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Researching the Research: A Central Banking Edition

Simona Malovaná, Martin Hodula, Zuzana Rakovská

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Researching the Research: A Central Banking Edition

Simona Malovaná, Martin Hodula, and Zuzana Rakovská *

Abstract

We build two unique data sets describing research in central banks in Europe and the United States. These data sets offer a novel insight into central banks' research activities, the research topics covered, collaborations between central banks and with other institutions, gender diversity and research popularization, among other things. We identify significant heterogeneity among central banks from different regions. Nevertheless, we are also able to identify several important stylized facts. First, following the Global Financial Crisis, financial stability surpassed monetary policy as the leading research topic. Second, we document a substantial decline in papers with single authors, from 40% in 2000 to less than 20% in 2019. Still, research in central banks is highly concentrated, as the top 10% of authors contribute to about 50% of all central banks' research publications. Third, while central banks form enormous research networks, we find that most of this research collaboration is region-specific. Fourth, we document an increasing representation of women in research teams, but the gender gap persists and is closing only slowly. In this respect, small central banks are found to employ more female researchers than large ones. Fifth, major central banks with a well-established research tradition achieve the highest average impact factor, with a few research papers contributing the most to this average.

Abstrakt

Sestavujeme dva unikátní soubory dat popisující výzkum v centrálních bankách v Evropě a ve Spojených státech. Tyto soubory dat nabízejí nový pohled na výzkumné aktivity centrálních bank, mimo jiné na témata jejich výzkumu, spolupráci mezi centrálními bankami a s ostatními institucemi, genderovou diverzitu a popularizaci výzkumu. U centrálních bank z různých regionů zjišťujeme značnou heterogenitu. Zároveň však identifikujeme několik důležitých stylizovaných fakt. Zaprvé, po globální finanční krizi nahradila měnovou politiku na pozici hlavního tématu výzkumu finanční stabilita. Zadruhé, dokumentujeme výrazný pokles počtu článků s jediným autorem, a to ze 40 % v roce 2000 na méně než 20 % v roce 2019. Přesto je výzkum v centrálních bankách velmi koncentrovaný, neboť nejaktivnějších 10 % autorů přispívá k více než 50 % výzkumných publikací centrálních bank. Zatřetí, ačkoli centrální banky tvoří velmi rozsáhlé výzkumné sítě, zjišťujeme, že většina této výzkumné spolupráce je zaměřena regionálně. Začtvrté, dokládáme rostoucí zastoupení žen ve výzkumných týmech, ale genderové rozdíly nadále přetrvávají a zmenšují se jen pomalu. V tomto ohledu zjišťujeme, že malé centrální banky zaměstnávají ve výzkumu více žen než ty velké. Zapáté, přední centrální banky se zavedenou výzkumnou tradicí dosahují nejvyššího průměrného impakt faktoru, přičemž k tomuto průměru nejvíce přispívá několik málo výzkumných prací.

JEL Codes: A1, A3, D85, E58, O31.
Keywords: Central banking, collaboration, gender diversity, impact factor, network analysis, research, topic analysis.

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1. Introduction

Economic and financial research plays a pivotal role in central banks around the world. Research units are tasked with providing policymakers with inputs which help to expand the knowledge base needed for the central bank's core activities. Given the fact that central banking tasks continue to grow in complexity, the importance of research and the demands placed on it are expected to grow too. Thus, the question is not whether to conduct research in central banks, but how to organize it, how much to invest in it and how to assure effective transmission of research outcomes into the policy decision-making process. Nowadays, an increasing number of central banks have their own research divisions or whole departments staffed with both junior and senior-level research economists.[1] This is a manifestation of the general belief that sound policy must build on cutting-edge economic thinking. Moreover, research in central banks has established itself as a prominent contributor to the academic literature over time. Claveau and Dion (2018) show that major monetary economics journals are increasingly dominated by central banks' research papers. Another interesting trend is the visibly increasing share of non-US central bankers who have been invited to the annual Jackson Hole Economic Policy Symposium.[2] This has allowed them to conduct high-level discussions about current topics, to evaluate the ex-ante appropriateness of intended measures and to analyse the efficiency of measures applied.

The importance of having a research department within a central bank is recognized by numerous current and former central bank representatives. Cecchetti (2002) notes that central banks equipped with research departments make better monetary policy. Bolton et al. (2014) highlight that having a high quality research team is essential if central bankers and financial supervisors are to meet the objectives given to them by their societies. Trichet (2007) states that central banks need top-quality research on monetary and financial economics. Carney (2014) emphasizes analytical excellence and the development of a single research agenda as means to promote the good of the people. Mishkin (2010) states that the more monetary policy is informed by good science, the more successful it will be. There are, in fact, numerous official discourses going in the same direction.[3]

In our paper, we provide a comprehensive international overview of the research conducted in central banks. We perform our exploration across both the cross-sectional and the time dimension. Specifically, we aim to shed some light on how central banks organize and communicate their research activities, how they perform in terms of research outputs, and what the recent trends are in areas such as the research topics covered, collaborations between central banks and with other institutions, and gender diversity. For this purpose, we create two unique data sets. The first one contains information on central banks' research activities in three main areas: research publications, popularization of research and organization of research. Each area is evaluated on a number of different factors, together making a list of 26 items. The second data set comprises information about more than 20,000 research papers published in European and US central banks over the period of 2000–2019. To the best of our knowledge, neither of these two data sets has previously been constructed. As such, they offer a unique insight into central banks' research activities, allowing us to explore heterogeneity among central banks from different regions and changes in research

[1] The high level of specialization and proficiency in economics and finance is also apparent from the governor appointments. Lebaron and Dogan (2016) analyse the biographies of 312 incumbent and former central bank governors from across the world, observing a high qualification level, predominantly in economics.

[2] The proportion of market participants fell from 27% in 1982 to 3% in 2013 as they were "replaced" by non-US central bankers, whose share increased from 3% to 31% (The Economist, 2014).

[3] Similar speeches on the importance of research in central banks were given at the end of the millennium as well – see Taylor (1998).

conducted before and after the Global Financial Crisis (GFC) of 2007–2009. Documenting these issues may help central banks to identify best practices.

We complement the existing body of literature along at least three dimensions. First, we add to the literature examining the research conducted in academia. This includes studies that analyse the formation of research networks among academics (Adams, 2012) and studies commenting on the demographics and trends in the articles published in economic journals (Card and DellaVigna, 2013; Hamermesh, 2013). Our paper verifies whether some of the trends observed in academic research regarding the number of coauthors, network density, distribution of authorship and others are also present in central banks' research. In this respect, our findings largely complement those of Essers et al. (2020), who employed data on 6,152 IMF Working Papers written in the period of 1990–2017, including authors' names and emails, number of pages and citations, and JEL codes, using the IMF website catalogue. In addition, they complemented the data with employee-level information. Our analysis offers a rather different perspective, as it includes an international sample of central banks and supranational institutions, while it supports many of the findings of Essers et al. (2020). Second, our paper echoes the literature on central bank communication (Dincer and Eichengreen, 2007; Blinder et al., 2008) by offering a unique view on how research – one of the underlying processes behind policy decision-making – is conducted. Third, we contribute to the growing body of literature on gender gaps in central banks (Charléty et al., 2017; Diouf and Pépin, 2017) by studying the gender structure of research teams.

The rest of the paper is organized as follows. Section 2 describes two unique data sets on central banks' research. Section 3 discusses the main purpose of research in central banks and categorizes the main research activities performed by them. Section 4 gets more into the detail and presents a few stylized facts on the topics researched in central banks, authorship networks, the gender structure of research teams and the impact factor of central banks' publications. Section 5 concludes.

2. Data Sets on Central Banks' Research Activity

We construct two unique data sets allowing us to explore various attributes of research in central banks. We focus our attention on two regions – the US and Europe. We complement these regions with data on two additional international institutions, namely the Bank for International Settlements (BIS) and the European Central Bank (ECB, also including the European Systemic Risk Board, ESRB), as both encompass research activities serving policy conduct in central banks. Altogether, we compile information on 55 central banks. We include all 12 regional Federal Reserve Banks in the Federal Reserve System and the Federal Reserve Board (FRB), and 40 European national central banks. Within Europe, we further distinguish between three regional areas - the Euro Area original members (EA orig.), Western and Northwestern Europe (W & NWE), and Eastern and Southeastern Europe and the Baltic Countries (E & SEE, BC; see Table 1). We hypothesize that research quantity, quality and collaboration, among other things, will be different between the regions. For instance, we assume a more dense collaboration network within the Euro Area original members, reflecting a longer period of mutual cooperation via various working groups and research networks. Furthermore, we assume higher quality of research conducted by central banks in W & NWE relative to E & SEE, BC due to a longer tradition of research in both central banks and academia. As such, the differentiation between these regions will help us to explore the potential heterogeneity.

Table 1: Division of Central Banks in Europe into Regions

	Euro Area Original Members *(EA orig.)*		**Western and Northwestern Europe** *(W & NWE)*		**Eastern and Southeastern Europe and Baltic Countries** *(E & SEE, BC)*	
Research Score Data Set & IDEAS/RePEc Data Set	AT	Austria	DK	Denmark	AL	Albania
	BE	Belgium	IS	Iceland	BG	Bulgaria
	DE	Germany	NO	Norway	CY	Cyprus
	ES	Spain	SE	Sweden	CZ	Czech Republic
	FI	Finland	SW	Switzerland	EE	Estonia
	FR	France	UK	United Kingdom	GR	Greece
	IE	Ireland			HR	Croatia
	IT	Italy			HU	Hungary
	LU	Luxembourg			LT	Lithuania
	NL	Netherlands			LV	Latvia
	PT	Portugal			MK	North Macedonia
					MT	Malta
					PL	Poland
					RO	Romania
					RS	Serbia
					SK	Slovakia
					SL	Slovenia
					UA	Ukraine
Only Research Score Data Set					BA	Bosnia and Herzegovina
					BY	Republic of Belarus
					MD	Republic of Moldova
					ME	Montenegro
					XK	Republic of Kosovo

Note: The Research Score Data Set includes an additional five central banks in Europe which report some characteristics of their research but do not have any public research publication series, or the series is very short, or the publications are not in English.

The first data set leverages information available on each of the 55 central banks' websites and social media accounts. The data set (hereafter referred to as the Research Score Data Set) comprises information on central banks' research activities in three main areas: research organization, publications and popularization. Each area is evaluated using several different factors, together making a list of 26 items (see Tables A1, A2 and A3 in Appendix A). The items include, for example, the types of research publication series, the extent of research opportunities offered, the level of autonomy of the research departments and the degree to which US and European central banks use their websites, social media (Twitter, LinkedIn and YouTube) and additional forms of communication such as blogs, newsletters and bulletins to promote the research. Out of the 26 items, 21 were harvested from banks' websites and four from banks' social media accounts, and the last item was collected as a single observation from the IDEAS/RePEc website (see the next paragraph). The data were collected during the observation period of February–March 2020 and should therefore be interpreted as of these months. Each item is assigned a score of between 0 and 1: 1 if the bank engages in the given activity in full; 0.50/0.25 if the activity is in place only partially; and 0 otherwise. To obtain a separate measure for each of the three areas and a single overall measure for all 26 items, the research scores are constructed as the sum of the scores assigned to the individual items; the individual items are not weighted. As such, we get an *Overall Research Score*, a *Research Organization Score*, a *Research Publication Score*

and a *Research Popularization Score*. All the scores are calculated on the level of individual central banks and visualized in the form of a geographical heat map (see Figure B1 in Appendix B).

The second data set comprises information about more than 20,000 research papers published in 50 central banks over the period of 2000–2019.[4] This data set was extracted from the IDEAS/RePEc website using the web-scraping technique, and it includes the paper's title, the authors' names and reported affiliations, the abstract, keywords and JEL codes, and an indication of whether the paper has been published in a scientific journal.[5],[6] We harvested information on working paper series, discussion paper series and occasional paper series, and on other research publication series similar to those three (for instance, research publication series with a special focus, such as MPC discussion papers or financial stability papers).[7] The final data set (hereafter referred to as the IDEAS/RePEc Data Set) went through numerous controls to ensure its completeness and correctness. Nevertheless, it was not possible to extract and match all information. For example, it is not possible to match the author to his or her affiliation if the name listed in the paper differs from the name registered in the database (if it has changed due to marriage, for example). It is also not possible to match a working paper to its journal version if the title has changed significantly. Moreover, not all the harvested information is reported for each research paper. For instance, abstracts are assigned to more than 99.6% of publications, keywords to about 83% and JEL codes to about 78%. About 69% of all authors have an assigned affiliation. In addition, the data are subject to the completeness and quality of reporting by central banks, listed journals and authors themselves. A few central banks in Europe either do not report their research publications in the database at all, or do not have such a series. Therefore, some information was harvested manually where available to complete the coverage of European countries (see Tables A4–A5 in Appendix A). We excluded entries with non-English abstracts (only about 2.3%) and we expanded the IDEAS/RePEc Data Set with some additional information on impact factor and the gender of the authors. Gender is identified using the R package *gender* based on the authors' first name (85% of all first names are recognized and assigned a gender with an average probability (precision)[8] of 98%). Impact factors, as reported by the IDEAS/RePEc database, are assigned both to the central banks' research publication series and to the scientific journals in which some of the research papers are published.

[4] Five central banks in Europe which report some characteristics of their research but do not have any public research publication series, or the series is very short, or the publications are not in English, were omitted from the second data set.

[5] The data was extracted from the IDEAS/RePEc database during the first half of 2020. As such, it represents the information which applies to the date on which it was collected. For example, the author's affiliation represents the affiliation reported by her at that time. As such, it does not represent a historical record of the affiliations to which the author reported at the time of paper's publication.

[6] A scientific journal is any publication series referred to as a journal by IDEAS/RePEc. As such, it includes central banks' in-house journals.

[7] The publication series were selected based on their research character so as to create a more or less homogeneous group, which means that rather short and analytical publication series were not included. We also excluded in-house journals, as these are by their nature closer to scientific journals than working paper series. Moreover, if the working paper (discussion paper, occasional paper, etc.) is then published in the central bank's in-house journal, it is indicated in our sample.

[8] The gender is inferred using historical data sets of first names and dates of birth. In this way it is possible to report the probability that a name was male or female. For more details, see the documentation on the package.

3. How to Understand and Organize Research in Central Banks

The term "research" is not well understood by many. Even in central banks, the views on what constitutes research may vary – both across different central banks and even among the employees of a bank (Meyer et al., 2008).[9] Research is characterised by a high degree of uncertainty, complexity and uniqueness of the questions researched and methods applied, and by high demands on resources.[10] In this regard, research differs from analysis. Analytical tasks are usually less complex and more repetitive and, to some extent, can be performed using automated data-retrieval techniques. As such, analysis is always associated with a lower degree of uncertainty, i.e. it is possible to predict relatively well what the output will be. While both analysts and researchers work with economic and financial data, researchers tend to work on both the front end (performing estimates and interpreting the results) and the back end of the data (compiling and analysing), whereas most analysts work only on the back end.

Both basic and applied research should be present in central banks, as they complement each other. Basic research is generally tasked with thoroughly investigating a problem to push back the frontiers of knowledge. Applied research, on the other hand, is supposed to have an immediate use and visible value added. Although basic research may not have any immediate application, it may have positive long-term spillovers for the institution and for the economy as a whole. In the context of central banking, basic research is motivated by a desire to increase understanding of the fundamental principles grounding the institution. Such research can try to understand and review, for example, the central bank's role in society, its contribution to public welfare, its aim and impact, or the functioning of the whole economy, including financial institutions and financial markets. Applied research, on the other hand, is usually designed to answer a specific research question aimed at an immediate application. This can include, for example, assessing the transmission of a particular monetary, macroprudential or supervisory policy instrument, or developing and refining a particular methodology, model or indicator. One type of research cannot (or should not) live without the other. Basic research provides fundamental knowledge that applied research can build upon. Likewise, basic research benefits from specific improvements and new fundamental questions generated by applied research.

Research in central banks usually stands somewhere between basic and applied research. Policymakers appreciate frontier thinking but are generally more interested in research that addresses practical issues faced by the central bank. This is where the two types of research may clash. With basic research, value added is mainly assessed by some form of publication metric, such as the impact factor of the journal publication. However, applied research tends to address aspects of less interest to journal editors and may not even be meant for journal publication in the first place. This is apparent from Figure 1, which shows that the average share of central banks' research papers published in scientific journals is close to 40% and rising only slightly over time (see Figure 1, panel A).[11] On top of that, the heterogeneity among central banks is quite pronounced (see Figure 1, panel B). Assessing the merits of applied research is thus much more difficult (Caballero et al., 2012). One cannot simply apply academic criteria to central bank research publications. Many central banks use their own publication series to exchange ideas about

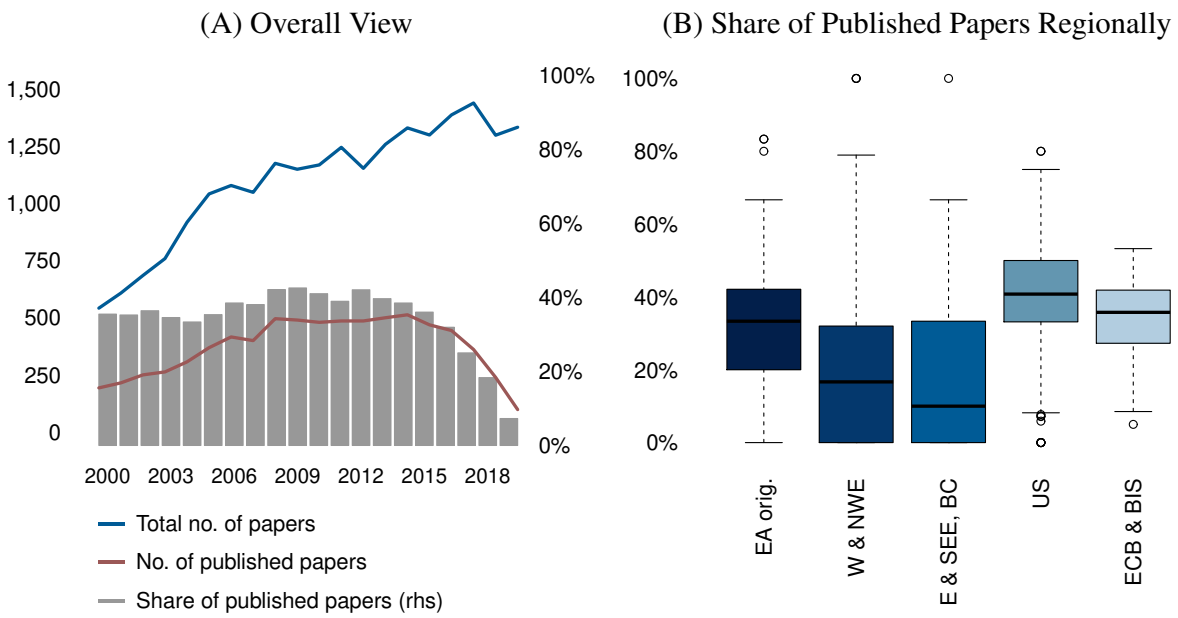
[9] Meyer et al. (2008) in their report noted that *"the Committee* [the External Review Committee of economic research activities at the Bank of Canada] *discovered that the term 'research' has a very wide range of meanings for many senior managers as well as staff economists at the Bank"*.

[10] By high demands on resources we mean especially human resources. Research is time demanding and requires high expertise, which may eventually translate into high financial costs per project.

[11] The noticeable decline in working papers published in journals since 2014 is due to publishing delays (Björk and Solomon, 2013).

bank-specific topics with other central banks and regulatory institutions, academia or the wider economic community. Central banks' paper series might be technical and also theoretical in nature, but, in essence, they form an easily accessible knowledge base. In this regard, research publications help to increase central banks' transparency. They can also serve as a strong conceptual and empirical basis for conducting monetary policy and maintaining price and financial stability. Mudge and Vauchez (2016) consider this approach to be one of the building blocks of the European Central Bank.

