediated through academic collaboration. When key institutions, namely, ECB, WB, and Deutsche Bank, are removed from the sample, we obtain the reduced network (Figure 8). In this network, central banks, together with the academic node, maintain the highest degree of centrality, reinforcing their dominant position. The influence of development and investment banks in this setting is marginal, with investment banks showing a slightly higher degree of centrality score (0.10) than development banks (0.09). Since degree centrality measures the number of connections that a node has within a network, higher values indicate greater influence. In both the full and reduced collaboration networks, central banks clearly emerge as central actors in the collaborative structure.

Beyond degree centrality, PageRank (Table 1) provides valuable information. This metric accounts not only for the number of connections a node has but also for the quality and importance of those connections, capturing the popularity of a node within the network. In both networks, academic institutions and central banks exhibit the highest PageRank scores, illustrating their dual role as both highly connected and highly influential actors.

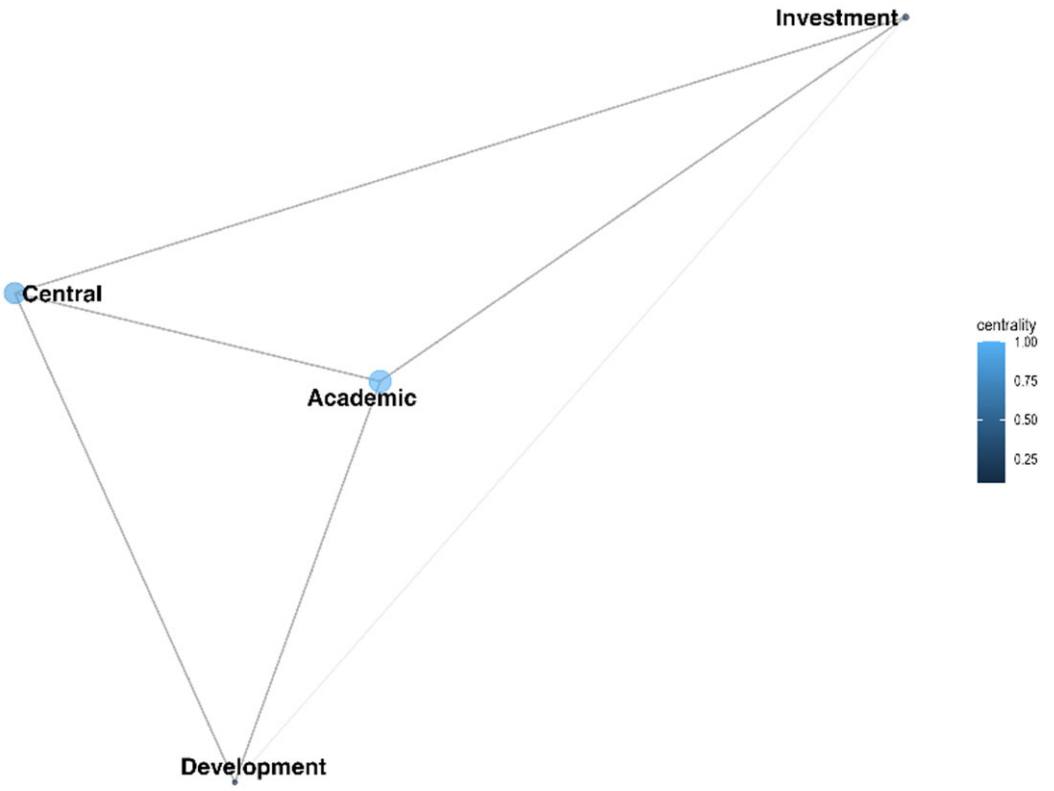

Figure 8. Collaboration Network, excluding WB, ECB, and Deutsch Bank.

Moreover, the edges (the connections between nodes) of the network allow to understand patterns of institutional collaboration. In both the full and reduced networks, the strongest collaboration is observed between academic institutions and central banks (Table 2). In the full network, collaborations between central and development banks account for approximately 12.6% of total connections. In addition, about 30% of collaborations occur between academic institutions and development banks, while 51% involve central banks and academia. However, after excluding the WB and the ECB, only central banks maintain a high level of collaboration with academic institutions. These findings further reinforce the dominant position of central banks in citation dynamics, suggesting that their epistemic authority is closely tied to their strong and sustained engagement with the academic and research community. In addition, the WB plays a key bridging role, particularly in its collaboration with the ECB. When these institutions are disaggregated in the network analysis, the ECB and WB display the highest node centrality. Overall, the collaboration networks emphasize the dominant role of central banks as leaders in both knowledge production and epistemic influence.

