Quantifying Central Banks' Scientization: Why and How to Do a Quantified Organizational History of Economics

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Abstract

A subset of research in the history of economics is organizational history – i.e., the study of the organizations producing, circulating and applying economic ideas. This article maintains that some research questions in organizational history call for quantitative methods because they ask about magnitudes. More precisely, we claim that quantitative methods should complement rather than replace other research methods when the research question is at least partly about magnitudes. We walk the walk with a study of one type of organization, central banks, and of its changing relationship with economic science. Our results point unambiguously toward a growing dominance of central banks in the specialized field of monetary economics. Central banks have swelling research armies, they publish a growing share of the articles in specialized scholarly journals, and these articles tend to have more impact today than the articles produced outside central banks.

Introduction

The history of economics is not only the history of economic *ideas*, but also the history of *organizations* responsible for the production, the dissemination and the application of these ideas.[1] The present article is a contribution to the organizational history of economics in two ways. First, it makes a substantive contribution in furthering our understanding of the relationship between central banks and

1 We must note that, today, only a small share of the production in the history of economics tilts toward organizational history. For instance, out of the 18 research articles published in the first issue of 2017 in the three main field journals (*Journal of the History of Economic Thought*, *European Journal of the History of Economic Thought* and *History of Political Economy*), only one – "On the Founding of the Econometric Society" by Olav Bjerkholt (2017)– is an organizational history. The present article can thus also be read as an invitation to do more of this type of research. It is currently more associated to the study of economics from the perspective of other disciplines such as international political economy (e.g., Hall 1989; Ban 2016) and economic sociology (e.g., Fourcade 2009), although there seems to be a growing interest for this type of research among historians of economics (e.g., Alacevich 2009; Svorenčík 2014; Fontaine 2016; Cherrier 2017).

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the science of monetary economics since the late 1970s. We provide strong evidence for the claim that central banks have become dominant in this specialized scholarly community. This substantive contribution is not meant as the last word on the topic, but rather as an enticement to further study the recent role of central banks in economic science.

Our second contribution is methodological. We firmly believe that the research question should dictate the methods deployed. Our research question is about the importance or centrality of one type of organization – central banks – in a research community. Importance and centrality being matters of *degree*, this type of research question calls for quantification. More precisely, it requires mixing an understanding of organizational structures and paths – an understanding which is not primarily quantitative – with various measurements. We make no claim to novelty here. The importance of mixing sources and methods has been recognized for a long time by scholars advocating for more quantitative research in history (Aydelotte, Fogel, and Bogue 1972; Fogel 1975). In our case specifically, the qualitative information about the context is crucial to conceive the quantitative research protocol.

A clarification about our methodological point is needed. By claiming that some research questions in organizational history call for complementing the historian's toolbox with quantitative methods, we imply neither that this opportunity is specific to organizational history nor that there are research questions that are, in principle, incompatible with quantitative methods. It seems highly plausible to us that historical questions focused on ideas (rather than organizations) could at least sometimes benefit from these methods. After all, the work of one of us on the history of specialties in economics (Claveau and Gingras 2016) can be interpreted as an attempt to use some quantitative methods to map the importance of sets of ideas through time. Our point is also compatible with the possibility that questions could be answered by a clever use of quantitative methods although these questions are

typically interpreted as being non quantitative (Hubbard 2010). We do not want to engage in this potentially heated debate. Our point should be less controversial: if the question is clearly about *degree*, quantitative methods must be considered.

In the first two sections, we use the existing literature on central banking to establish broad characteristics of the tightening relationship between central banks and the science of economics. It gives the mostly non-quantitative understanding of organizational structures and paths on which a meaningful quantitative investigation must build. In these sections, our examples are drawn mostly from the European Central Bank, the Bank of England and the Federal Reserve (following the empirical focus in Dietsch, Claveau, and Fontan 2018). The next three sections turn to the quantification of the centrality of central banks in monetary economics. They support and make more precise the claims about a process of convergence between central banks and the science of economics. In these sections, we count heads, publications and impact in turn. Our first count (heads) uses data from the Federal Reserve only, but we argue that the historical pattern is indicative of a worldwide pattern. Our two other measurements cover all central banks. Methodological points are interspersed throughout the article.

Where our story starts: central banking as an esoteric art

In a 1981 paper called *The Art of Central Banking*, Karl Brunner nicely described key characteristics of central banks up to the 1980s:

> Central Banking [has been] traditionally surrounded by a peculiar and protective political mystique. […] *The mystique thrives on a pervasive impression that Central Banking is an esoteric art*. Access to this art and its proper execution is confined to the initiated elite. [...]

> Communication with the unitiated breaks down." (Brunner 1981, 5; cited in Goodfriend 1986, 64, our emphasis).

In this depiction, the overarching characteristic is that of an "esoteric art," which can be contrasted to science in at least two ways.

First, central banking was an art and not a science, if we rely on the once classic threefold distinction proposed by John Neville Keynes (1890) between positive economics, normative economics and the art of economics.[2] For J.N. Keynes, economic science is limited to the first two types, while the art of economics is about managing the economy. This art is more than the mere application of the generalizations of economic science to policy. Art involves know-how that builds on the appropriate personal character and is then perfected on the job.