Figure 1: Share of Central Banks' Research Papers Published in Scientific Journals

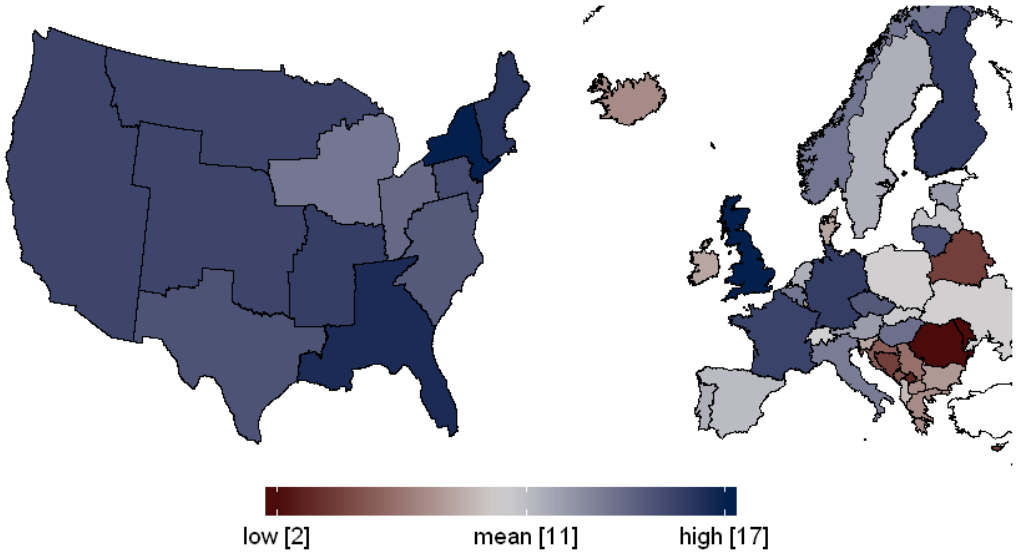


Note: Panel A: The total number of research papers published by the 50 central banks in their own publication series between 2000 and 2019 is 21,908; the total number of central banks' research papers published in scientific journals is 7,455. Panel B: Each point of the distribution refers to the share of central banks' research papers published in scientific journals in the given year between 2000 and 2019. In four instances the share is 100%, with the number of working papers produced being only one or two in a given year and for a given central bank.
Source: IDEAS/RePEc Data Set

In-house research in central banks has value added along multiple dimensions. First, there are the *direct* benefits. Research can aid policymakers in dealing with current policy issues, such as determining the driving factors of current phenomena, analysing the impact of measures taken and quantifying the implications of alternative policy choices. Under the same category, research is well suited to deal with future policy issues as well. Second, there are plenty of *indirect*, often overlooked, benefits (see the next paragraph).

Research in central banks is important for spreading knowledge both inside and outside the institution. High-quality research publications can enhance a central bank's reputation and increase its credibility and make it easier to defend policy actions both publicly and privately (Issing, 2005; Dincer and Eichengreen, 2007; Blinder et al., 2008). A modern central bank strives to be predictable to the market most of the time and extensively communicates its decisions to the public. Moreover, having high-quality research is self-enforcing, as the central bank has a greater chance of attracting (and keeping) high-quality economists. These benefits are important to maintain, even at the cost of letting some research time be spent on topics outside the central bank's mandate, i.e. the central bank can deploy some of its research capacity for the public good.

Figure 2: Overall Research Scores of Central Banks – US and Europe



Note: The information was collected manually using the central banks' websites and social media accounts. The detailed data behind the scores can be found in Tables A1 and A2. The choropleth maps do not reflect the scores for the Federal Reserve Board (FRB), the European Central Bank (ECB, including the ESRB) and the Bank for International Settlements (BIS).
Source: Research Score Data Set

There is a high-degree of heterogeneity as to the amount of research activities carried on by individual central banks. The research activities performed by central banks are not limited to publications only. Figure 2 depicts the degree of engagement in various research activities, summarized in the *Overall Research Score*, for all the national central banks in our sample (see Section 2). The maximum score is 17 (Bank of England) and the minimum is 2 (the central banks of Romania and the Republic of Moldova). The difference is especially pronounced between central banks in Eastern and Western Europe, with a higher *Overall Research Score* achieved in the West (see Figure 2). Nevertheless, there are three exceptions – the Czech National Bank, the Central Bank of Hungary and the Bank of Lithuania, which all exhibit an above-average *Overall Research Score*.[12] Even though each of these three central banks achieves its high score by different means (i.e. by engaging in a different set of research activities), all of them are catching up quite well with the well-established and more research-oriented central banks in Europe. Unsurprisingly, all the US Federal Reserve Banks achieve a high *Overall Research Score* of between 12.5 and 16.75, reflecting the high importance assigned to research in the system. All these institutions are recognized for their intense investment in scientific prestige and scholarly research.

The *Overall Research Score* consists of three sub-indices - a *Research Organization Score*, a *Research Publication Score* and a *Research Popularization Score*. Each of the following subsections focuses on one area (for more details on the sub-indices, see Appendix A).

[12] For more details on the Czech National Bank's research model, see Malovaná (2020).

3.1 Research Organization in Central Banks

The vast majority of the central banks in our sample have a separate research department.[13] Most of these departments (divisions, units) fall under the area of monetary policy, forecasting or general economic analysis. Even though the majority of the central banks in our sample (28 out of 55) have a legal mandate to maintain financial stability, only a few of them have reflected this in the organizational structure of their research activities. Only eight central banks have their own financial research department – three among the US Federal Reserve banks, four among the central banks of the E & SEE, BC region, and the ECB.

Some central banks have affiliated research institutes, which usually focus on a special economic topic. The purpose of such affiliated institutes is to conduct high-quality research and to act as a centre of excellence for the selected area. An example of such an institute in Europe is the Bank of Finland Institute for Economies in Transition, which specializes in research of economies in transition. In the US, there is, for example, the Consumer Finance Institute at the Federal Reserve Bank of Philadelphia, which has expertise in the consumer credit and payments markets. The activities of affiliated centres are usually performed by researchers drawn from across the central bank, but there are also some institutes formed of employees from academia only (the Einaudi Institute for Economics and Finance created by the Bank of Italy) and institutes with a mixture of the two (the Center for Excellence in Finance and Economic Research at the Bank of Lithuania).

3.2 Publication Activities of Central Banks

Central banks publish their research outcomes in various publication series. The most prevalent form of research publication series are working paper series (28 out of 40 central banks in Europe and all 12 Federal Reserve Banks), discussion paper series (eight central banks in Europe) and occasional paper series (five central banks in Europe). In addition, many central banks also use more specific series, such as technical publications (Research Technical Papers – Central Bank of Ireland), policy-related publications (Research and Policy Notes – Czech National Bank) or finance-related publications (Financial Stability Papers – Bank of England; Banking and Financial Studies – Deutsche Bundesbank). An overview of central banks' publication series can be found in Tables A4 and A5 in Appendix A.

The existence of an in-house research publication series is an important determinant of a well-established scientific institution; however, there are also other aspects to be considered. The *Research Publication Score* summarizes information not only on the existence of such a series, but also on open-source research data and the presentation of central banks' publication activity via its own website and via IDEAS/RePEc. A number of central banks publicly share their research data,[14] which then creates a positive externality, as it allows other researchers to replicate the results or to follow up on that research. Nevertheless, these activities are dominated by the US Federal Reserve Banks (11 out of 12), while there are only five central banks in Europe that share their research data publicly.[15] Next, a number of central banks promote successful placement of their papers in

[13] There are six central banks for which we report no research unit, five of them located in the E & SEE, BC region (Bosnia and Herzegovina, Croatia, Republic of Kosovo, Romania and Ukraine) and one, the Central Bank of Iceland, in the W & NWE region (see Tables A1 and A3 for more details).

[14] We consider here only research data that can be shared publicly. Naturally, some data used in central bank publications cannot be publicly shared due to confidentiality reasons.

[15] Denmark, Germany, Lithuania, the Netherlands and the United Kingdom (see Tables A1 and A3 for more details).

peer-reviewed journals on their websites. This tendency, however, is recognized mainly across the US Federal Reserve Banks, while central banks in Europe seem to lag behind.[16]

3.3 Research Popularization in Central Banks

Central banks are dedicating more and more resources to communicating and enhancing the visibility of their research. Popularization is an important part of overall research activities, as it connects the central bank and its researchers to the wider economic community. There are a number of ways of increasing the visibility of research outcomes; we have identified three sets of such activities within central banks: (1) use of social media, (2) a separate website dedicated to research, and (3) additional forms of presentation or communication, such as blogs, newsletters and bulletins.

First, central banks are becoming more active on social media. Almost all central banks in Europe (except for the Central Bank of Montenegro) and all the US Federal Reserve Banks use at least one social media platform as a modern channel of communication. The most frequently used social media among central banks are Twitter and LinkedIn. The majority of these central banks even have their own YouTube channel. Many of these central banks use social media for research popularization. This trend is more common and more frequent among the US Federal Reserve Banks and larger central banks in Europe with a well-established research tradition. Moreover, four US Federal Reserve Banks (New York, Philadelphia, Richmond and Cleveland) and two national central banks in Europe (the Bank of England and the Bank of Finland) have established a separate Twitter account exclusively for posts about research work. Central banks in the E & SEE, BC region lag behind, as only 22% of them use social media for research purposes (see Figure B2 in Appendix B).

Second, central banks are leveraging the potential of their own websites to increase the visibility of their in-house research. The majority of central banks in Europe (80%), all the US Federal Reserve Banks, the ECB and the BIS have a separate website dedicated to research activities.[17] They use this website to highlight research topics prioritized by the central bank (more than 50% of the central banks in our sample),[18] to promote research events such as conferences and workshops (94%), to offer some form of fellowship or traineeship (60%) and to communicate opportunities for external collaboration (64%). Central banks are less active when it comes to the organization of research competitions and awards (20%, mostly from the E & SEE, BC region) and calls for projects (14%). Central banks also promote these activities via social media or conventional media. Another way to increase the visibility of research is via individual researchers' profiles, which provide a more personalized view. Central banks may use this tool to boost the scientific prestige of their research staff. All the US Federal Reserve Banks and the majority of central banks in Western Europe (including the ECB and the BIS) promote their researchers on their websites. However, less than one third of central banks in the E & SEE, BC region follow this practice.

Third, some central banks are exploiting the potential of additional forms of presentation and communication, such as research blogs, bulletins and newsletters. These types of presentation

[16] Even though almost all the central banks in our sample successfully placed at least one research paper in a scientific journal, only 30% of central banks in Europe report that on their websites.

[17] Seven banks in the E & SEE, BC region and one central bank in the EA orig. region have no research website (see Tables A1 and A3 for more details).

[18] More than 67% of central banks in Europe engage in such activity, while only 42% of the US Federal Reserve Banks do so.

rarely offer new information, but they do summarize existing research outcomes and activities in a more "digestible" (i.e. shorter, simpler and non-technical) form. The use of these additional forms of presentation and communication of research outcomes is concentrated in the US and Western Europe. Only about one third of central banks in the E & SEE, BC region use one or more of them. Research newsletters are the most common among these three (employed by 55% of central banks in our sample). However, they take the form usually of a simple e-mail notification about website updates (67%) and less frequently of an original document (23% are e-mail campaigns; 10% are new research publications). Research blogs and research bulletins are less common. Only about one third of central banks in the US and Western Europe use research blogs, and about one quarter of these central banks publish research bulletins.

4. Research in Central Banks: Some Stylized Facts

There is a significant heterogeneity in research publication activity among central banks from different regions. Table 2 presents basic summary statistics for the IDEAS/RePEc Data Set used in the rest of this section (for more details on the data set, see Section 2). The US Federal Reserve Banks, including the FRB, achieve the highest figures in most categories, reflecting the important role of research in the US system. The share of research papers published by the US Federal Reserve Banks and the FRB in scientific journals between 2000 and 2019 is more than 40%. Central banks in the original EA member states and supranational institutions (the BIS and the ECB, including the ESRB) have shares about 10 pp lower. The US Federal Reserve Banks and the FRB also have the highest number of publications per author, reflecting higher productivity and/or an opportunity to devote more time to research. Fairly similar "productivity" can be observed in the BIS and the ECB. The US Federal Reserve Banks and the FRB show a relatively high share of authors with multiple affiliations, which translates to stronger collaboration networks (see Subsection 4.2) with positive synergies for the quantity and quality of research outcomes. However, the male-to-female authors ratio is the second worst among the regions, with 3.4 times more male than female authors (see also Subsection 4.3). Interestingly, central banks from the W & NWE and E & SEE, BC regions show the highest heterogeneity in most categories, as is apparent from high standard deviations.

Table 2: Summary Statistics – IDEAS/RePEc Data Set

	EA orig.	W & NWE	E & SEE, BC	USA	ECB & BIS	Total
No. of CB research papers	6,692	1,880	1,982	8,161	3,193	21,908
No. of journal publications	2,147	520	399	3,252	1,137	7,455
No. of authors	4,741	1,512	1,577	4,069	1,433	13,332
of which:						
Female authors	1,201	316	429	867	307	3,120
Male authors	2,586	936	724	2,653	894	7,793
Registered in IDEAS/RePEc	2,253	799	713	2,206	621	6,592
of which:						
- with multiple affiliations	620	155	184	514	158	1,631
- with affiliation to CB	1,008	471	371	727	276	2,853
- with affiliation to CB and at least one other affiliation	197	76	112	187	34	606
Mean and standard deviation						
Share of CB research papers	32.8	27.4	15	40.4	30.8	27.7
published in journals	(6.5)	(14.3)	(9.2)	(7.5)	(7.1)	(13.4)
Publications per author	1.6	1.4	1.3	2.2	1.9	1.6
	(0.5)	(0.3)	(0.3)	(0.4)	(0.6)	(0.5)
Male-to-female authors ratio	2.5	3.3	2.1	3.4	3.5	2.7
	(0.8)	(1.0)	(2.3)	(0.6)	(1.0)	(1.6)
Share of authors registered	48.5	55.6	37.6	58.4	43.3	51.6
in IDEAS/RePEc	(7.6)	(24.4)	(22.9)	(9.5)	(3.4)	(20.2)
of which:						
- with multiple affiliations	14.3	10	8.9	14.4	11.1	11.9
	(3.9)	(3.4)	(6.3)	(4.6)	(0.2)	(5.5)
- with affiliation to CB	21.5	34.1	23.1	18.2	13.3	26
	(7.5)	(25.8)	(17.2)	(2.6)	(10)	(20.3)
- with affiliation to CB and	4.9	4.1	6.8	5.5	1.8	5.6
at least one other affiliation	(2.7)	(1.5)	(5.5)	(3.4)	(1.2)	(4.2)

Note: The data are subject to completeness and quality of reporting by central banks, journals and authors themselves. They cover the 2000–2019 period. Standard deviations in brackets. CB – central bank, EA orig. – Euro Area original members, W & NWE – Western and Northwestern Europe, E, SEE & BC – Eastern and Southeastern Europe, and Baltic Countries. For more details on the composition of each geographical region, see Table 1; for more details on the data themselves, see Section 2.
Source: IDEAS/RePEc Data Set

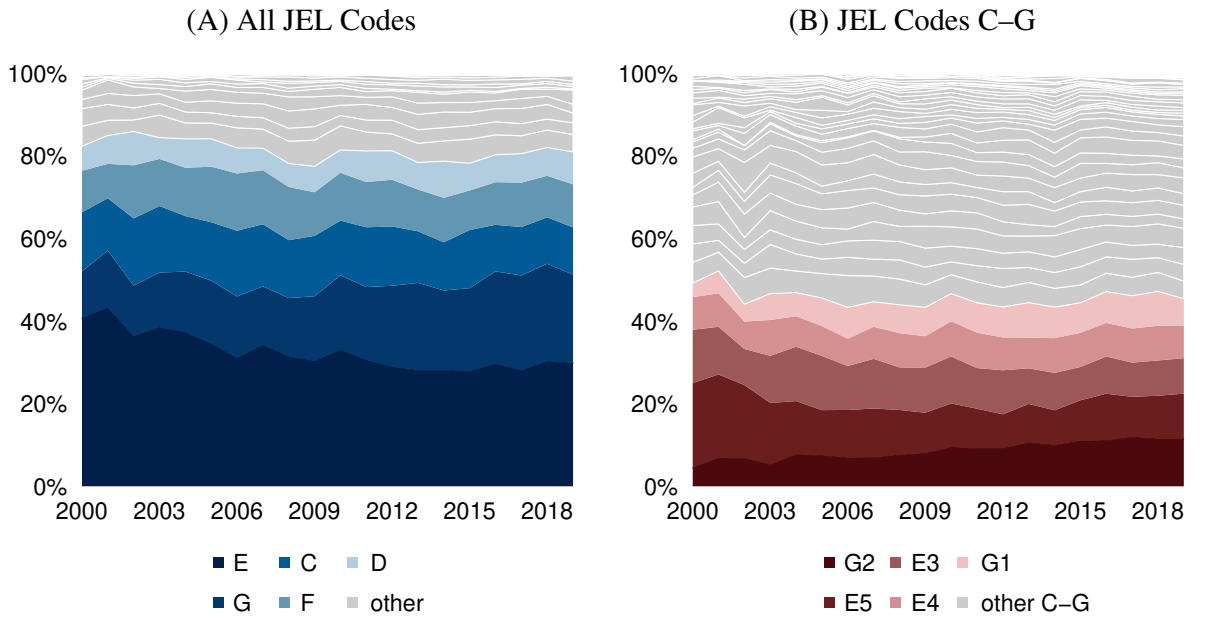
4.1 Topics Researched in Central Banks

In terms of JEL codes, the broad research areas selected by central banks are fairly stable over time, reflecting central banks' core activities. Unsurprisingly, more than half of the research falls into two categories – *E: Macroeconomics and Monetary Economics* and *G: Financial Economics* (see Figure 3, panel A).[19] This reflects the two main objectives – price stability and financial stability – and the two main sets of instruments – monetary policy and prudential policy – usually assigned to central banks. Even though some central banks may not be directly assigned the goal of financial stability, they have to be interested in the pursuit of this goal, because any disruption to financial institutions and financial markets has a direct impact on the monetary policy transmission mechanism (Smets, 2014). The third most common area of research according to JEL codes is *C: Mathematical and Quantitative Methods*. This reflects the strong rigorous basis of the policy decision-making process in central banks, and consequently the need for quantitative research inputs into the policy discussion. A more detailed breakdown of JEL

[19] In contrast, Essers et al. (2020) report that almost half of all the IMF Working Papers published in the period 1990–2017 address research topics connected to *E: Macroeconomics and Monetary Economics* or *F: International Economics*.

categories shows that the main focus of central banks' research is indeed on financial institutions and financial markets, monetary policy, prices and business cycle fluctuations, and money, credit and interest rates (see Figure 3, panel B).

Figure 3: JEL Code Analysis

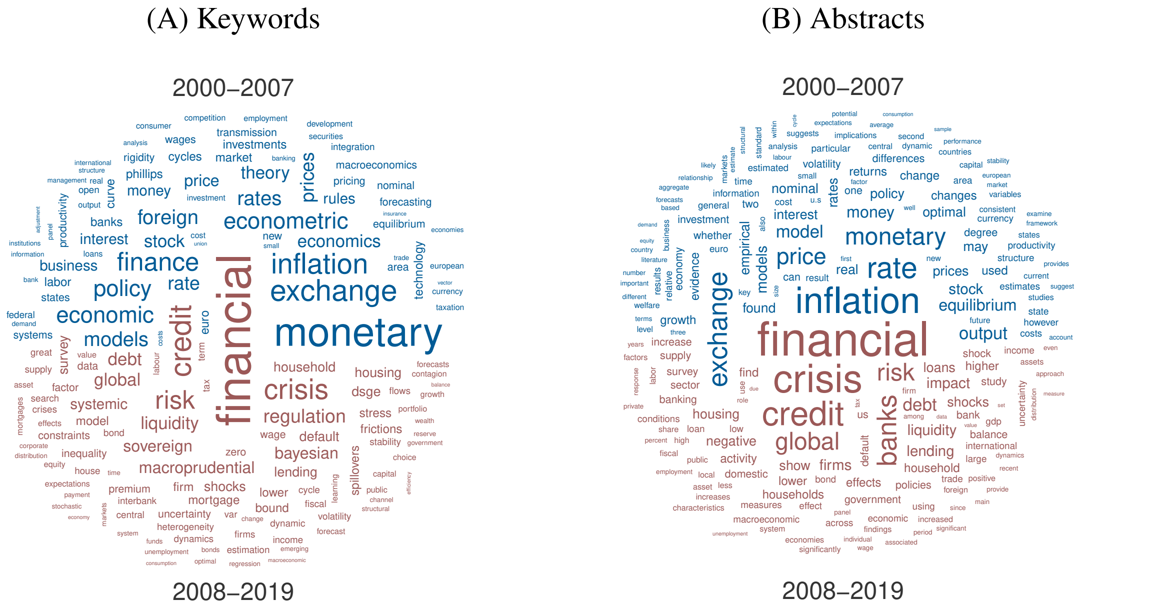


Note: The figure depicts the percentage of publications with a particular JEL code assigned. E: Macroeconomics and Monetary Economics, G: Financial Economics, C: Mathematical and Quantitative Methods, F: International Economics, D: Microeconomics; G2: Financial Institutions and Services, E5: Monetary Policy, Central Banking, and the Supply of Money and Credit, E3: Prices, Business Fluctuations, and Cycles, E4: Money and Interest Rates, G1: General Financial Markets.
Source: IDEAS/RePEc Data Set

Following the GFC, financial stability has emerged as the leading research topic. A simple word cloud of keywords and words in abstracts shows that central banks' research agenda *before* the GFC focused mostly on monetary policy issues and macroeconomic topics in general, such as inflation targeting, exchange rate dynamics, convergence and unemployment (see Figure 4, upper blue part). Following the outbreak of the GFC in 2008, the topics visibly changed in favour of the macro-finance area (see Figure 4, lower red part). The leading research agenda *after* the GFC is related to financial stability policy conduct, with numerous papers analysing the role of credit dynamics and performing financial risk assessments.