Discussion

While scientific production has become an institutional norm across many sectors, its diffusion among financial institutions and the relational dynamics driving it remain underexplored. This study examined the inter-dependencies in scientific knowledge production across central, development, and investment banks, using two methodological approaches: (1) Granger-causality tests to detect linear temporal relationships, and (2) multivariate Markov chain models (MTD and GenMarkov) to capture non-linear dynamics. We assessed both scientific production (number of publications per year) and scientific impact (citations per publication per year).

Table 1. Node centrality measures

	Full network		Reduced network	
Node	Centrality degree	PageRank	Centrality degree	PageRank
Academic	0.932	0.415	0.896	0.455
Central	1	0.311	1	0.388
Development	0.603	0.218	0.097	0.077
Investment	0.062	0.056	0.102	0.080

Table 2. Edge weights between nodes

Node 1	Node 2	Full network	Reduced network
Academic	Central	0.512	0.796
Academic	Development	0.316	0.078
Academic	Investment	0.034	0.083
Central	Development	0.126	0.020
Central	Investment	0.011	0.024
Development	Investment	0.000	0.000

The results validate our first hypothesis, confirming that central banks have established themselves as epistemic leaders. Through their influence on both publication and citation dynamics, central banks have shaped a field-wide norm of scientific production that development and investment banks increasingly emulate. This process reflects both normative isomorphism and coercive isomorphism. On the one hand, the professionalization of research has led to a growing number of academically trained staff across all three types of institutions, reinforcing shared norms of scientific output (Drori, 2003; Zapp, 2021). On the other hand, the epistemic authority of central banks has likely exerted coercive pressures on development and investment banks, stemming from broader cultural and institutional expectations to engage with scientific knowledge. In this context, producing and disseminating research becomes a mechanism of legitimacy, compelling other institutions to adopt similar practices.

In contrast, the second hypothesis, that development banks influence investment banks, was not supported. While development banks play a crucial role in financial innovation and policy leadership (Dreher and Gassebner, 2012; Güngen, 2023; Mendez and Houghton, 2020; Park and Vetterlein, 2010), this influence does not extend to the domain of scientific production as an institutionalized norm. Nevertheless, the World Bank stands out as a key intermediary, particularly through its collaboration with the ECB. Rather than shaping the research agenda of investment banks, the World Bank appears to function as a strategic enabler of central bank leadership, enhancing its own legitimacy through association.

These findings raise important questions about the role of science in institutional authority. The modern scientific system is constituted by organizational 'actors', that is, empowered social units (Meyer and Jepperson, 2000). These actors operate within scientized pictures, which are settings that are presented as objective and authoritative because they are framed within the discourse of science. Thus, scientized pictures define the environment and competence of these actors, along with the reasonable actions they can incur (Drori, 2003). Central banks, being the leaders in research production, define the scientized pictures (Drori, 2003; Lebaron, 2008). Investment and development banks operate within this environment, reinforcing central banks' legitimacy. As epistemic leaders, central banks effectively define research, thereby influencing the boundaries of inquiry in economic

and financial policy. This has implications for the neutrality of scientific knowledge. If institutions with significant regulatory and policy authority also dominate the production of research, the line between scientific objectivity and institutional interest becomes increasingly blurred (Haas, 1990; Kapstein, 1992; Lebaron, 2008). The ability to set research agendas may further strengthen institutional hierarchies, raising critical concerns about the independence, diversity, and accountability of policy-relevant knowledge in global finance.

The intellectual production of both national and international organizations is not neutral in relation to policymaking (Haas, 1990; Kapstein, 1992). For example, Jelveh et al. (2024) quantified partisanship in economics publications, revealing a strong correlation between political behaviour and scientific output. Academic journals themselves are not immune to bias: Mithas et al. (2025), through a bibliometric analysis of journals listed by the Financial Times, demonstrate that research production is dominated by Western and Chinese institutions. The decision to publish is deeply institutionalized, often shaped by organizational and political dynamics (Goutsmedt et al., 2025), and tends to align with prevailing political and economic interests (Drori, 2003). Moreover, central banks' roles and beliefs do have a role in the economic and social order (Lebaron, 2008). It is, sometimes, a commonplace to state that markets for ideas develop in settings characterized by a plurality of individual actors (Coase, 1974; Gans and Stern, 2010). Our paper explored this dynamic in an empirical, quantifiable, and replicable way in the globalized persuasion space of economic sciences (Klamer et al., 1988; Mendonça, 1998). We hope to have proposed a way to map and measure how research is pushed and pulled among the framework institutions of contemporary capitalism (Chang and Lari, 2024; Mirowski and Sent, 2002). If power lies with those who master science, the findings of this study provide evidence of the hegemony of central banks among development and investment banks.