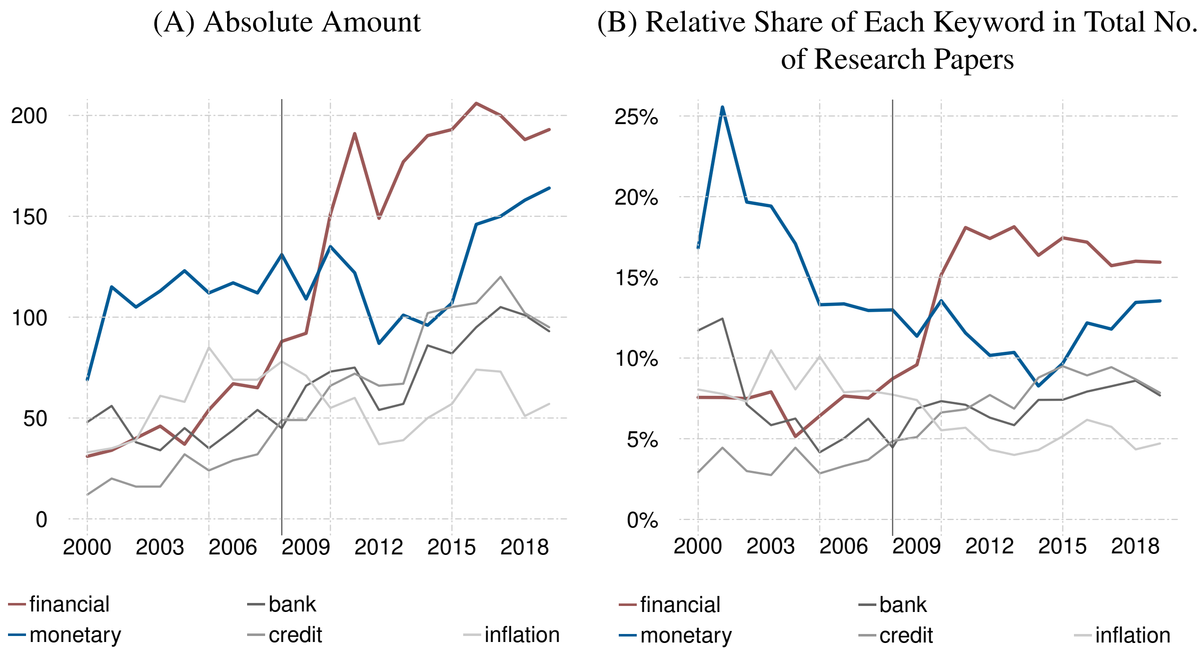
Looking at the dynamics of the five most common keywords, we spot some long-term trends reflecting economic developments and policy challenges (see Figure 5). First, the keywords nicely mirror changes in policy mandates. That is obvious from the increasing dominance of the keywords "financial", "credit" and "bank". These keywords reflect the rising interest of central banks in research topics related to the conduct of financial stability policies. There is an apparent structural break that occurred somewhere around the outbreak of the GFC in 2008. This is when the relative share of *financial* issues overtook that of *monetary* issues. Second, we document a rather stable role of *inflation*-related topics in relative terms. The absolute number of the keyword "inflation" has been gradually rising since 2000, reflecting the fact that the majority of the central banks analysed operate in fully fledged inflation targeting regimes. Cumulatively, the first five words appear in 46% of all central banks' research papers with reported keywords over the period analysed.

Figure 4: Word Cloud Before and After the GFC



Note: Only keywords (the most frequent words in abstracts) with a minimum count of 150 (1,500) are included. The upper (blue) part of the clouds reflects the period 2000–2007, while the lower (red) part refers to the period 2008–2019. We report word clouds based on both keywords and abstracts because about 17% of the publications in our sample do not report keywords, while more than 99% report abstracts.
Source: IDEAS/RePEc Data Set

Figure 5: The Five Most Common Keywords in Central Banks' Research Papers

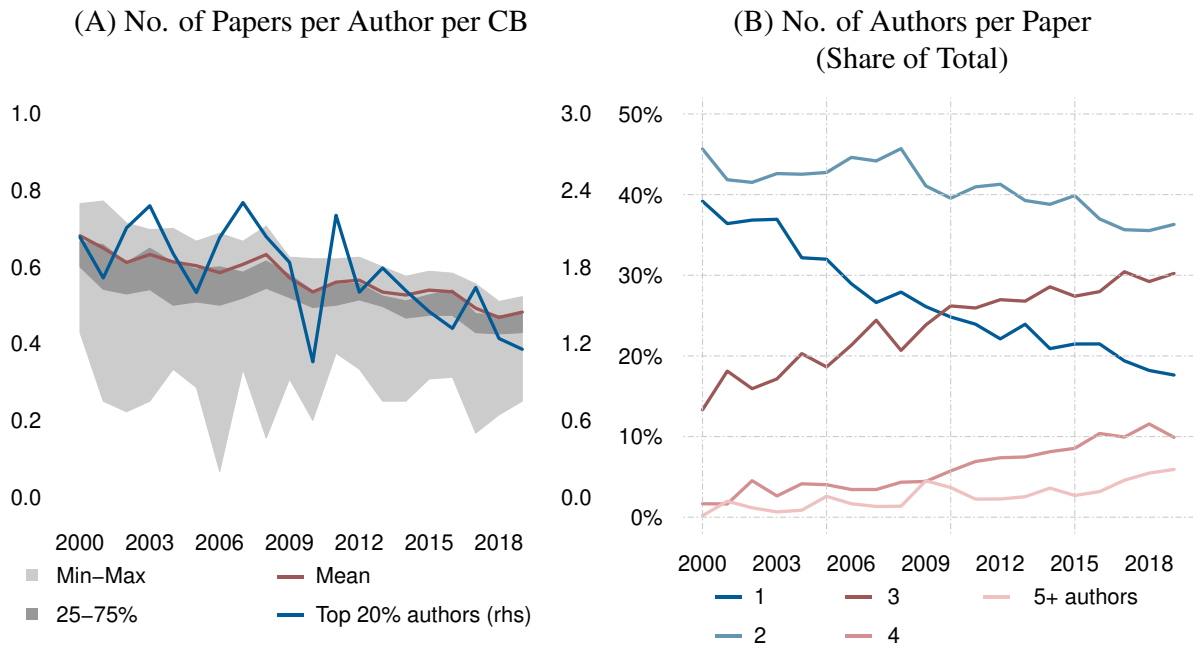


Note: Panel A: Based on 18,256 research papers with keywords published by all European, US and supranational central banks as indicated in Section 2 in the period 2000–2019. Panel B: The relative share is calculated as the ratio of the frequency of each keyword to the total number of research papers with reported keywords in every given year.
Source: IDEAS/RePEc Data Set

4.2 Authorship Networks

Research in central banks is heading towards a more collaborative environment. We follow Adams (2012) and consider authorship as a proxy for research collaboration. While the number of publications per author per central bank is decreasing steadily over time (see Figure 6, panel A), the number of authors per publication is increasing (see Figure 6, panel B). What is most striking is the drop in the share of publications with a single author from 40% in 2000 to less than 20% in 2019. The share of publications with exactly three authors, on the other hand, has more than doubled in the last two decades, reaching 30% in 2019. It is also becoming increasingly common to have publications with four and five or more authors. This is consistent with the general tendency in economic research identified by numerous studies over the last couple of years (see, for example, Card and DellaVigna, 2013; Hamermesh, 2013; Kuld and O'Hagan, 2018; Essers et al., 2020).[20] The rising number of collaborators is generating positive knowledge spillovers not only to the direct collaborative partners (Azoulay et al., 2010; Borjas and Doran, 2015), but also indirectly to other researchers who are connected to them within a complex network (Hsieh et al., 2018). Among other things, there is compelling evidence that teaming up is good for individual productivity (Ductor et al., 2014; Ductor, 2015).

Figure 6: Collaboration Between Researchers



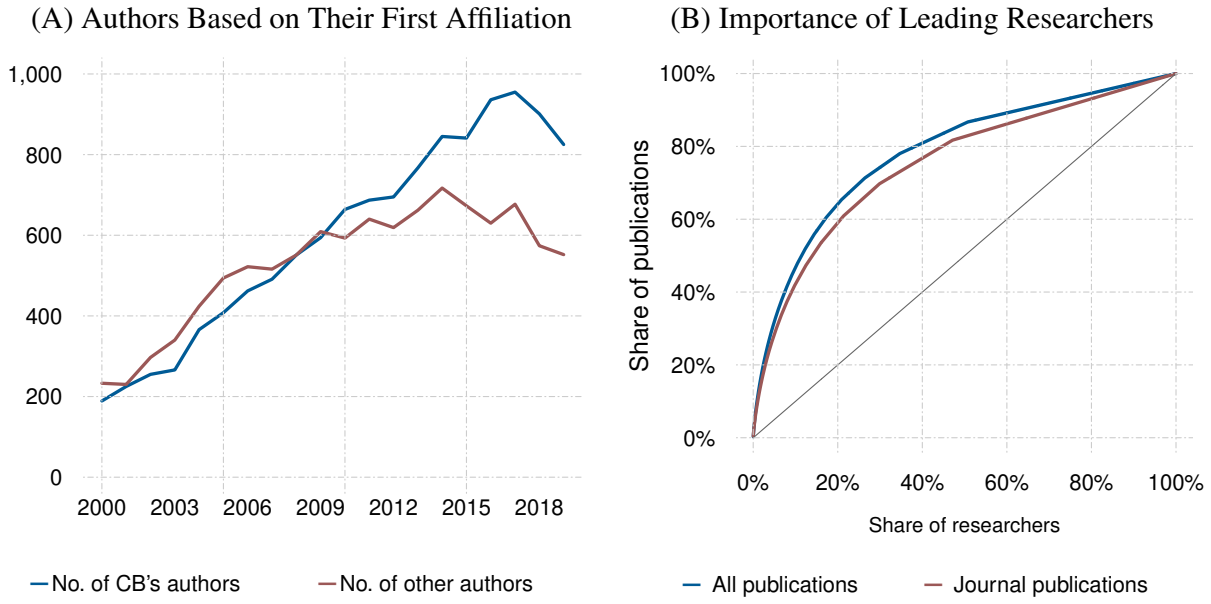
Note: Panel A: Calculated as the number of research publications published by the central bank in the given year divided by the number of authors participating in the research publications in the given year. Panel B: Calculated as the number of publications with the given number of authors in the given year divided by the total number of publications in the given year.
Source: IDEAS/RePEc Data Set

[20] Using article information from the top five and top three economic journals respectively, Card and DellaVigna (2013) and Hamermesh (2013) show that the distribution of the number of authors has shifted steadily rightward. Specifically, Card and DellaVigna (2013) report that the number of authors per paper increased from 1.3 in 1970 to 2.3 in 2012. This is confirmed by Kuld and O'Hagan (2018) on a large sample of the top 255 economic journals. They show that the share of multi-authored papers increased from 50% in 1996 to over 75% in 2014. Similarly, by studying the history of IMF Working Papers, Essers et al. (2020) found that both the number of authors publishing within the IMF and the number of publications issued in the IMF has increased over the last few decades, with the former having the faster pace.

The closer collaboration among researchers reflects more intensive cooperation both inside and outside the network of central banks. The increasing number of authors per central bank publication is due to a larger number of researchers affiliated with a central bank and also to a larger number of those affiliated with an institution other than a central bank (see Figure 7, panel A). The number of researchers in both groups was growing at a similar pace until the GFC; after that, researchers affiliated to the central bank took the lead.[21] This may reflect a combination of factors – for example, greater cooperation between central banks (see below) stemming from a need to share very specific knowledge and data, or more resources devoted to research by individual central banks.

Although the number of authors involved in central bank research is growing steadily, the importance of a relatively small number of top researchers remains high. In other words, a relatively small proportion of authors contribute to a relatively large proportion of central banks' publications (see Figure 7, panel B). Specifically, the top 10% of authors contributed to about 50% of all central banks' research publications in our sample. Quantity, however, does not necessarily reflect quality (see Section 4.4).

Figure 7: Authors' Affiliation and the Role of Leading Researchers



Note: Panel A: The absolute number of authors affiliated either to the central bank or to some other institution (based on the first reported affiliation if there are multiple ones). Panel B: The percentage share of individual authors (researchers) in the total number of authors in our sample in relation to the percentage share of publications authored by these researchers in the total number of publications in our sample.
Source: IDEAS/RePEc Data Set

Central banks form enormous research networks. We study the collaboration networks at the level of individual institutions. We calculate the bilateral connections between central banks and other institutions based on papers using the IDEAS/RePEc Data Set (see Section 2). Each edge in our network represents a collaborative connection between authors based on their reported affiliation and the central bank in which the research paper was published. The former is either the

[21] Note that the authors' affiliation was harvested from the IDEAS/RePEc database (see Section 2). As such, it represents the self-reported affiliation at the time the data were collected and does not represent a record of the author's historical affiliations.

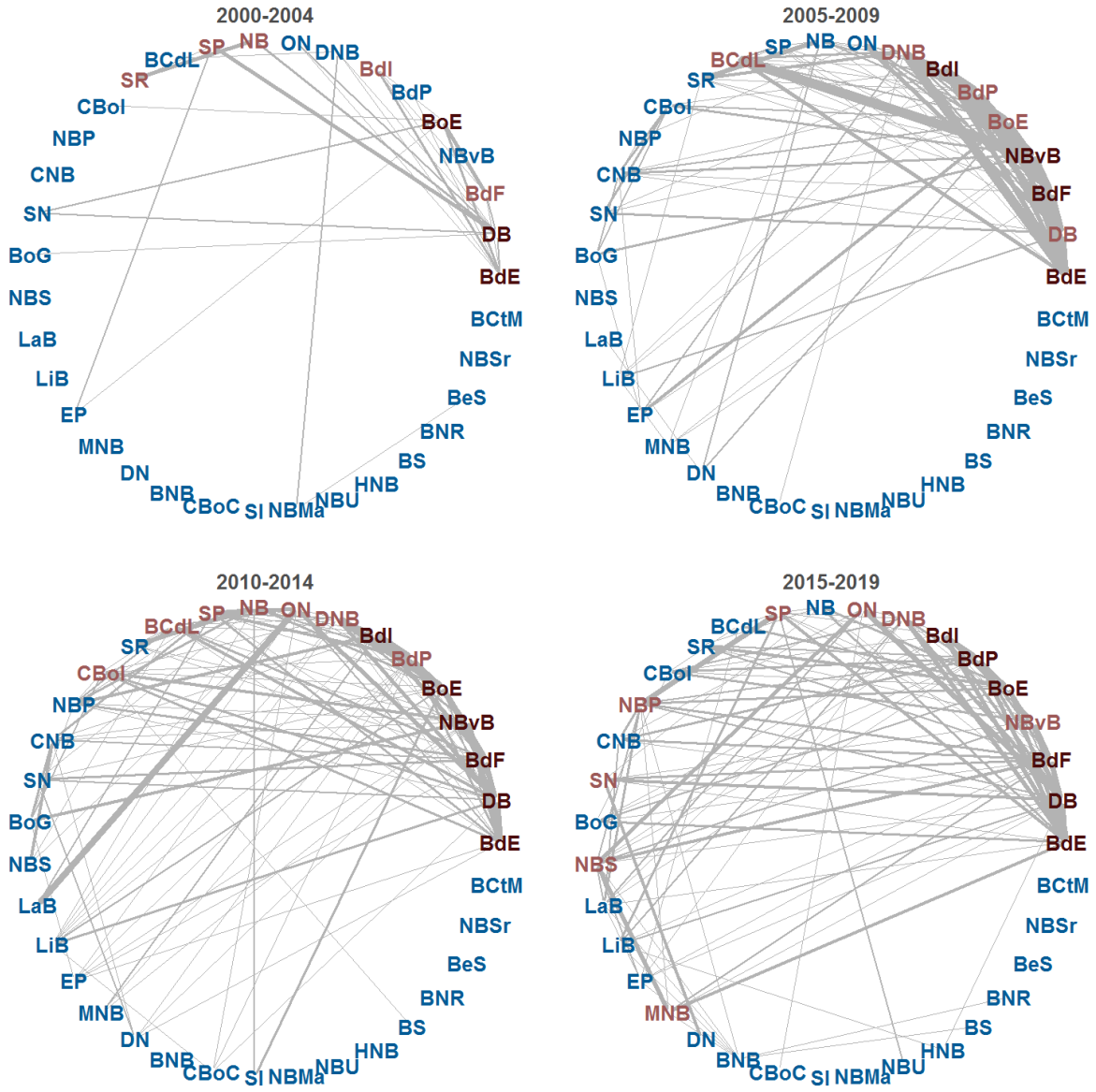
reported affiliation from IDEAS/RePEc (95.8%) or the affiliation extracted manually from the research papers (4.2%; see the column *Data Source* in Table A4). The nodes are individual institutions. The edge width reflects the total number of these collaborative connections in a given period. As such, the width of the edges does not reflect the total number of research papers between the two central banks but rather the total number of collaboration relationships. For the purposes of our analysis, we use a five-year window scheme, which allows us to avoid exceptional cases in the evolution of the network. The evolution of the network is captured by comparing the changes in the network between four non-overlapping periods, 2000–2004, 2005–2009, 2010–2014 and 2015–2019. To make the network more visually tractable, we divide the resulting analysis into three parts. First, we take a closer look at the collaboration networks formed by central banks in the European region. Second, we focus on the Federal Reserve System in the US. Third, we analyse the cooperation networks that are formed by central banks with institutions other than central banks (e.g. universities, research institutes and international organizations).

Research collaboration between national central banks in Europe has grown considerably over time.[22] There is a distinct difference in the density of the collaboration network between the first and the second decade analysed (see Figure 8). Over the first five-year period (2000–2004), just eight central banks accounted for 80% of all publications, of which only three central banks – the Bank of England, Deutsche Bundesbank and Banco de Espana – accounted for 50% of all publications. During the subsequent five-year period (2005–2009), the cooperation between these institutions intensified, while some formerly isolated central banks joined the research network. The central banks that increased their collaboration with the leading research cluster the most were from Central Europe (Poland and the Czech Republic) and the Baltic region (Estonia and Lithuania).

The density of the research collaboration network increased significantly in the years following the GFC (see Figure 8). This may have been due to several factors combined. First, it may have been the outcome of an increase in knowledge integration, especially in the new EU member states that joined the EU in 2004, 2007 and 2013. Second, the European System of Central Banks (ESCB) encompasses many research networks and working groups that are meant to stimulate interaction between researchers and promote information exchange. The ECB is usually the leading and coordinating institution. Past and present examples of such platforms include the Household Finance and Consumption Research Network (HFCN), the Euro Area Business Cycle Network (EABCN), the Wage Dynamics Network (WDN) and the Macroprudential Research Network (MaRs).[23] Third, the GFC, among other things, revealed a dark side of highly connected financial markets (Stiglitz, 2010; Haldane and May, 2011; Acemoglu et al., 2015; Acharya et al., 2017). The fact that dense interconnection serves as a mechanism for the propagation of shocks is now widely acknowledged. As a result, researchers in central banks have begun to form more intense scientific networks, which has led to shared knowledge, data points and even whole databases. This has been reflected in an increased number of publications.

[22] We only consider publications issued by national central banks, not those published by the ECB or the BIS. These two supranational institutions are analysed separately (see Figure B3).
[23] See *Research networks* on the ECB's website.

Figure 8: Collaboration Networks Between Central Banks – Europe



Note: Each edge between two central banks (nodes) represents authors affiliated to one of the two central banks whose paper was published in the other central bank. The width of the edge reflects the total number of such authors. As such, the width of the edges does not reflect the total number of research papers between the two central banks but rather the total number of collaboration relationships. Central banks shown in red account for 80% of publications (dark red for 50% and light red for the additional 30%).
BoE: Bank of England, CNB: Česká Národní Banka, BdI: Banca d'Italia, BdE: Banco de Espana, BdF: Banque de France, SR: Sveriges Riksbank, NB: Norges Bank, SP: Suomen Pankki, BdP: Banco de Portugal, CBoI: Central Bank of Ireland, ON: Oesterreichische Nationalbank, DNB: de Nederlandsche Bank, SN: Schweizerische Nationalbank, DB: Deutsche Bundesbank, LiB: Lietuvos Bankas, LaB: Latvijas Banka, EP: Eesti Pank, NBP: Narodowy Bank Polski, NBS: Národná Banka Slovenska, MNB: Magyar Nemzeti Bank, BoG: Bank of Greece, CBoC: Central Bank of Cyprus, CBCG: Centralna Banka Crne Gore, NBoU: National Bank of Ukraine, NBS: Narodna Banka Srbije, NBnRSM: Narodna Banka na Republika Severna Makedonija, SI: Sedlabanki Íslands
Source: IDEAS/RePEc Data Set

The US Federal Reserve System is a complex collaborative network of individual reserve banks, with a few leading the research activities. The density of the research collaboration network has remained very high throughout the two decades (see Figure 9). There is no significant difference between the first and the second decade like that seen in Europe. The US network is much richer and more evenly distributed than the European network. In the US, we do not identify any "lost sheep", as all of the individual Federal Reserve Banks and the FRB have established strong collaborations with the rest. In terms of the authorship counts, we can identify a cluster of four US central banks that can be (historically) considered the leading ones, accounting jointly for 50% of the total publications. These are the Federal Reserve Bank of San Francisco, the Federal Reserve Bank of Chicago, the Federal Reserve Bank of New York and the Federal Reserve Board.

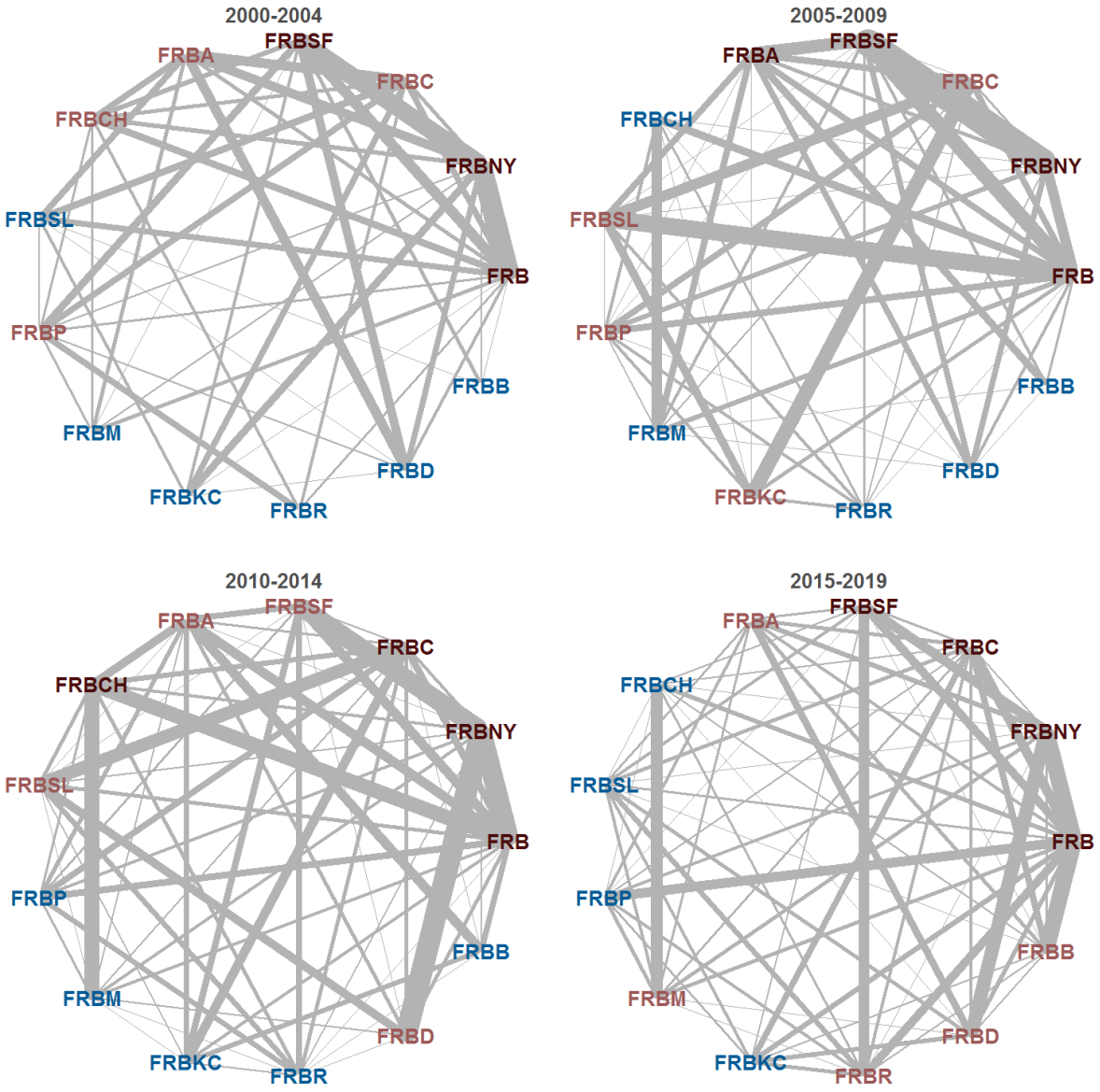
The ECB quickly established itself as a leading research institution in Europe.[24] The FRB, as a leading research institution, served as a model when the DG Research (a separate research unit) was formed in the ECB (Mudge and Vauchez, 2016). Therefore, the ECB quickly established a very strong scholarly profile, in line with its aim to be a research-oriented central bank. The ECB has maintained a fruitful research collaboration with the EA national central banks over the two decades, while its collaboration with central banks outside the EA has intensified only gradually over time (see Figure B3). While at its origin, the ECB primarily recruited its researchers from the US job market, nowadays the team at the DG Research is mainly Europe-centric and researchers are often recruited from the national central banks of the ESCB.

The US Federal Reserve Banks and the central banks in Europe maintain fruitful collaborations with academia and research institutions. The research collaboration between central banks and other institutions (e.g. universities, research institutes and international organizations) has increased over the last two decades (see Figure 10). Most of this research collaboration is region-specific, meaning that central banks usually collaborate with institutions in their own countries or regions (such as national universities). A relatively small set of institutions collaborate with central banks in all four regions (in dark blue) or in three out of the four regions (in light blue). The institutions with the most authored publications with central banks are renowned research institutes and universities (see Figure 11). In the US, these are the National Bureau of Economic Research (NBER), the Institute of Labor Economics (ILE), the Centre for Economic Policy Research (CEPR) and the University of Pennsylvania (Penn). Another of the most active research collaborators with the US Federal Reserve Banks is the International Monetary Fund (IMF). Other academic collaborators hail mostly from US universities. Surprisingly, there are also some important links to universities outside the US, namely the Universita Commerciale Luigi Bocconi and the National University of Singapore. In Europe, most authorship relations are found for the CEPR, while the rest are top-shelf European universities. The CEPR is also the single most important collaborator for all four regions considered.

As pointed out by Claveau and Dion (2018), the relationship between researchers from central banks and those from other research institutions can be considered a two-way stream. On the one hand, central banks actively invite other researchers to collaborate on policy-related topics, which may be pursued either via various visiting research programmes or by direct cooperation with these institutions. On the other hand, researchers in central banks are entitled to spend some time on basic research in addition to applied (policy-oriented) research. This allows them to collaborate on topics which may be of greater interest to academics.

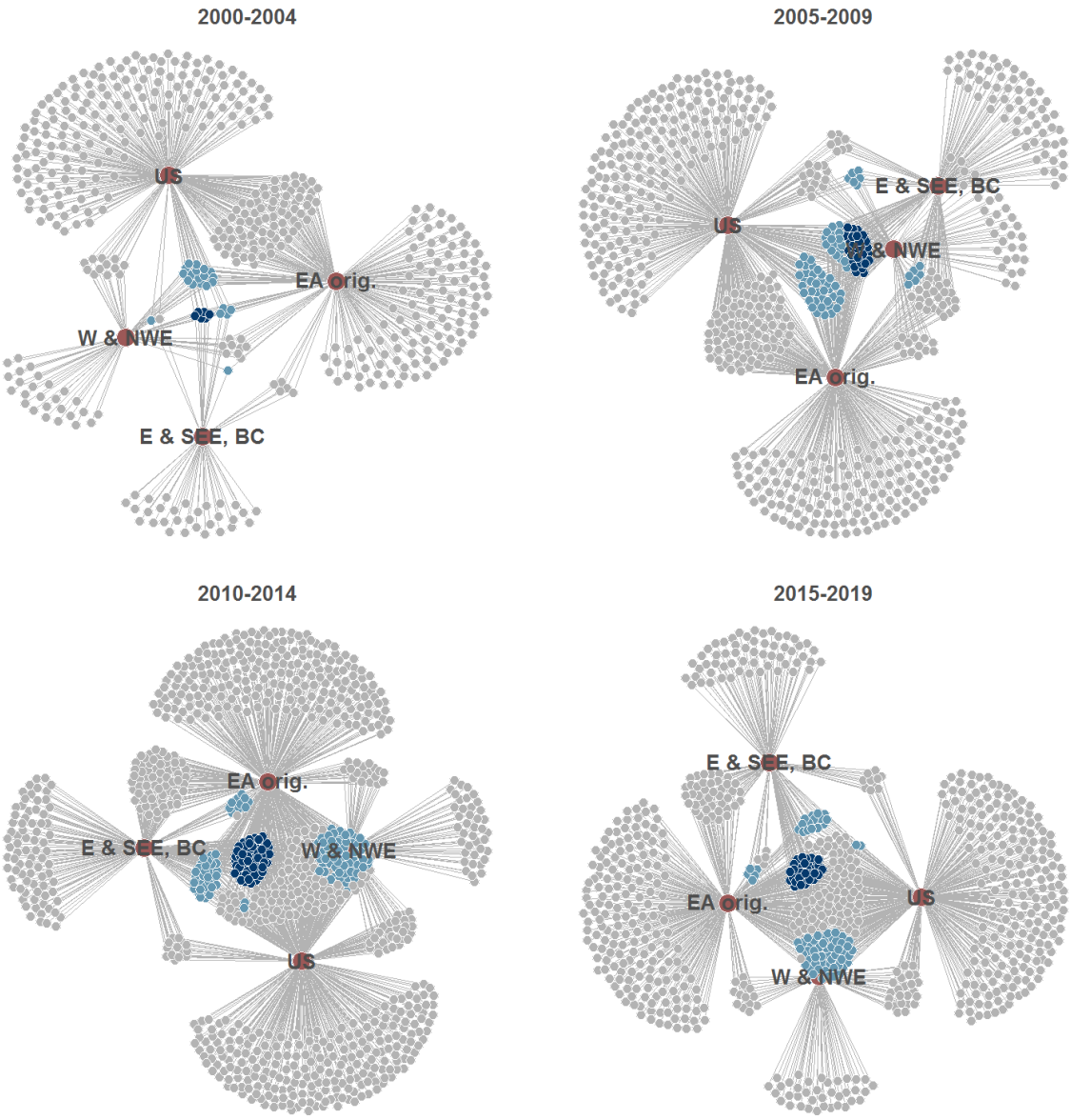
[24] We analyse the ECB separately from the European national central banks due to its supranational character. The ECB is also a relatively young institution, at least when compared to some of its centuries-old national counterparts. The ECB was founded on 1 June 1998 alongside the European System of Central Banks (ESCB).

Figure 9: Collaboration Networks Between Central Banks – United States



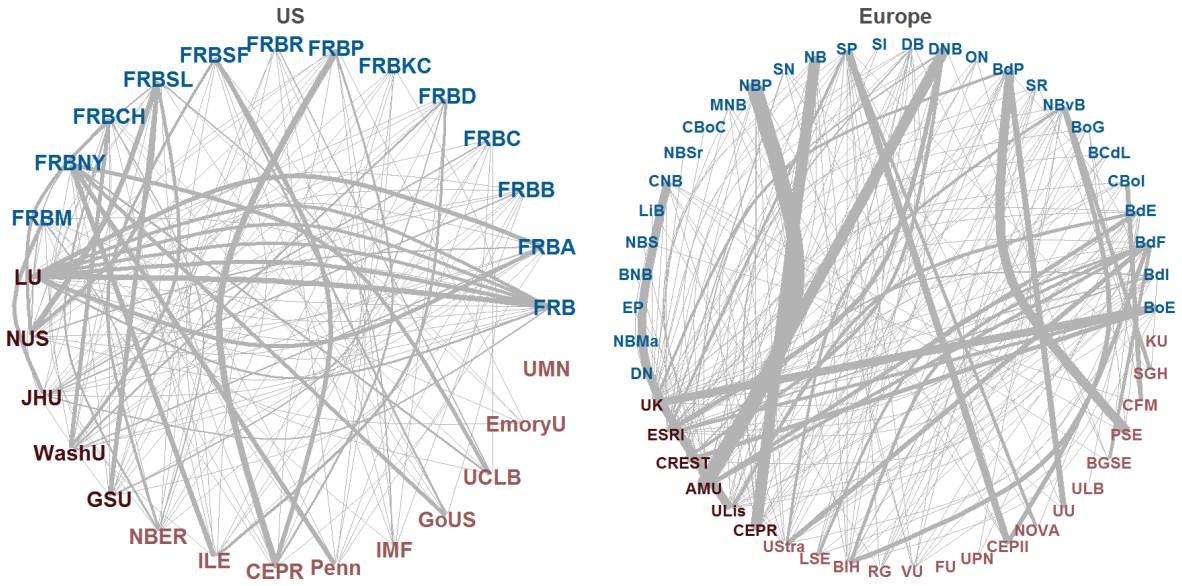
Note: Each edge between two central banks (nodes) represents authors affiliated to one of the two central banks whose paper was published in the other central bank. The width of the edge reflects the total number of such authors. As such, the width of the edges does not reflect the total number of research papers between the two central banks but rather the total number of collaboration relationships. Central banks shown in red account for 80% of publications (dark red for 50% and light red for the additional 30%).
FRB: Federal Reserve Board (Board of Governors of the Federal Reserve System), FRBA: Federal Reserve Bank of Atlanta, FRBB: Federal Reserve Bank of Boston, FRBC: Federal Reserve Bank of Chicago, FRBC: Federal Reserve Bank of Cleveland, FRBD: Federal Reserve Bank of Dallas, FRBKC: Federal Reserve Bank of Kansas City, FRBM: Federal Reserve Bank of Minneapolis, FRBNY: Federal Reserve Bank of New York, FRBP: Federal Reserve Bank of Philadelphia, FRBR: Federal Reserve Bank of Richmond, FRBSF: Federal Reserve Bank of San Francisco, FRBSL: Federal Reserve Bank of St Louis.
Source: IDEAS/RePEc Data Set

Figure 10: Collaboration Networks Between Central Banks and Other Institutions



Note: Each grey node represents one institution other than the central bank to which the authors in our sample are affiliated. Central banks are divided into four regions and represented by dark red nodes. Each edge represents authors affiliated to an institution other than the central bank whose paper was published in the central bank in the given region. The width of the edges does not give any information in this case. Central banks shown in red account for 80% of publications (dark red for 50% and light red for the additional 30%).
Institutions with authored publications with central banks in all four regions are shown in dark blue; institutions with authored publications with central banks in three out of the four regions are shown in light blue.
Source: IDEAS/RePEc Data Set

Figure 11: Institutions with Most Authorships with Central Banks (Top 1%)



Note: The top 1% of institutions based on the number of collaborations with central banks between 2000 and 2019. Each edge represents authors affiliated to an institution other than the central bank whose paper was published in the central bank. The width of the edge reflects the total number of such authors. As such, the width of the edges does not reflect the total number of research papers between the two but rather the total number of collaboration relationships. Central banks are shown in blue. Institutions with more than 150 collaborations with central banks over the period 2000–2019 are shown in dark red.
LU: Lindenwood University, NUS: National University of Singapore, JHU: Johns Hopkins University, WashU: Washington University in St. Louis, GSU: Georgia State University, NBER: National Bureau of Economic Research, ILE: Institute of Labor Economics, CEPR: Centre for Economic Policy Research, Penn: University of Pennsylvania, IMF: International Monetary Fund, GoUS: Government of the United States, UCLB: Universita Commerciale Luigi Bocconi, EmoryU: Emory University, UMN: University of Minnesota.
UK: Univerzita Karlova v Praze, ESRI: Economic and Social Research Institute, CREST: Centre de Recherche en Économie et Statistique, AMU: Aix-Marseille Université, ULis: Universidade de Lisboa, CEPR: Centre for Economic Policy Research, UStra: Université de Strasbourg, LSE: London School of Economics, BIH: BI Handelshoyskolen, RG: Rijksuniversiteit Groningen, VU: Vrije Universiteit Amsterdam, FU: Fordham University, UPN: Université Paris-Nanterre, CEPII: Centre d'études prospectives et d'informations internationales, NOVA: Universidade Nova de Lisboa, UU: Universiteit Utrecht, ULB: Université Libre de Bruxelles, BGSE: Barcelona Graduate School of Economics, PSE: Paris School of Economics, CFM: Centre for Macroeconomics, SGH: Szkoła Główna Handlowa w Warszawie, KU: KU Leuven.
Source: IDEAS/RePEc Data Set

Looking at the authorship network connections from a different angle may give us an estimate of researchers' mobility. As mentioned above, the networks presented are formed of collaborative connections between authors based on their affiliation and the central bank in which the research paper was published. Panel A in Table 3 provides a numerical representation of these network graphs. In particular, it reports the count of relationship pairs between authors based on their reported affiliations and the publishing central bank. If the author reports affiliations to multiple institutions, a relationship pair is created for each institution–central bank pair. In contrast, panel B in Table 3 employs an approach which disregards the information about the publishing central bank and, as such, takes into account information about authors' reported affiliations only. Under this approach, therefore, each relationship pair represents an institutional connection between individual authors.[25]

The affiliations reported in the IDEAS/RePEc Data Set usually reflect the *current* institutional assignment of the authors, as they are directly from the authors' profiles on the IDEAS/RePEc website. However, the publication itself is historically linked to a given central bank. As such, the affiliations recorded in this publication are fixed, regardless of the authors' mobility across institutions. For most research papers, it can be expected that at least one of the authors was affiliated with the given central bank at the time of publication. Therefore, if the reported affiliations of all the authors differ from the publishing central bank, it is very likely that at least one author has changed her affiliation since then. For this reason, comparing panel A and panel B gives a rough estimate of researchers' mobility between central banks and from central banks to other research institutions. Even though it is not possible to track each individual movement of researchers between central banks and to other research institutions, this comparison provides at least a simplified view of this trend.