Conclusion

In a pioneering statement on central banks as a revamped core institution in the governance of the modern economic system, Milton Friedman (1995: 7) said: 'the monetary authority should guide itself'. In order to be an autonomous rule-setter, economic institutions may have found indigenous capabilities in knowledge production as source of such self-assurance and legitimacy.

This empirical paper considers the scientific research activities of central, development, and investment banks, while focusing on identifying leader and follower dynamics. The methodological approach advanced Granger-causality tests and multivariate Markov chain models (MTD and GenMarkov) to capture linear and non-linear relationships, respectively. The findings from the Granger-Causality analysis revealed an absence of linear causal relationships among these banks' research production. The MTD model captured a complex dynamic between institutions; however, it did not control for the number of authors, which influences research productivity and impact. The GenMarkov model, accounting for the average number of authors per publication/year, yielded significant results, thus suggesting non-linear relationships among these institutions. Specifically, central banks emerged as leaders influencing development and investment banks' research production. Regarding research impact, central banks and development banks share a codependent relationship, driven by the ECB and WB.

Hence, central banks lead, while development and investment banks follow. Yet, 'who cares?' If knowledge production is shaped by a small set of powerful institutions, then understanding how that knowledge is produced, diffused, and legitimized becomes a matter of public concern. This work sheds light on the relationships of research production among financial institutions and provides valuable insights into the knowledge environment within the institutional banking sector. Given that research production functions as a form of forward-looking governance through agenda-setting, the broader significance of these findings lies in revealing a hierarchical structure among key financial institutions. The dynamics uncovered should feed into ongoing debates about the influence of these institutions in society, raising important questions: how might their scientific discourse be shaped, and to what extent is their research independent and free from institutional bias? While science is often perceived as

independent, objective, and impartial, the intersection of policymaking and scientific production raises concerns about the validity of such research. This calls for a closer examination of whether scientific production reflects unbiased knowledge or primarily advances institutional perspectives that may then be replicated by similar organizations and adopted across other fields. As such, caring about who produces and amplifies knowledge is essential to evaluating the independence, pluralism, and accountability of expertise in the financial and economic system.

This study presents some limitations that open future lines of research. First, the aggregation of time series data prevents us from capturing finer-grained dynamics between specific institutions or understanding how research flows across individual citation networks. Future studies could address this by incorporating micro-level citation network analysis or topic modelling to trace how knowledge diffuses through specific fields and communities, and if this changes according to historical events, such as the 2008 financial crisis. In addition, factors such as institutional size, R&D budgets, internal research structures, and changes in journal editorial policies may also influence patterns of publication and citation. While our field-level approach does not incorporate these institution-specific characteristics due to data constraints, we recognize them as important variables that could shape research dynamics. Second, while our focus was on the volume and interdependence of research output, we do not examine the content or framing of that research. Thus, an important next step would be to assess whether institutions differ in how they conceptualize problems or prioritize agendas. Specifically, future lines of research should move beyond the questions of 'who leads' and 'who follows', to examine *how* research influence is exerted and *what* kinds of knowledge are being produced.

Supplementary Material. The supplementary material for this article can be found at https://doi.org/10.1017/S1744137425100283

Funding statement. This work was supported by national funds through FCT (Fundação para a Ciência e a Tecnologia), under the project – UIDB/04152/ and UID/GES/00315/2013 - Centro de Investigação em Gestão de Informação (MagIC)/NOVA IMS). Sandro Mendonça acknowledges the Portuguese Science and Technology Foundation (FCT) [grant number UID/GES/00315/2013; project number PTDC/EGE-ECO/30690/2017]. BRU-IUL and REM/UECE are financially supported by the FCT, Portugal.

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Cite this article: Vasconcelos C, Damásio B, and Mendonça S (2025). Banking on research: Who leads? Who follows? Who cares? *Journal of Institutional Economics* **21**, e42, 1–19. https://doi.org/10.1017/S1744137425100283