The distribution of collaborative connections calculated based on the two approaches differs between regions, indicating researchers' mobility to the ECB, the BIS and academia. Taking into account the publishing central bank (the first approach), the most network connections exist between authors from the group of original Euro Area member states, followed by the ECB & BIS and connections to other research institutions (see Table 3, panel A). These make up about 70% of all network connections.[26] By the nature of the calculation, the second approach yields fewer network connections on aggregate than the first one (see the examples in footnote 25). However, we can see that the absolute number of connections has increased significantly for the ECB & BIS–ECB & BIS bucket, and also for some collaboration pairs with other research institutions (see Table 3, panel B). This most likely reflects higher mobility to these institutions. In particular, the result suggests that researchers tend to leave national central banks for supranational institutions and

[25] To better understand the difference between the two representations of our authorship network, let's assume three basic examples. First, let's assume that central bank *X* published a research paper authored by two researchers who are both affiliated with the same central bank *Y*. In this case, panel A would show two network connections between *X* (the publishing central bank) and *Y* (the authors' affiliation), while panel B would report only one network connection between *Y* and *Y*, as both authors are affiliated with the same institution. Second, let's assume that central bank *X* published a research paper written by a single author with a reported affiliation to central bank *Y* and another research institution *Z*. Panel A would report two network relationships – one between *X* and *Y* and the other between *X* and *Z*. However, panel B would show only one relationship, between *Y* and *Z*. Third, let's assume that central bank *X* published a research paper written by a single author with only one affiliation to the same central bank, i.e. to *X*. Panel A would show one network connection, between *X* and *X*, while panel B would not report any connection.

[26] 27% for the EA orig.–EA orig. bucket, 12.1% for the ECB & BIS–ECB & BIS bucket, and 29.8% for all connections with other research institutions.

for research institutions other than central banks.[27] Besides researchers' mobility, the difference between the two approaches may also reflect researchers affiliated with the ECB & BIS or other research institutions publishing their papers in national central banks without the collaboration of researchers from national central banks. However, we consider this highly unlikely or limited in scope.

Table 3: Number of Collaborations Among Central Banks and Between Central Banks and Other Research Institutions

(A) Based on Author's Self-Reported Affiliation and Publishing Central Bank

	EA orig.	E & SEE, BC	W & NWE	ECB & BIS	US	Other institutions
EA orig.	22,133	1,819	956	5,555	3,813	7,175
	(27.0%)	(2.3%)	(1.2%)	(6.8%)	(4.7%)	(8.8%)
E & SEE, BC		2,499	42	1,522	279	1,821
		(3.1%)	(0.1%)	(1.9%)	(0.4%)	(2.3%)
W & NWE			3,268	559	294	1957
				(0.7%)	(0.4%)	(2.4%)
ECB & BIS			(4.0%)	9,869	595	3,728
				(12.1%)	(0.8%)	(4.6%)
US					4,537	9,576
					(5.6%)	(11.7%)

(B) Based Purely on Author's Self-Reported Affiliation

	EA orig.	E & SEE, BC	W & NWE	ECB & BIS	US	Other institutions
EA orig.	3,099	240	108	3,317	333	7,352
	(6.2%)	(0.5%)	(0.2%)	(6.6%)	(0.7%)	(14.7%)
E & SEE, BC		762	22	483	26	1,899
		(1.5%)	(0.0%)	(1.0%)	(0.1%)	(3.8%)
W & NWE			533	339	140	1,807
			(1.1%)	(0.7%)	(0.3%)	(3.6%)
ECB & BIS				12,806	531	5,123
				(25.5%)	(1.1%)	(10.2%)
US					2,916	8,307
					(5.8%)	(16.6%)

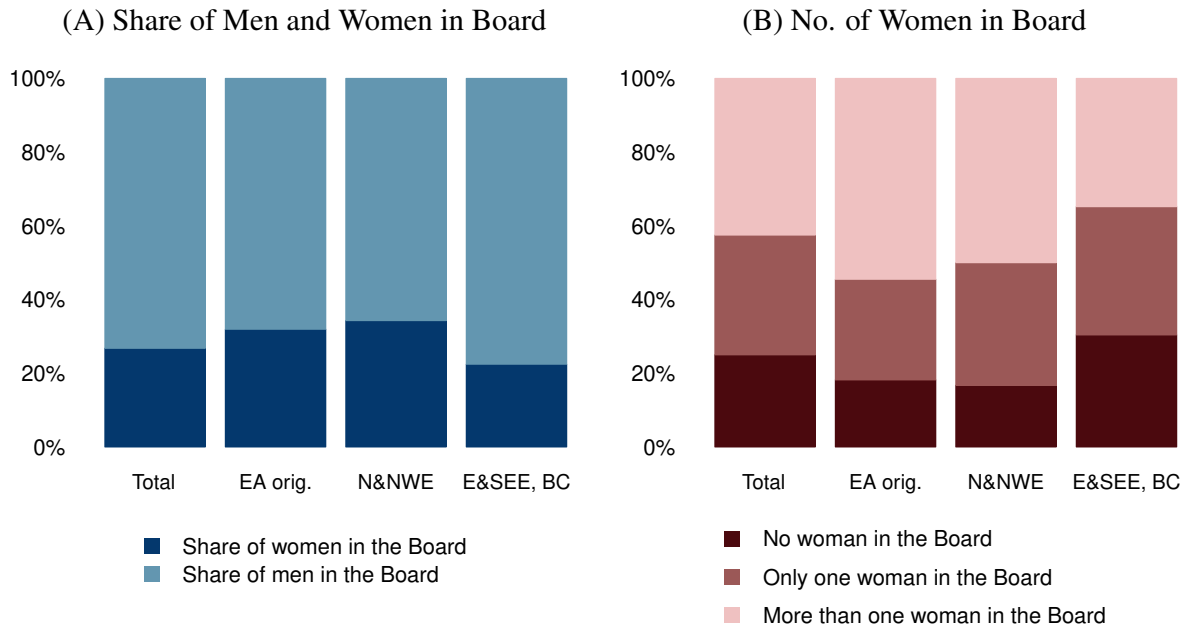
Note: The percentage share in parentheses is calculated as the individual counts divided by the total number of network connections. Panel A: The counts represent network connections between the publishing central bank and the authors' affiliations. Panel B: The counts represent network connections between the authors' affiliations regardless of the publishing central bank.

[27] The mobility towards these institutions is also apparent from higher relative shares of network connections (the number in parentheses in Table 3). The relative share is significantly higher in panel B than in panel A in the ECB & BIS–ECB & BIS bucket and the ECB & BIS–EA orig. bucket, and for most connections with other research institutions.

4.3 Gender Structure of Authorship Teams

Women are still significantly under-represented in central banks. Even though there have been a few visible examples of appointments to high-ranking positions in recent years (such as the appointments of Janet Yellen as the Chair of the Federal Reserve from 2014 to 2018 and Christine Lagarde as the President of the ECB as of November 2019), the share of women in central banks' boards remains low across Europe. Women make up less than 30% of boards, the share being lower in the E & SEE region and higher in the W & NWE region (see Figure 12, panel A). In addition, about one third of central banks in Europe have only one women on the board (see Figure 12, panel B). The literature offers various explanations for this tendency. Hospido et al. (2019) suggest that besides the two usual channels – male dominance in the field of economics and macroeconomics, and the parenthood motive – there is also a "gender applications gap", which refers to the reluctance of women to apply for promotion in the first place. According to the authors, women are less likely to apply for promotions because of the fear of competition, but once they do apply they are more likely than men to succeed in the process. Another explanation is proposed in Charléty et al. (2017), who find some sort of a succession rule to be in place. By analysing appointments to 26 OECD central bank boards, they find that female appointment is four times more likely when the departing member is female rather than male.

Figure 12: Composition of Central Banks' Boards by Gender – Europe

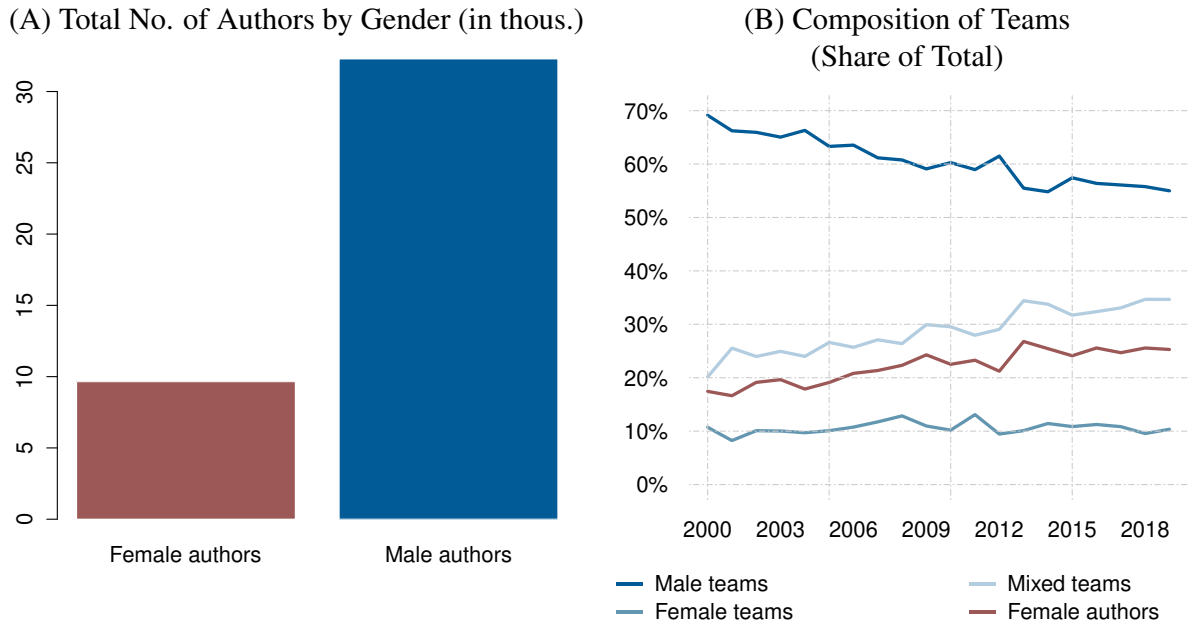


Note: Composition as of July 2020. For data on individual central banks, see Table A6 in Appendix A.
Source: IDEAS/RePEc Data Set

Research also continues to be male-dominated, but the trend is changing. In absolute terms, men make up about two thirds of all the authors of the central bank research papers under study (see Figure 13, panel A). However, the share of female authors has risen significantly over time, reaching 25% at the end of 2019 (see Figure 13, panel B). This trend is driven by an increasing share of mixed teams (involving both women and men), reflecting greater collaboration among researchers and larger teams (see Section 4.2). The share of female researchers is also growing in other research & development (R&D) sectors (see Table 4). A similar trend can be observed among doctoral graduates, as the average annual growth rate of female doctoral graduates in the EU

was 2.4% between 2007 and 2016, while that of male doctoral graduates was only 1.4% (European Commission, 2019). While Boschini and Sjögren (2007) find women are less likely to coauthor than men, we are witnessing that the trend is changing (albeit at a slow pace), at least in central banks' research. Still, all-male research teams continue to dominate, with a more than 50% share of all teams in 2019. Auriol et al. (2020) argues that it is important to monitor the gender gap in research, because the topics favoured by female economists might deviate from those favoured by men. If women are less represented in research teams, then these topics might become systematically under-invested and, as a result, their policy impact might be lost in the economy.

Figure 13: Distribution of Authors by Gender



Note: Gender of authors identified based on their first name using the R package *gender* and the related database; see Section 2.
Source: IDEAS/RePEc Data Set

Small central banks engage more female researchers. The relationship between the share of female authors and the total number of authors per central bank per year seems to follow a downward-sloping convex curve. This means that with an increasing total number of authors, the share of female authors decreases faster. However, this relationship differs between regions (see Figure 14). Smaller central banks in Europe (in terms of total number of authors) engage more female researchers. On the other hand, central banks in the US and in the EA original member states employ a lower share of female researchers. A similar pattern was observed by Auriol et al. (2020), who showed that the more prestigious the research institution is, the fewer female economists are present. The authors also found that this systematic under-representation is present already at entry level and that the ranking of the institution causes the gap to be even wider. Regarding the gender structure of authors, the situation seems to be the least balanced in the ECB and the BIS. In these institutions, the share of female authors is the lowest, while the total number of authors is among the highest. The reasons may be (at least) twofold. There may be significantly fewer female researchers publishing, and therefore, with a higher total number of authors, the share of female authors decreases, or male researchers may be preferred in various ways (for example, in recruitment, in the formation of teams or in the publication process).

Table 4: Share of Female Researchers in Different Sectors (%)

	Central Banks	Business Enterprise Sector	Government Sector	Higher Education Sector	Private Non-profit Sector
Europe Total	27.0	19.9	40.1	39.6	44.2
EA Original Members	26.7	19.1	38.9	37.6	45.0
W and NW Europe	26.2	20.5	38.4	43.3	42.0
E and SE Europe, and BC	31.7	23.8	43.8	40.5	41.1
2000–2004	21.5	18.2	35.5	32.8	40.1
2005–2009	25.9	19.2	39.3	38.4	43.5
2010–2014	28.2	20.3	41.4	41.2	44.7
2015–2017	29.5	21.0	43.8	43.1	49.1

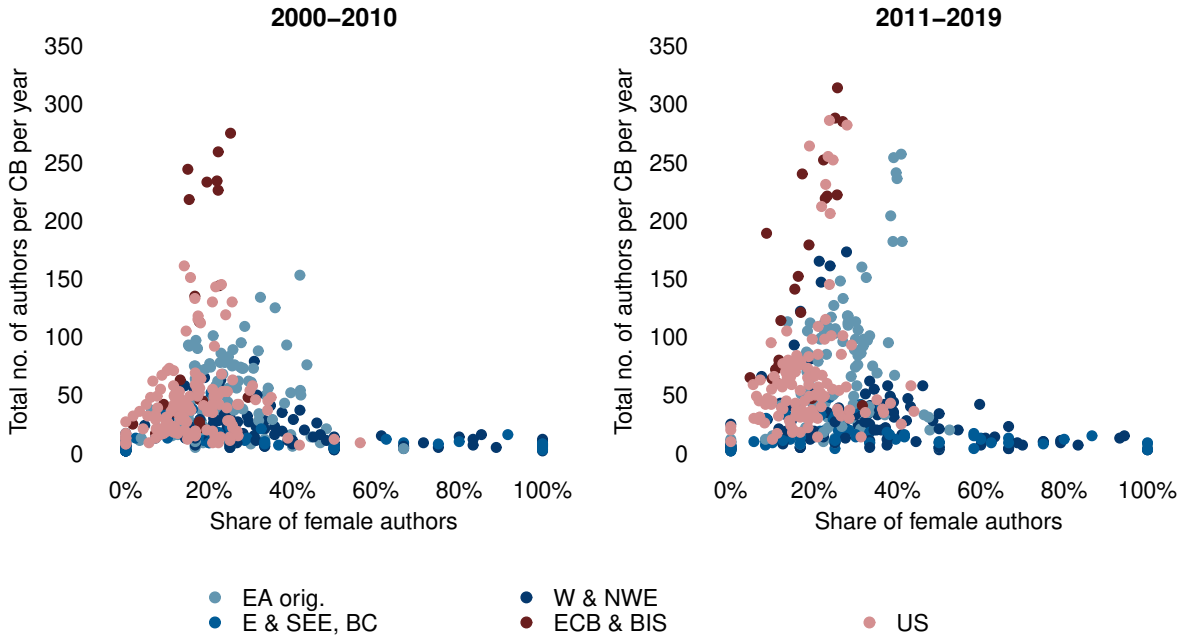
Note: The data cover the period of 2000–2017. Unlike the RePEc/IDEAS Data Set, the Eurostat database contains data on only 15 E & SEE, BC countries: RO, MT, GR, AL, SL, BG, CY, CZ, EE, HR, LV, LT, HU, MK, SK, RS, PL, UA. Figure 13 refers to data on the whole sample (including the US, the ECB and the BIS); therefore, it may differ slightly from the numbers in this table.
Source: RePEc/IDEAS Data Set (central banks), Eurostat (other sectors)

Central banks rank in the lower half of R&D institutional sectors in terms of the proportion of women in research. Table 4 shows that the private non-profit, government and higher-education sectors exhibit higher shares of female researchers than central banks, while the lowest percentage is recorded by the business enterprise (BE) sector. This comparison should be taken with caution, because the figures for central banks refer to authors of research papers while those for other sectors represent the headcount of R&D personnel as reported in the enterprise survey.[28] Nevertheless, by assuming that researchers usually present their results in the form of a research paper, this can be considered a reasonable approximation.

In 2015–2017, women made up more than 40% of the research population in the private non-profit, government and higher-education sectors. These three sectors together employed more than 99% of all researchers in the EU as of 2018 (European Commission, 2019), which suggests a gradually closing gap. Nevertheless, women are still vastly under-represented in business enterprise research.[29] That central banks lie somewhere between the shares for business enterprises and higher education is not surprising. Based on OECD (2015, p. 90), the R&D activities of corporations from the financial sector and its sub-sectors, and hence also central banks' R&D activities, fall under either of the two R&D categories.

[28] The data are gathered via national questionnaires in paper and/or electronic format, and the statistical unit used is enterprise. R&D personnel include all those engaged directly in the R&D activities of the given enterprise (https://ec.europa.eu/).
[29] One of the possible drivers of this result is the constant shortage of female graduates (and also doctoral graduates) in the several narrow fields of science, technology, engineering and mathematics (STEM) (Huyer, 2015; European Commission, 2019). Research in these fields covers a significant portion of business enterprise research, so it is reasonable to assume that this broadly discussed issue also affects the gender disparity in science.

Figure 14: Relationship Between the Share of Female Authors and the Total Number of Authors



Note: Gender of authors identified based on their first name using the R package *gender* and the related database; see Section 2.
Source: IDEAS/RePEc Data Set

4.4 Impact Factor

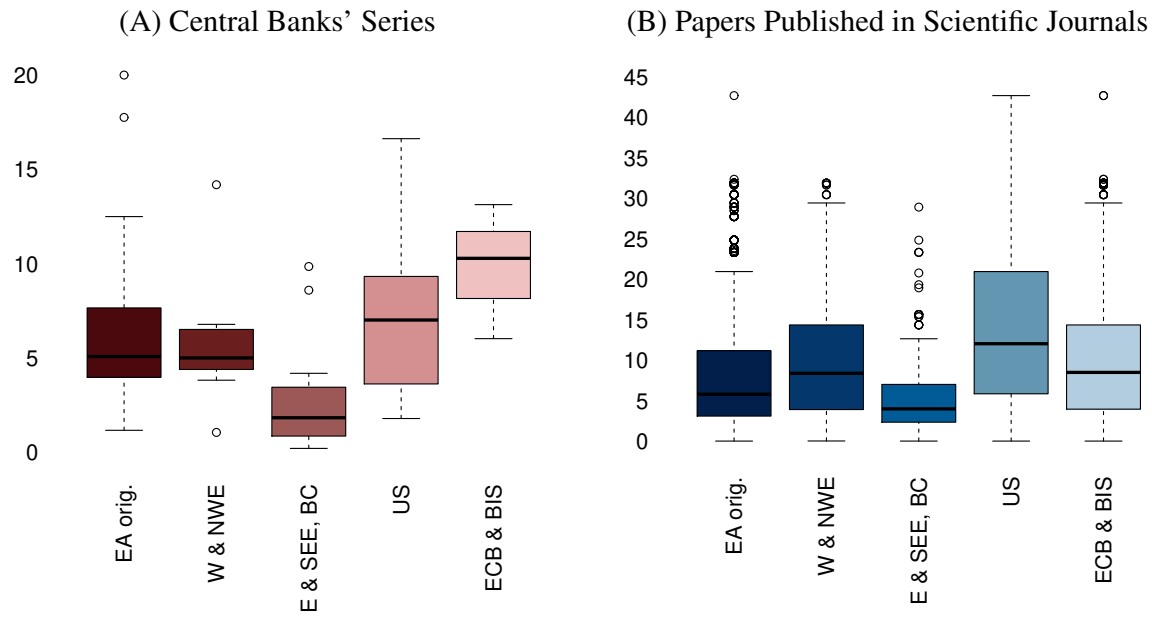
The impact factor is a standard measure for assessing the academic quality of a scientific publication. We present a few comparative figures for the simple impact factor[30] for central banks' publication series and for scientific journals in which the central banks' research papers were published (for more details on data, see Section 2). It is important to consider both central banks' research papers and subsequent journal publications, since even an article not meant for publication in a scientific journal may have a large impact. In fact, this is much more common for central banks' publication series than for academic publication series. In central banks, many researchers without an academic career path are top-field professionals whose work, even if published "only" as a working paper or a staff note, may have high value added and greater applicability in the decision-making process.

The impact factor of central banks' research publications varies substantially both between and within the regions. Not surprisingly, the ECB, the BIS and the US Federal Reserve banks, including the FRB, receive the highest impact factors for their in-house research publication series (see Figure 15, panel A). The recorded dispersion is relatively large in the case of the US Federal Reserve Banks and the FRB, ranging from as little as 2 to 16; the Federal Reserve Bank of San Francisco and the Federal Reserve Bank of New York rank the highest, while the Federal Reserve

[30] There are different types of impact factors. RePEc/IDEAS reports, among others, a simple impact factor, a recursive impact factor and a discounted impact factor. The simple impact factor is calculated as the number of all citations of papers in a particular series or journal divided by the number of papers in the series or journal (self-citations are not considered). The recursive impact factor is calculated in the same way, except that each citation carries some weight. The discounted impact factor gives more weight to what is cited now. For more details, see Zimmermann (2012).

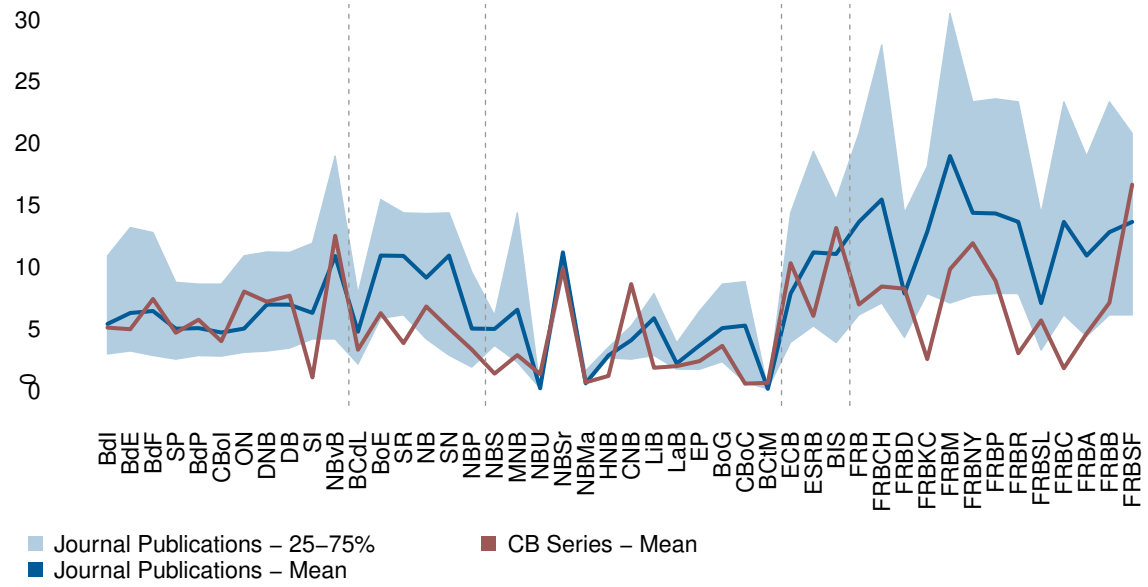
Bank of Cleveland and the Federal Reserve Bank of Kansas City rank the lowest. When considering only those papers which have been published in scientific journals, we find the US region on top, followed by the two supranational institutions and the W & NWE region (see Figure 15, panel B). Interestingly, there is a high correlation between the impact factor assigned to the central banks' research publication series and the average impact factor of the papers published in scientific journals (see Figure 16). The impact factors of the US Federal Reserve Banks and the FRB and the ECB and the BIS reflect the high emphasis placed on research in these institutions, the high share of researchers from academia involved in the research, and the related high importance given to publishing in high-impact journals. Another significant factor contributing to the relatively high average impact factor is the fact that research papers on the US economy (and other large economies or international samples) generally have a higher probability of publication in a high-impact scientific journal. It is usually harder to publish small country-specific research or applied research which is of interest to a particular central bank but of little interest to an international scientific journal.

Figure 15: Simple Impact Factor – Regional Distribution



Note: Panel A: The simple impact factor assigned to central banks' publication series (working paper series, discussion series, occasional papers, etc.). Panel B: The distribution of the non-zero simple impact factor assigned to the scientific journals in which the central banks' research papers were published. It accounts for 7,411 papers between 2000 and 2019 in total (data as of March 2020). Recursive and discounted impact factors are reported in Appendix B.
Source: IDEAS/RePEc Data Set

Figure 16: Simple Impact Factor – Individual Central Banks



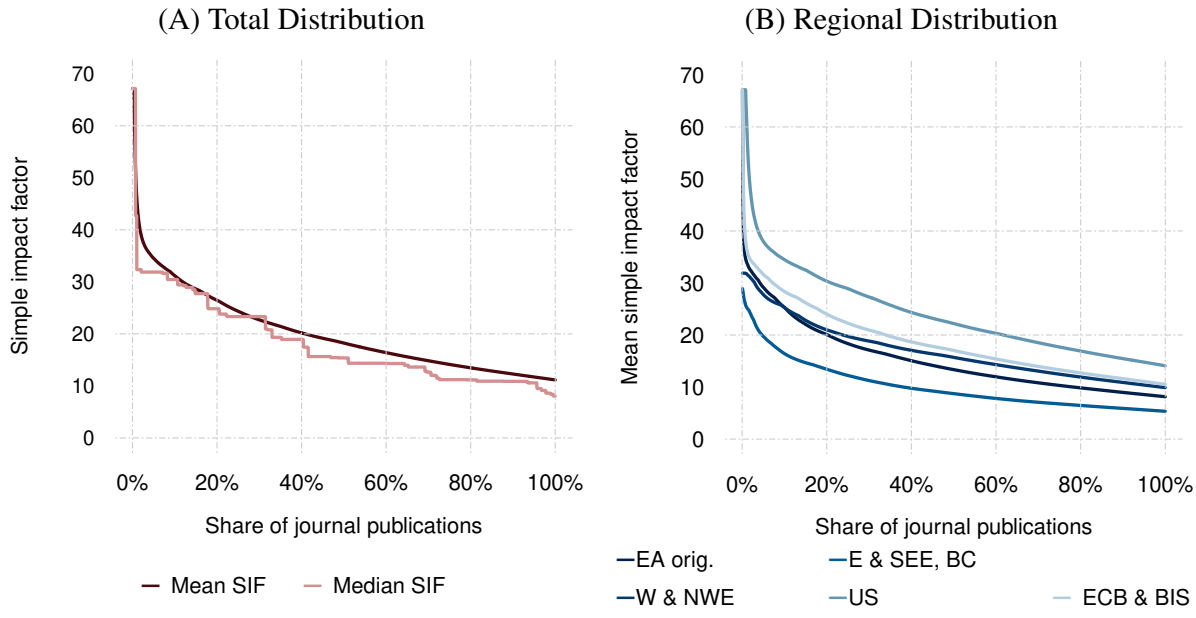
Note: The interquantile range and mean in blue refer to the non-zero simple impact factor assigned to the scientific journals in which the central banks' research papers were published. The dark red line refers to the simple impact factor assigned to the central banks' publication series. Horizontal lines separate individual regions as follows: EA orig., W & NWE, E & SEE, BC, ECB & BIS and US. Only central banks with publication series with an impact factor assigned in the IDEAS/RePEc database are reported. Recursive and discounted impact factors are reported in Appendix B.
Source: IDEAS/RePEc Data Set

Even though numerous studies have addressed the problematic nature and the misuse of journal impact factors for judging the value of scientific research (Seglen, 1997; Simons, 2008; Vanclay, 2012), this practice continues. The impact factor is derived from the number of citations received by the papers in a particular series or journal. As such, it may help researchers and others in searching for bibliographic references to a particular paper and enabling mutual communication. However, it does not say much about the actual impact of that particular paper for that particular field. The informative value of the impact factor may be limited due to the fact that a small number of papers published in a series or journal may have received a large proportion of the citations. The overall impact factor is then boosted by this small share of papers and says nothing about the quality of the other papers published in that series or journal. This pattern is also visible in our data, which show that a very small proportion of central banks' research papers published in scientific journals contribute the most to the average and median impact factor (see Figure 17, panel A). The same pattern persists if we divide the sample into individual regions, with a heightened effect in the US, the ECB and the BIS (panel B). These central banks are the ones with the highest average impact factors. This means that the quality of the research in central banks should not be evaluated based on the average impact factor, as this can be skewed by a few journal publications.

Nevertheless, the impact factor has become the one of the most important, if not the only, measure of the scientific performance of researchers and the quality of their published work. In the competition for faculty appointments and research funding, an increasing emphasis is being placed in academia on publishing in scientific journals with a high impact factor. We presume that this trend is less common among researchers in central banks, as they are not usually financially

rewarded based on their publications in scientific journals and are not dependent on external research funding. In other fields, especially medicine and biology, this behaviour is sometimes referred to as "impact factor mania" (Casadevall and Fang, 2014) or "impactitis" (van Dienst et al., 2001).[31] Surprisingly, researchers with a higher number of articles published have a more negative opinion about the impact factor (Buela-Casal and Zych, 2012). That said, some studies find that the impact factor does not guarantee quality (Eisner, 2018). In the field of medicine, a large proportion of studies cannot be reproduced, while the number of retracted papers is positively correlated with the journal impact factor, indicating that poor research quality and fraud can sometimes be encouraged by the need to publish in high-impact scientific journals (Eisner, 2018; Christensen and Miguel, 2018). Both the research and the community utilizing its outcomes would benefit from researchers being less concerned about the journal impact factor and more concerned about the quality, clarity and understandability of the message reported and the applicability of the outcomes. Rather than focusing on publishing in high-impact journals, researchers should try more actively to deliver their outcomes to a much broader readership (for example via non-technical summaries, blog posts and traditional and social media).

Figure 17: Importance of Publications in High Impact Factor Journals



Note: The equivalent figures for the recursive and discounted impact factors are reported in Appendix B.
Source: IDEAS/RePEc Data Set

5. Conclusions

In this paper, we explore research in 55 central banks in Europe and US, focusing on the quantity and quality of publication activity, topic analysis, the cooperation network between individual central banks and with academia, the gender structure of teams and research popularization, among other things. For this purpose, we employ two unique data sets containing information on different aspects of central banks' research and on more than 20,000 research papers published in these central banks over the 2000–2019 period.

[31] Casadevall and Fang (2014) argue that this behaviour persists because it has significant benefits for both individual researchers and scientific journals, who pursue their own self-interests.

There is a significant heterogeneity in research activities across central banks from different regions. This heterogeneity is mostly apparent between larger, well-established central banks with a longer research tradition, usually located in the US and Western and Northwestern Europe, and smaller central banks, usually located in Eastern and Southeastern Europe. The well-established central banks produce more research papers per author, publish a higher proportion of these papers in scientific journals and generally achieve a higher average impact factor. On the other hand, they employ fewer female researchers relative to male researchers. Furthermore, the vast majority of the central banks in our sample have a separate research department, but only a minority distinguish between financial and economic research in their organizational structure. Central banks are also dedicating more and more resources to communicating and enhancing the visibility of their research. They are becoming more active on social media and are exploiting the potential of additional forms of presentation and popularization, such as research blogs, bulletins and newsletters. However, the use of social media for research popularization is more common among the US Federal Reserve Banks and larger central banks in Europe with a well-established research tradition.

We have identified seven stylized facts of research in central banks. First, in terms of the topics researched, financial stability has emerged as the leading topic after the GFC. Based on a word cloud of keywords and words in abstracts, we find that monetary policy issues and macroeconomic topics in general dominated before the GFC, while the macro-finance area has taken over since then.

Second, research in central banks is becoming increasingly collaborative. While the number of publications per author per central bank is decreasing steadily over time, the number of authors per publication is increasing. What is most striking is the drop in share of the publications with a single author, from 40% in 2000 to less than 20% in 2019. The share of publications with exactly three authors, on the other hand, has more than doubled in the last two decades, reaching 30% in 2019. It is also becoming increasingly common to have publications with four and five or more authors. Partly as a result of the increasingly collaborative environment, the number of papers published in central banks' series has more than doubled over the period under review.

Third, central banks form enormous research networks. The closer collaboration among researchers reflects more intensive cooperation both inside and outside the network of central banks. In other words, the increasing number of authors per central bank publication is due to a larger number of researchers affiliated with a central bank and also to a larger number of those affiliated with an institution other than a central bank. Still, we find that most of this research collaboration is region-specific, meaning that a central bank is more likely to collaborate with a research institution from its own country or region. Further, our alternative approach to network analysis suggests that researchers tend to leave national central banks to relocate to supranational institutions, identifying a potential problem associated with human capital flight.

The second and third stylized facts are consistent with the general tendencies in economic research identified by numerous studies over the last couple of years (see, for example, Card and DellaVigna, 2013; Hamermesh, 2013; Kuld and O'Hagan, 2018; Essers et al., 2020). They may to a large extent reflect the increasing scale and complexity of central banks' duties, as well as increasing integration, especially among European countries, and increasing interconnectedness of world economies and financial systems. Surprisingly, the increased collaboration with academia has not been reflected in an increased share of central banks' papers published in academic journals. This share stands at nearly 40% if we abstract from publishing delay.

Fourth, a relatively small proportion of authors contribute to a relatively large proportion of central banks' research papers. Specifically, the top 10% of authors contributed to about 50% of

all central banks' research publications in our sample. This finding suggests (albeit very indirectly) that even central banks may be prone to the "extinction effect" that has been found to be present in academic research (Azoulay et al., 2010). Specifically, the departure of a leading researcher may result in a decrease in the quality of a central bank's research publications.

Fifth, the number of female researchers relative to male researchers is increasing over time, but the gap still persists. The share of female authors in our sample rises from about 19% in 2000 to 25% in 2019. This trend is driven by an increasing share of mixed research teams (involving both women and men), while the share of all-women research teams remains stable over the whole period analysed. Further, small central banks engage more female researchers than larger central banks. A similar pattern was observed by Auriol et al. (2020), who showed that the more prestigious the research institution is, the fewer female economists are present. As for the relative comparison with other R&D sectors, central banks stand somewhere between the business enterprise sector and the government and higher education sectors.

Sixth, larger, well-established central banks with a longer research tradition achieve a higher impact factor for their in-house research publication series and for the average impact of their papers published in scientific journals. Nevertheless, the impact factor should be interpreted with a grain of salt, because it is derived from the number of citations received by papers in a particular series or journal. The informative value of the impact factor may be limited due to the fact that a small number of papers published in a series or journal may have received a large proportion of the citations. The overall impact factor is then boosted by this small share of papers and says nothing about the quality of the other papers published in that series or journal.

Seventh, a relatively small proportion of central banks' research papers published in scientific journals contribute the most to the average and median impact factor. This indicates that the bias described in the previous paragraph may also apply to the impact factor of central banks' in-house publication series. This may be true because there is a high positive correlation between the impact factor assigned to central banks' in-house publication series and the average impact factor of the papers published in a scientific journal.

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Appendix A: Data

Table A1: Research Score Data Set (1)

Code	Central Bank	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Europe																											
AL	Banka e Shqiperise	1	0	0	1	1	0	0	1	0	1	1	0	0.25	0.5	0	0	0	0	1	0	0	1	0	0	0	0
AT	Oesterreichische Nationalbank	1	0	0	1	0	0.5	1	1	0	1	0	0	0.25	0	0	1	1	0	1	0	1	1	0	0	1	0
BY	National Bank of the Republic of Belarus	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BE	National Bank of Belgium	1	0	0	1	0	1	0	1	0	1	1	0	0.25	0	1	1	1	0	1	0	1	1	0	0	0	1
BA	Centralna Banka Bosne I Herceg	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
BG	Bulgarian National Bank	1	1	0	1	0	0.5	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0
HR	Hrvatska Narodna Banka	0	0	0	0	0	0	0	1	0	0	0	0	0.25	0	0	0	0	0	1	0	0	1	0	0	1	1
CY	Central Bank of Cyprus	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0
CZ	Česká Národní Banka	1	1	0	1	1	1	1	1	0	1	0	1	0.5	0	1	0	0	0	1	0	0	1	1	0	1	0
DK	Danmarks Nationalbank	1	0	0	1	0	0.5	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0.5	0	1
EE	Eesti Pank	1	0	0	1	0	1	1	1	0	1	0	0	0.25	0	0	0	0	0	1	0	1	1	0.5	0	1	1
FI	Suomen Pankki	1	0	1	1	0	1	1	0	1	1	1	1	0.25	0	1	0	1	1	1	0	1	1	0.5	0	0	0
FR	Banque de France	1	0	0	1	0	0	1	1	0	1	1	1	0.5	0	0	1	1	0	1	1	1	1	1	0	0	1
DE	Deutsche Bundesbank	1	0	0	1	0	1	1	0	1	1	0	0	0.25	0	1	1	1	0	1	1	1	1	1	0.5	0	1
GR	Bank of Greece	1	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
HU	Magyar Nemzeti Bank	1	1	0	1	1	0.5	1	1	0	1	0	0	0	0	0	0	1	0	1	0	1	1	1	0	0	1
IS	Central Bank of Iceland	0	0	0	1	1	1	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0
IE	Central Bank of Ireland	1	0	0	0	0	0	0	0	1	1	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1
IT	Banca d'Italia	1	0	1	1	1	1	0	1	0	1	0	0	0.5	0.5	0	0	1	0	1	0	1	1	0	0	0	1
XK	Banka Qendror e Republikës së Kosovës	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
LV	Latvijas Banka	1	0	0	1	0	1	1	1	1	0	0	1	0.25	0	1	1	0	0	1	0	0	0	0	0	0	0
LT	Lietuvos Bankas	1	0	1	1	0	1	1	1	1	1	0	0	0.25	0	0	0	0	0	1	0	1	1	1	0.5	1	1
LU	Banque Centrale du Luxembourg	1	0	0	1	0	0.5	1	1	0	0	0	0	0.25	0	0	0	0	0	1	0	1	1	0	0	0	0
MT	Bank Centrali ta' Malta	1	0	0	1	0	0.5	0	1	0	1	1	0	0	0	0	0	1	0	1	0	1	1	1	0	0	0
MD	Banca Nationala a Moldovei	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
ME	Centralna Banka Crne Gore	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
NL	de Nederlandsche Bank	1	0	0	1	0	1	1	1	0	1	0	0	0	0.5	0	0	0	0	1	0	1	1	1	0.5	0	0
MK	Narodna Banka na Rep. Severna Makedonija	1	0	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
NO	Norges Bank	1	0	0	1	0	1	1	1	0	1	0	1	0.25	0	0	0	0	0	1	0	1	1	1	0	1	1
PL	Narodowy Bank Polski	1	0	0	1	1	0.5	0	1	0	1	0	0	0	0	0	1	0	0	1	0	1	1	0	0	0	0
PT	Banco de Portugal	1	0	0	1	0.5	1	1	1	0	1	1	0	0	0	0	0	0	0	1	1	0	1	0.5	0	0	0
RO	Banca Nationala a Romaniei	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
RS	Narodna Banka Srbije	1	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
SK	Národná Banka Slovenska	1	1	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0
SI	Banka Slovenije	1	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0
ES	Banco de Espana	1	0	0	1	0	1	0	1	0	1	1	0	0	0.5	0	0	0	0	1	0	1	1	0	0	0	1
SE	Sveriges Riksbank	1	0	0	1	0	0.5	1	1	0	1	0	0	0	0.5	0	0	0	0	1	0	1	1	1	0	0	1
CH	Schweizerische Nationalbank	1	0	0	1	0	0	0	1	0	1	1	0	0.25	0.5	0	1	0	0	1	0	0	1	0	0	0	1
UA	National Bank of Ukraine	0	0	0	1	0	0.5	1	1	0	1	0	0	0	0	0	0	0	0	1	0	1	1	0	0	1	1
UK	Bank of England	1	0	1	1	0	1	1	1	0	0	1	1	0.25	0	1	0	1	1	1	1	1	1	0.5	0.5	0	1

Note: See the notes to Table A2.

Table A2: Research Score Data Set (2)

Code	Central Bank	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
US																											
US	Federal Reserve Board	1	1	0	1	0.5	0	1	0	1	1	0	0	0	0	0	1	1	2	1	0	1	1	0	0.5	0	1
US	Federal Reserve Bank of Atlanta	1	1	1	1	0.5	0	1	1	1	1	0	1	0.25	0	1	1	0	0	1	0	1	1	0	0.5	0	0
US	Federal Reserve Bank of Boston	1	0	1	1	0	1	1	1	0	1	0	0	0.25	0	1	1	1	0	1	0	1	1	1	0.5	0	0
US	Federal Reserve Bank of Cleveland	1	0	1	1	0	1	1	1	0	1	0	0	0	0	0	0	1	1	1	0	0	1	0.5	0.5	0	1
US	Federal Reserve Bank of Dallas	1	0	1	1	0	0	1	1	0	1	0	0	0.25	0	0	1	1	0	1	1	0	1	1	0.5	0	1
US	Federal Reserve Bank of Chicago	1	0	0	1	0	0	1	1	0	1	0	1	0.5	0	1	0	0	0	1	0	1	1	0.5	0.5	0	1
US	Federal Reserve Bank of Kansas City	1	0	0	1	0	1	1	1	0	1	1	0	0.25	0	1	0	1	0	1	0	1	1	0.5	0.5	0	1
US	Federal Reserve Bank of Minneapolis	1	0	1	1	0	1	1	1	0	1	0	0	0.25	0	1	0	1	0	1	0	1	1	1	0	0	1
US	Federal Reserve Bank of New York	1	0	0	1	0	0.5	1	1	0	1	0	1	0.25	0	1	1	1	1	1	0	1	1	0.5	0.5	0	1
US	Federal Reserve Bank of Philadelphia	1	0	1	1	0	0	1	1	0	1	0	0	0.5	0	1	1	1	1	1	0	0	1	1	0.5	0	0
US	Federal Reserve Bank of Richmond	1	0	0	1	0	0	1	1	0	1	0	0	0.5	0	1	1	1	1	1	0	0	1	0.5	0.5	0	1
US	Federal Reserve Bank of San Francisco	1	0	1	1	0	0	1	1	0	1	0	1	0.25	0	1	0	1	0	1	0	1	1	0.5	0.5	0	1
US	Federal Reserve Bank of St Louis	1	1	1	1	1	1	1	1	0	1	0	1	0.5	0	0	0	0	0	1	0	0	1	0.5	0.5	0	1
International																											
-	Bank for International Settlements	1	0	1	1	1	1	1	1	0	1	0	0	0.25	0	1	1	1	0	1	1	1	1	1	0.5	1	1
-	European Central Bank	1	1	0	1	1	1	1	1	1	1	1	0	0	0	1	1	1	0	1	1	1	1	1	0	1	1
-	European Systemic Risk Board	1	0	0	1	1	0.5	1	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0

Note: This table forms the Research Score Data Set. Columns A to Z show the scores of the individual items: 0 – no such characteristic is in place in the given CB; 1 – the given characteristic is in place in full; 0.25 or 0.5 – the given characteristic is in place, but only partially.

Columns: **A** – Is there a separate research department? **B** - Is financial research separated in the CB's organizational structure? **C** – Is there an associated research institution? **D** – Is there a separate website for research? **E** – Is there a separate website for financial research? (if 0.5, then financial research can be separated from other research, for example by tags, but there is no separate website for it) **F** – Are the research areas promoted on the research website? (if 0.5, then the research areas are stated only briefly) **G** – Is there a web page which summarizes researchers' profiles? **H** – Is there a working paper (WP) series published by the CB? **I** - Is there a discussion paper (DP) series published by the CB? **J** – Is there any other publication series except for the WP and DP series? **K** – Does the CB publish its own research bulletin? **L** – Is there a research blog in the CB? **M** – Is there a research newsletter in email form? (if 0.25, then the research newsletter takes the form of email notifications about updates to research websites; if 0.5, then the research newsletter takes the form of an email campaign) **N** – Is there a research newsletter in pdf/document form? (if 0.5, then the research newsletter takes the form of a pdf/document) **O** – Have there been any posts related to the research activities of the CB on LinkedIn in the last 6 months (as of February/March 2020) **P** – Have there been any posts related to the research activities of the CB on YouTube in the last 6 months (as of February/March 2020) **Q** – Have there been any posts related to the research activities of the CB on Twitter in the last 6 months (as of February/March 2020) **R** – Is there a separate Twitter account for research? **S** – Does the CB have a RePEc account? **T** – Does the CB advertise any calls for projects on its website? **U** – Does the CB offer any form of research cooperation? **V** – Are there any research events organized by the CB? **W** – Is there any web page which lists the journal articles written by the CB's staff? (if 0.5, then journal articles written by the CB's staff can be accessed only via the researchers' profile pages) **X** – Does the CB provide data sources for its research publications? (if 0.5, then the CB provides research data in general, but these data sets are not explicitly connected to given research publications) **Y** – Does the CB organize any research competitions or appraisals? **Z** – Does the CB offer any trainee/internship programme connected to research?

Table A3: Items Included in the Research Scores

Item	Overall Research Score	Research Organization Score	Research Publication Score	Research Popularization Score	Item	Overall Research Score	Research Organization Score	Research Publication Score	Research Popularization Score
A	Y	Y	N	N	N	Y	N	N	Y
B	Y	Y	N	N	O	Y	N	N	Y
C	Y	Y	N	N	P	Y	N	N	Y
D	Y	N	N	Y	Q	Y	N	N	Y
E	Y	Y	N	N	R	Y	N	N	Y
F	Y	N	N	Y	S	Y	N	Y	N
G	Y	N	N	Y	T	Y	N	N	Y
H	Y	N	Y	N	U	Y	N	N	Y
I	Y	N	Y	N	V	Y	N	N	Y
J	Y	N	Y	N	W	Y	N	Y	N
K	Y	N	N	Y	Y	Y	N	Y	N
L	Y	N	N	Y	Z	Y	N	N	Y
M	Y	N	N	Y	AA	Y	N	N	Y

Note: See the notes to Table A2.

Table A4: Publication Series Covered in the IDEAS/RePEc Data Set (1)

No.	Country	Central Bank	Data Source	Research Series*	Time Period	No. of Publications	
Europe							
1	IT	Banca d'Italia	IDEAS/RePEc	WP	2000–2019	893	1430
				DP	2006–2019	537	
2	RO	Banca Nationala a Romaniei	institution's website	OP	2002–2019	28	28
3	ES	Banco de España	IDEAS/RePEc	WP	2000–2019	686	782
				OP	2005–2019	96	
4	PT	Banco de Portugal	IDEAS/RePEc	WP	2000–2019	382	382
5	MT	Bank Centrali ta' Malta	IDEAS/RePEc	WP	2013–2019	33	33
6	UK	Bank of England	IDEAS/RePEc	WP	2000–2019	737	832
				FSP	2006–2018	44	
				MPCDP	2000–2019	51	
7	GR	Bank of Greece	IDEAS/RePEc	WP	2003–2019	276	276
8	AL	Banka e Shqiperise	institution's website	RP	2000–2019	82	
9	SL	Banka Slovenije	institution's website	WP	2013–2019	20	97
				DP	2000–2019	77	
10		Banque Centrale du Luxembourg	IDEAS/RePEc	WP	2001–2019	124	124
11	FR	Banque de France	IDEAS/RePEc	WP	2000–2019	671	681
				OP	2006–2017	10	
12	BG	Bulgarian National Bank	institution's website	DP	2001–2019	61	61
13	CY	Central Bank of Cyprus	IDEAS/RePEc	WP	2007–2019	55	55
14	IE	Central Bank of Ireland	IDEAS/RePEc	RTP	2000–2019	214	214
15	CZ	Česká Národní Banka	IDEAS/RePEc	WP	2002–2019	245	281
				RPN	2003–2019	36	
16	DK	Danmarks Nationalbank	institution's website	WP	2002–2019	141	141
17	NL	de Nederlandsche Bank	IDEAS/RePEc	WP	2004–2019	660	660
18	DE	Deutsche Bundesbank	IDEAS/RePEc	DP	2013–2019	346	834
				DP1ES	2000–2011	368	
				DP2BFS	2003–2011	120	
19	EE	Eesti Pank	IDEAS/RePEc	WP	2000–2019	159	159
20	HR	Hrvatska Narodna Banka	IDEAS/RePEc	WP	2000–2019	53	53
21	LV	Latvijas Banka	IDEAS/RePEc	WP	2001–2019	75	89
				DP	2009–2019	14	
22	LT	Lietuvos Bankas	IDEAS/RePEc	WP	2008–2019	66	95
				DP	2016–2019	16	
				OP	2016–2019	13	
23	HU	Magyar Nemzeti Bank	IDEAS/RePEc	WP	2000–2019	138	210
				OP	2001–2019	72	
24	MK	Narodna Banka na Republika Severna Makedonija	IDEAS/RePEc	WP	2000–2019	60	60
25	SK	Národná Banka Slovenska	IDEAS/RePEc	WP	2006–2019	69	69
26	RS	Narodna Banka Srbije	IDEAS/RePEc	WP	2005–2015	31	31
27	PL	Narodowy Bank Polski	IDEAS/RePEc	WP	2002–2019	294	294
28	UA	National Bank of Ukraine	IDEAS/RePEc	WP	2016–2019	9	9
29	BE	Nationale Bank van België/Banque national de Belqique	IDEAS/RePEc	WP	2000–2019	334	334
30	NO	Norges Bank	IDEAS/RePEc	WP	2003–2019	337	337
31	AT	Oesterreichische Nationalbank	IDEAS/RePEc	WP	2000–2019	187	187
32	IS	Sedlabanki Íslands	IDEAS/RePEc	WP	2000–2019	76	76
33	SW	Schweizerische Nationalbank	IDEAS/RePEc	WP	2004–2019	215	215
34	FI	Suomen Pankki	IDEAS/RePEc	RDP	2000–2019	597	1064
				BOFIT	2000–2019	467	
35	SE	Sveriges Riksbank	IDEAS/RePEc	WP	2000–2019	279	279

Note: * WP – Working Papers; DP – Discussion Papers; OP – Occasional Papers; FSP – Financial Stability Papers; MPCDP – Monetary Policy Committee Discussion Papers; RP – Research Papers; RTP – Research Technical Papers; RPN – Research and Policy Notes; DP1ES – Discussion Paper Series 1: Economic Studies; DP2BFS – Discussion Paper Series 2: Banking and Financial Studies; RDP – Research Discussion Papers; BOFIT – BOFIT Discussion Papers

Table A5: Publication Series Covered in the IDEAS/RePEc Data Set (2)

No.	State	Central Bank	Data Source	Research Series*	Time Period	No. of Publications	
US							
36	Georgia	Federal Reserve Bank of Atlanta	IDEAS/RePEc	WP	2000–2019	494	494
37	Massachusetts	Federal Reserve Bank of Boston	IDEAS/RePEc	WP SRAWP	2000–2019 2007–2019	310 48	358
38	Ohio	Federal Reserve Bank of Cleveland	IDEAS/RePEc	WP	2000–2019	499	499
39	Texas	Federal Reserve Bank of Dallas	IDEAS/RePEc	WP GIWP	2000–2019 2007–2019	197 373	570
40	Illinois	Federal Reserve Bank of Chicago	IDEAS/RePEc	WP	2000–2019	477	477
41	Missouri	Federal Reserve Bank of Kansas City	IDEAS/RePEc	WP	2000–2019	278	278
42	Minnesota	Federal Reserve Bank of Minneapolis	IDEAS/RePEc	WP	2000–2019	166	166
43	New York	Federal Reserve Bank of New York	IDEAS/RePEc	WP	2000–2019	806	806
44	Pennsylvania	Federal Reserve Bank of Philadelphia	IDEAS/RePEc	WP	2000–2019	657	657
45	Virginia	Federal Reserve Bank of Richmond	IDEAS/RePEc	WP	2000–2019	262	262
46	California	Federal Reserve Bank of San Francisco	IDEAS/RePEc	WP	2000–2019	571	571
47	Missouri	Federal Reserve Bank of St. Louis	IDEAS/RePEc	WP	2000–2019	876	876
48	Washington, D.C.	Federal Reserve Board	IDEAS/RePEc	FEDS IFDP	2000–2019 2000–2019	1537 610	2147
International							
49	-	Bank for International Settlements	IDEAS/RePEc	WP	2000–2019	752	752
50	-	European Central Bank	IDEAS/RePEc	WP	2000–2019	2335	2335
51	-	European Systemic Risk Board	IDEAS/RePEc	WP	2016–2019	106	106

Note: * WP – Working Papers; SRAWP – Supervisory Research and Analysis Working Papers; GIWP – Globalization Institute Working Papers; FEDS – Finance and Economics Discussion Series; IFDP – International Finance Discussion Papers

Table A6: Composition of Central Banks' Boards by Gender

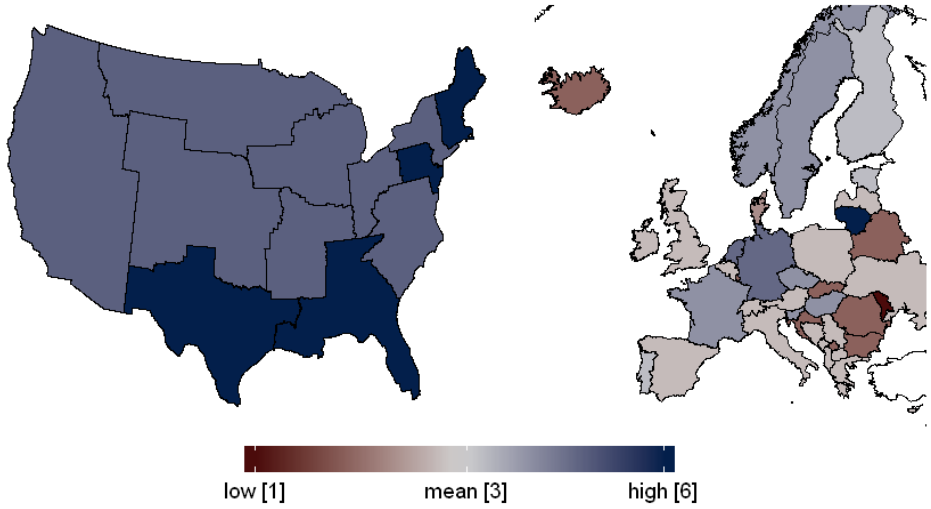
No.	Central Bank	Board's Name	Composition		
			Male	Female	Governor*
1	Banca d'Italia	Governing Board	4	1	male
2	Banca Nationala a Romaleiei	Board of Directors	9	0	male
3	Banco de Espana	Governing Council**	4	6	male
4	Banco de Portugal	Board of Directors	4	1	male
5	Bank Centrali ta' Malta	Board of Directors	5	2	male
6	Bank of England	Monetary Policy Committee	8	1	male
7	Bank of Greece	General Council	11	1	male
8	Banka e Shqiperise	Supervisory Council	4	4	male
9	Banka Slovenije	Governing Board	4	1	male
10	Banque Centrale du Luxembourg	Council	7	2	male
11	Banque de France	General Council	4	5	male
12	Bulgarian National Bank	Governing Council	4	3	male
13	Central Bank of Cyprus	Board of Directors	7	1	male
14	Central Bank of Ireland	Commission	6	3	male
15	Česká Národní Banka	Bank Board	7	0	male
16	Danmarks Nationalbank	Board of Governors	3	0	male
17	de Nederlandsche Bank	Governing Board	4	2	male
18	Deutsche Bundesbank	Executive Board	4	2	male
19	Eesti Pank	Executive Board	2	1	male
20	Hrvatska Narodna Banka	Council	5	3	male
21	Latvijas Banka	Council	4	2	male
22	Lietuvos Bankas	Board	4	1	male
23	Magyar Nemzeti Bank	Board	4	0	male
24	Narodna Banka na Republika Severna Makedonija	Council	3	3	female
25	Národná Banka Slovenska	Bank Board	5	0	male
26	Narodna Banka Srbije	Board	1	3	female
27	Narodowy Bank Polski	Monetary Policy Committee	9	1	male
28	National Bank of Ukraine	Board	5	1	male
29	Nationale Bank van België/Banque national de Belqique	Board of Directors	6	0	male
30	Norges Bank	Executive Board	4	6	male
31	Oesterreichische Nationalbank	Governing Board	4	0	male
32	Sedlabanki Íslands	Board	2	2	male
33	Schweizerische Nationalbank	Governing Board	2	1	male
34	Suomen Pankki	Board	2	1	male
35	Sveriges Riksbank	Executive Board	4	2	male
36	Central Bank of Bosnia and Herzegovina	Governing Board	4	5	male
37	National Bank of the Republic of Belarus	Board	4	1	male
38	National Bank of Moldova	Executive Board	4	0	male
39	Central Bank of Montenegro	Council	6	0	male
40	Central Bank of the Republic of Kosovo	Executive Board	3	0	male

Note: * Sometimes referred to as the President or the Chairman. ** Excluding non-voting members. Composition as of July 2020.

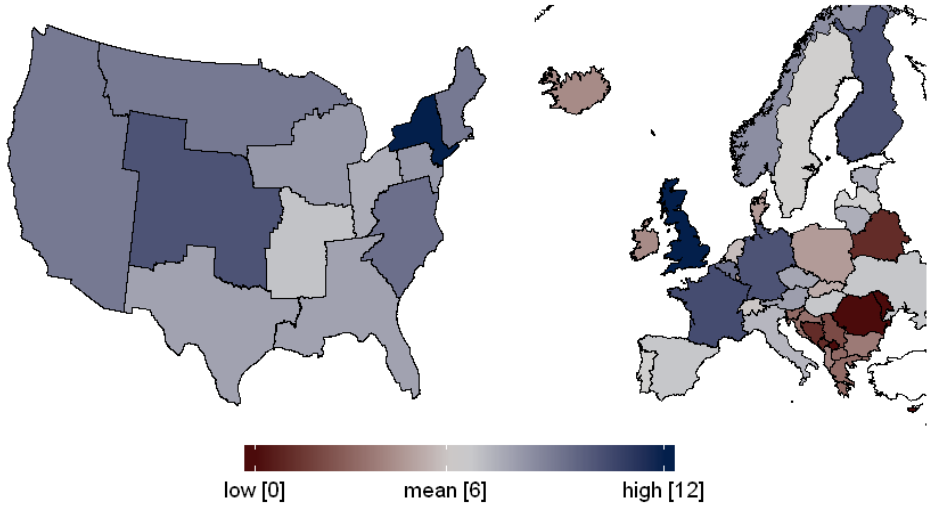
Appendix B: Additional Figures

Figure B1: Research Score Groups

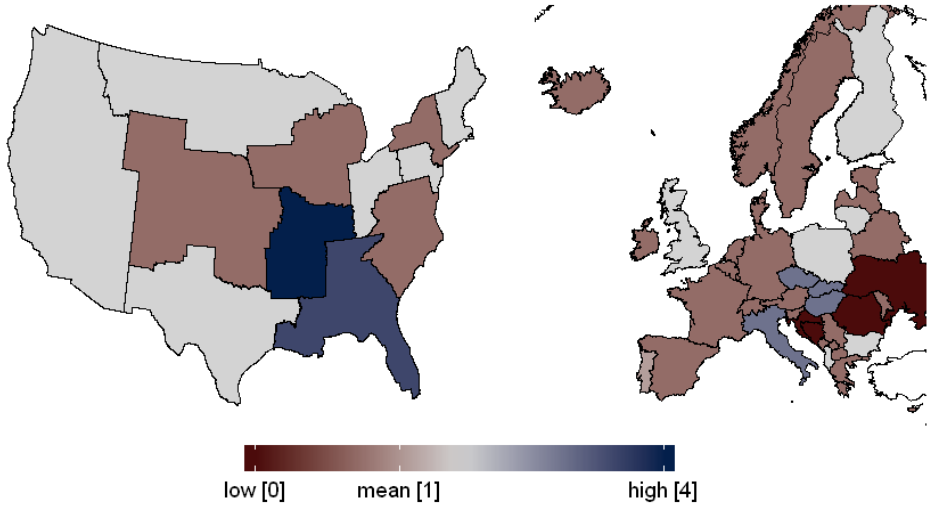
(A) Research Publications Score



(B) Research Popularization Score

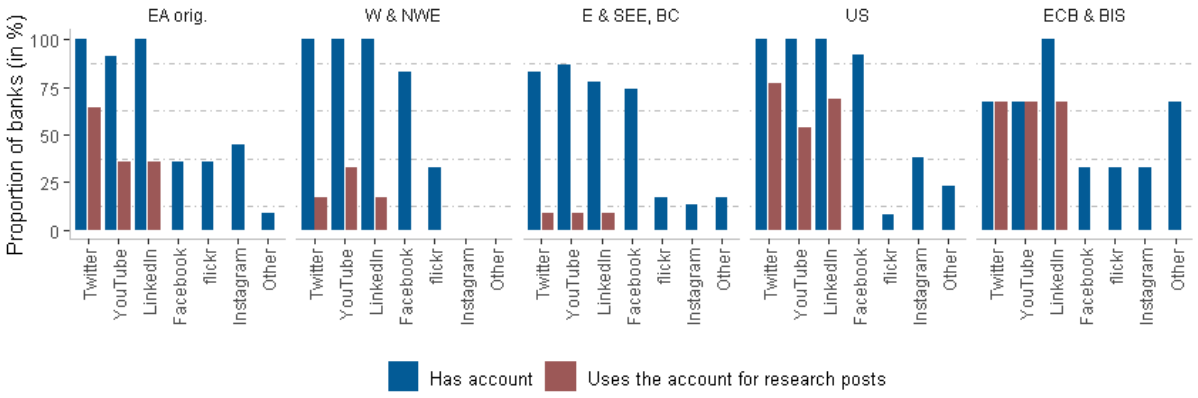


(C) Research Organization Score



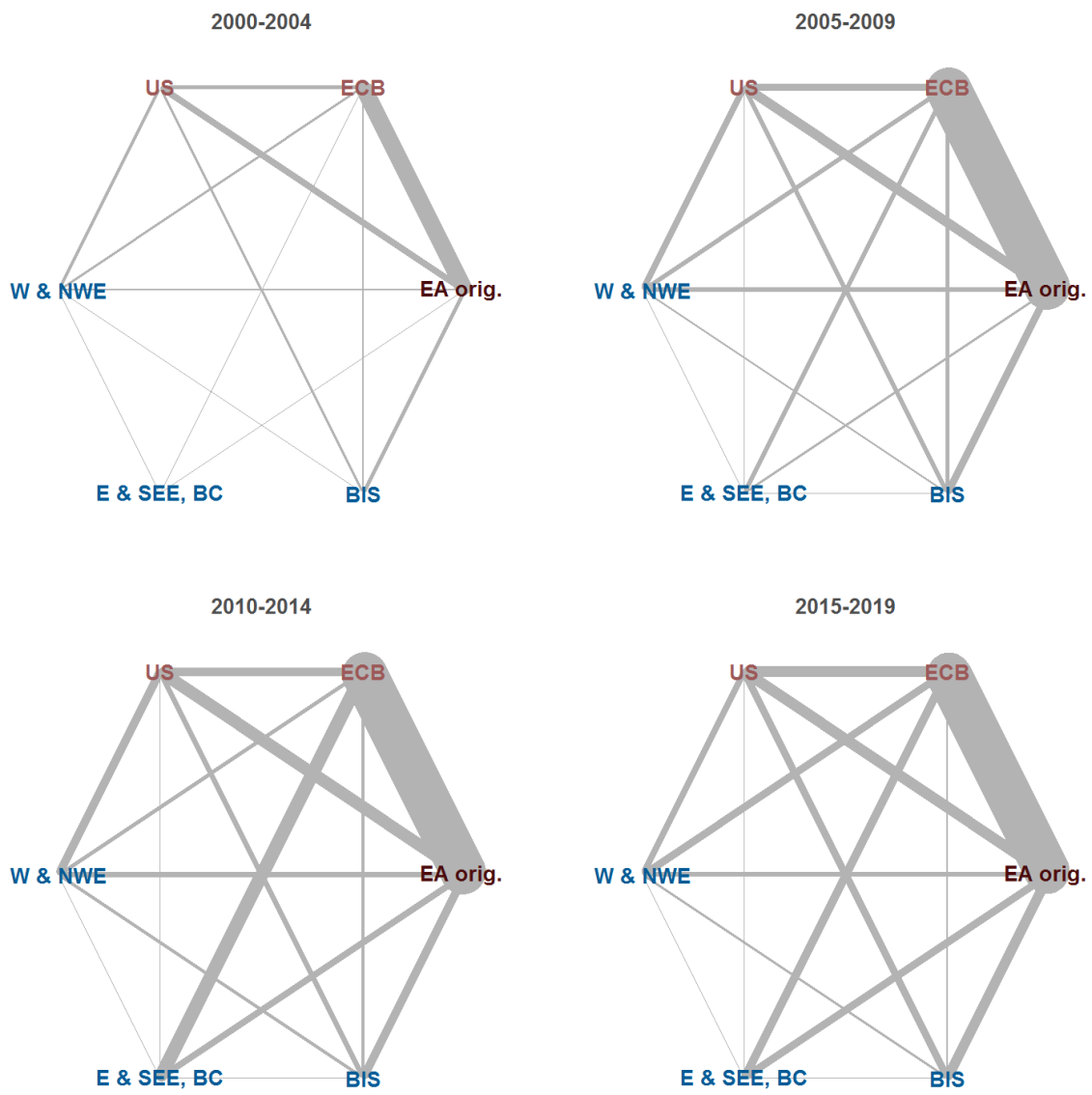
Note: The detailed data behind the individual scores can be found in Tables A1 and A2. The choropleth maps do not reflect the scores for the Federal Reserve Board (FRB), the European Central Bank (ECB, including the ESRB) and the Bank for International Settlements (BIS).
Source: Research Score Data Set

Figure B2: Central Banks on Social Media



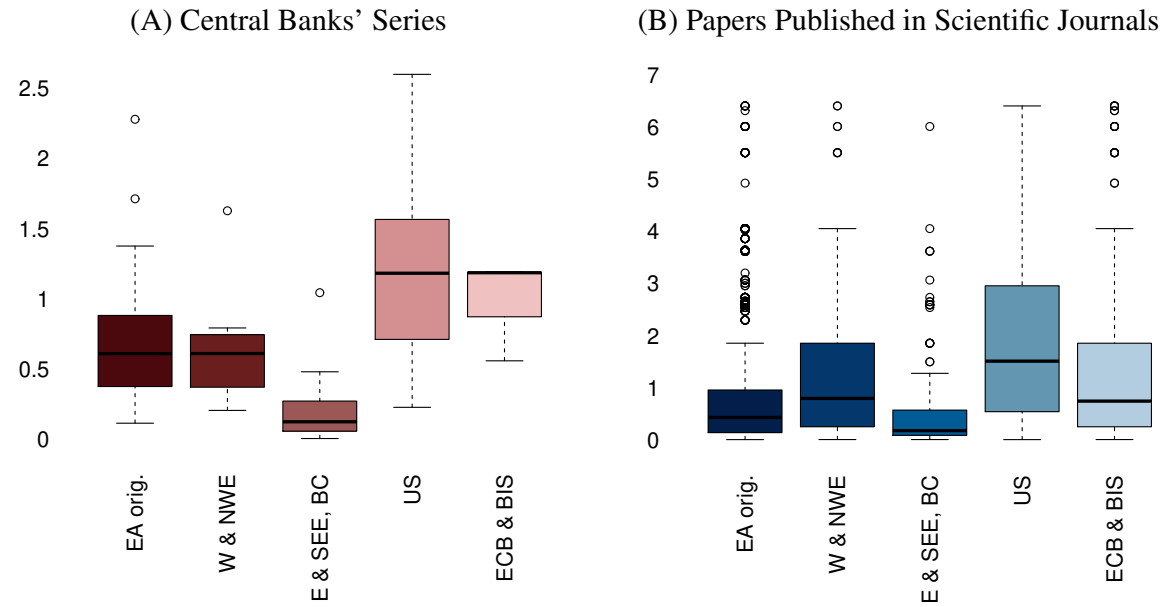
Note: The data about the utilization of social media were collected manually using central banks' websites and social media accounts. *Other* includes services such as Spotify, Pinterest and Slideshare. To obtain the information about the use of social media for research purposes, we manually analysed each central bank's posts in the last 6 months on the three most-frequently used social media platforms – YouTube, Twitter and LinkedIn. The period of data collection was February to March 2020.
Source: Research Score Data Set

Figure B3: Authorship Networks Between Central Banks – Regionally



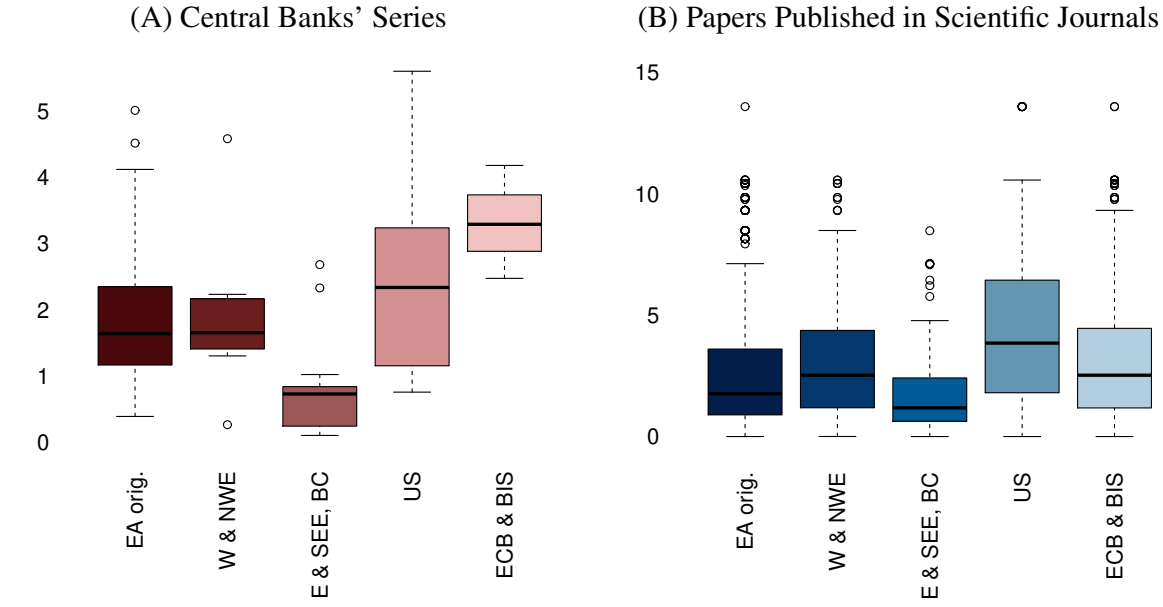
Note: Based on authors' self-reported affiliation in IDEAS/RePEc.
The edge width indicates the relative frequency of authorships between the listed central banks (i.e. the number of publications in the given time period). Central banks shown in red account for 80% of publications (dark red for 50% and light red for the additional 30%).
Source: IDEAS/RePEc Data Set

Figure B4: Recursive Impact Factor – Regional Distribution



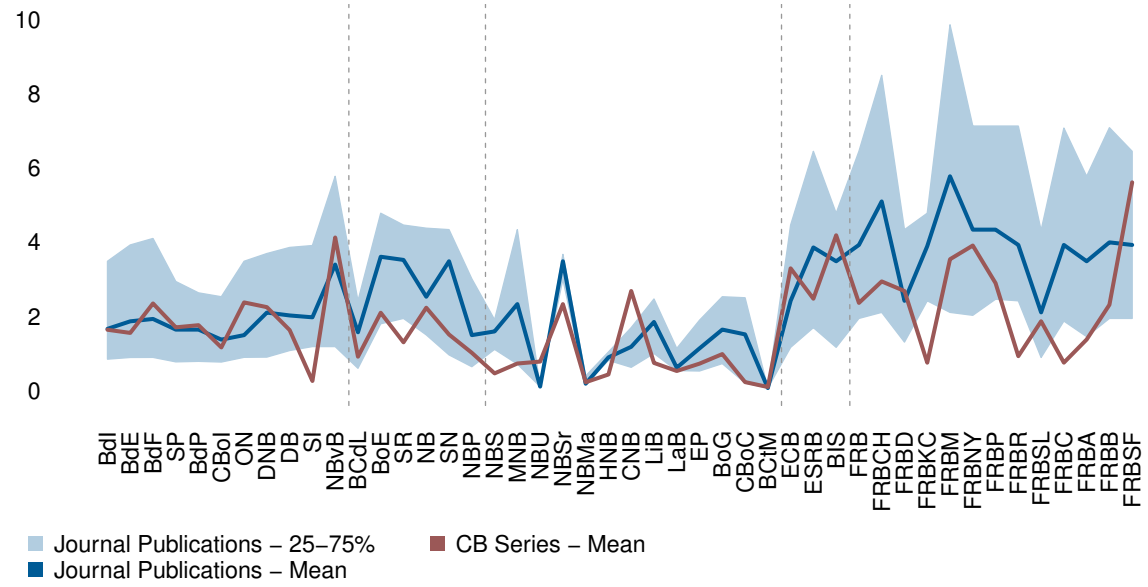
Note: See the note to Figure 15.
Source: IDEAS/RePEc Data Set

Figure B5: Discounted Impact Factor – Regional Distribution



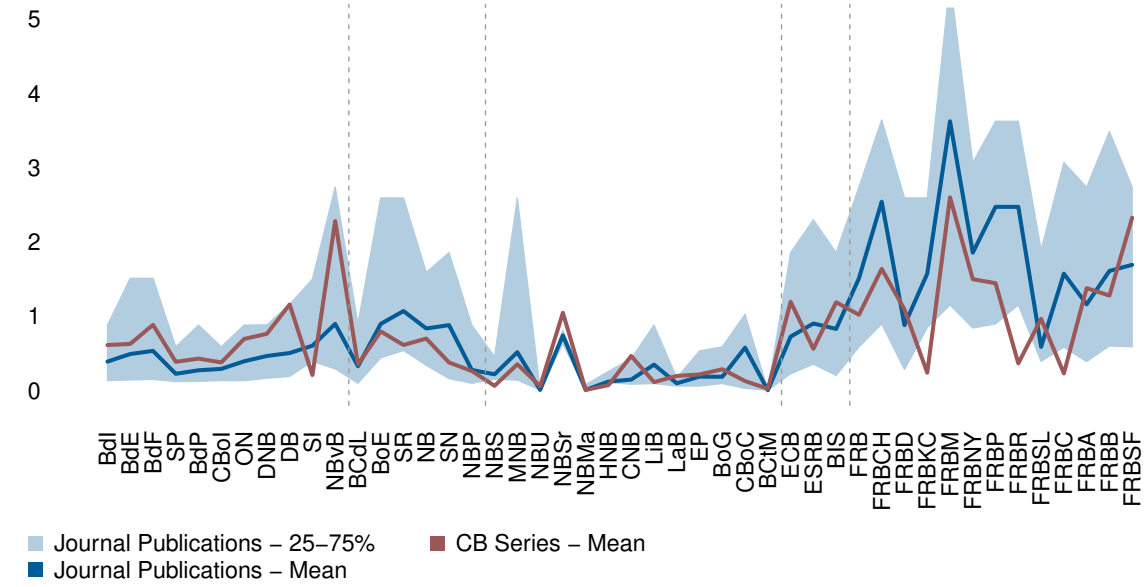
Note: See the note to Figure 15.
Source: IDEAS/RePEc Data Set

Figure B6: Recursive Impact Factor – Individual Central Banks



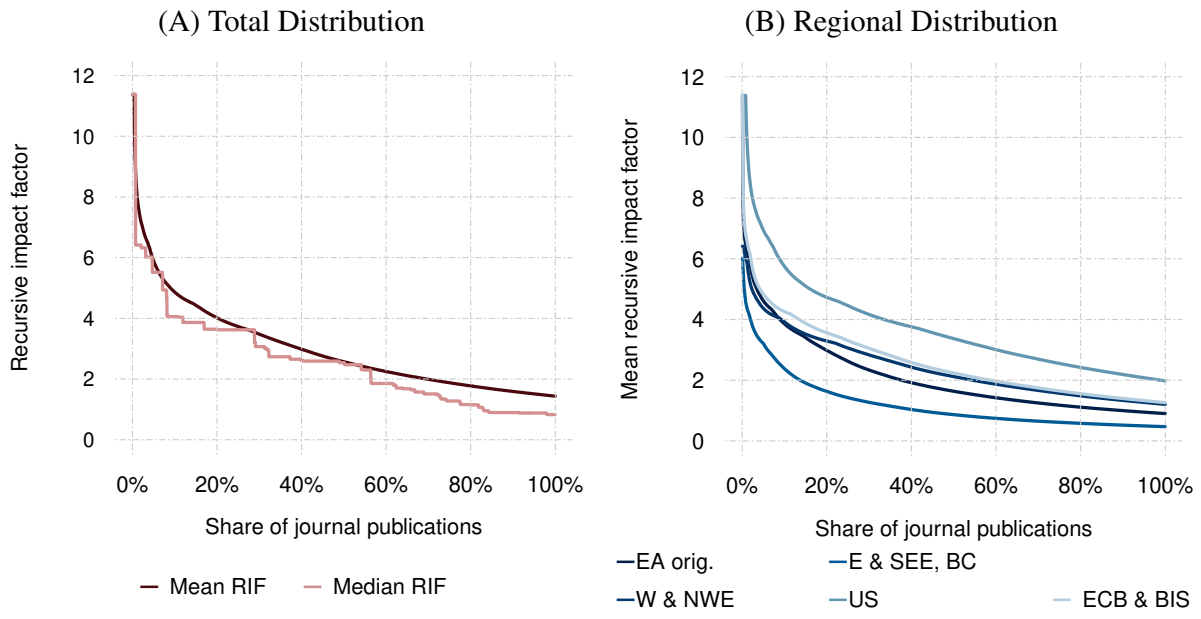
Note: See the note to Figure 16.
Source: IDEAS/RePEc Data Set

Figure B7: Discounted Impact Factor – Individual Central Banks



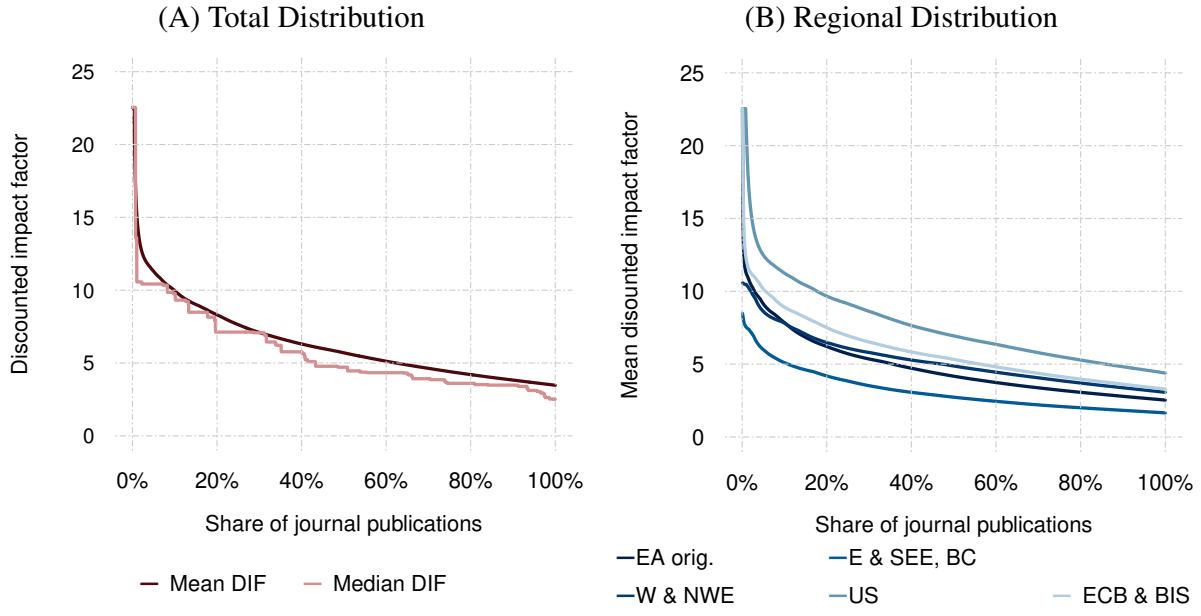
Note: See the note to Figure 16.
Source: IDEAS/RePEc Data Set

Figure B8: Importance of Publications in High Impact Factor Journals – Recursive Impact Factor



Note: See the note to Figure 17.
Source: IDEAS/RePEc Data Set

Figure B9: Importance of Publications in High Impact Factor Journals – Discounted Impact Factor



Note: See the note to Figure 17.
Source: IDEAS/RePEc Data Set

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