In line with this distinction, the paradigmatic central banker for most of the 20th century was not an economist, but a strong, decisive and charismatic man. The power of the central bank over the economy at that time "depended more on the political leadership of [the] chairman than any other factors." (Kettl 1988). Central banking was seen as a "one-man practical performance" not closely tied to economic science (Marcussen 2009, 379–80; see also Conti-Brown 2016, chap. 3). Indeed, economic theory was taken to be too narrow to be compatible with the "discretionary, holistic, eclectic and pragmatic" style of the successful central banker (Marcussen 2009, 383).

A second way to contrast 'science' and central banking up to the 1980s is by reference to the Mertonian norms of science: universalism, communism, disinterestedness and organized skepticism (Merton 1973). With perhaps the exception of desinterestedness, central banking up to recently did not share what Merton presented as the normative structure of science.

2 For discussions of this distinction, see Colander (1992) and Hands (2001, 29–34).

A 1929 exchange between John Maynard Keynes and Sir Ernest Musgrave Harvey, then Deputy Governor of the Bank of England, exemplifies how much central bankers's understanding of their mission clashed with the scientific ideal. During the hearings of the *Committee on Finance and Industry* in the aftermath of the stock market crash, Harvey defended the opaqueness of his institution:

> **Committee member John Maynard Keynes:** [I]s it a practice of the Bank of England never to explain […] the reasons for its policy?
>
> **Harvey**: It is a dangerous thing to start giving reasons.
>
> **Keynes**: Or to defend itself against criticism?
>
> **Harvey**: […] As regards defence against criticism, I am afraid, though the Committee may not all agree, we do not admit there is need for defence; to defend ourselves is somewhat akin to a lady starting to defend her virtue. (Committee on Finance and Industry 1931, 30–31).

In the same hearings, Keynes emphasized that the opaqueness of the Bank of England was detrimental to what Merton calls organized skepticism:

> **Keynes:** Does not the policy of secrecy as to its intentions deprive the Bank of what I might call the collective wisdom of the community? These questions are very difficult and very novel. They require a great deal of co-operative thinking by all people who are competent to contribute to the common stock. Does not the policy of secrecy of the Bank mean that no one outside the Bank can express an opinion which is founded on sound information? (Committee on Finance and Industry 1931, 31)

In short, our story begins with a situation where central banks are distant from economic science both in terms of the type of knowledge they rely on and in terms of norms they abide by.

Esoteric art no more: scientization and economic science

The picture of central banks we have painted so far does not correspond to the current state of these organizations. Foremost, they have been engaged in a process that Martin Marcussen (2009) calls "scientization." For Marcussen, the scientization of central banking is closely related to the Weberian concept of "rationalization," i.e., the broad historical process in modern societies to increasingly rely on standardized, calculable rules and thus diminish the importance of tradition and mystical powers in decision making.[3] The "mystical art" of central banking described previously was in tension with the rationalization of modern societies. Through a series of changes in the late 20th and early 21st centuries, central banks have moved closer to archetypal technocratic organizations.

What Marcussen subsumes under the concept of scientization is thus a wide-ranging process of change. For instance, it includes a shift away from "one-man show", and toward committee decision-making. Indeed, monetary policy committees have been gradually implemented in most central banks. Marcussen argues persuasively that a characteristic such as committee decision-making, although it might seem to have little to do with 'science', participates to a coherent dynamics of change that can justifiably be labeled 'scientization.'

Since the main concern of this article is the changing relationship between central banking and economic science, instead of further documenting the wider trend highlighted by Marcussen, let us now selectively take characteristics emphasized in the literature on the recent history of central banking to come to focus on our topic. Firstly, scientization implies a significant increase in the transparency of central banks (Goodfriend 1986; Blinder et al. 2001, 2008; Issing 2005; Eijffinger and Geraats 2002; Warsh 2014; Jabko 2009; Dincer and Eichengreen 2007). While central bankers used to base their

3 The process described by Weber was well underway already in the early 20th century. What is striking is how long it took for central banks to follow along.

power on their mysteriousness, they have come to maintain exactly the opposite: they now strive to be highly predictable to market participants and to extensively communicate with the broader public. Although transparency is typically defended by central bankers on grounds of policy effectiveness and accountability (Dietsch, Claveau, and Fontan 2018, 82–86), it also brings central banking closer to the normative structure of science. In particular, it facilitates organized skepticism.

Secondly, central bankers have become a transnational "epistemic community" (Kapstein 1992; Haas 1992), developing a distinctive "macro-epistemic culture" (Knorr Cetina 2007). This community has progressively built a consensus around transnational epistemic norms and good practices (Johnson 2016). Central banking is thus becoming less national; it now approximates science in striving for universally valid answers. This worldwide epistemic culture among central bankers was created and is now sustained through extensive interactions between central bankers. For instance, there has been a significant change in the composition of the guest list for the high-profile, annual gathering organized by the Federal Reserve Bank of Kansas City in Jackson Hole: the proportion of "market participants such as Wall Street economists" fell from 27% in 1982 to 3% in 2013, while the proportion of non-US central bankers increased from 3% to 31% (The Economist 2014, reproduced in Bea 2016).

By being more transparent and by being part of a transnational epistemic community, central bankers come closer to the ethos of science, but why do we emphasize *economic* science among all sciences? The third point to make is that the human composition of central banks has shifted. Bankers and lawyers used to be dominant (Conti-Brown 2016, chap. 4). Anecdotally, Theresa May, the current Prime Minister of the United Kingdom, started her career at the Bank of England in 1977. Although she was a geography graduate, she worked in the Economic Intelligence Department.[4] Things have radically changed. Today, the research divisions of central banks are staffed almost exclusively by

4 May mentioned this anecdote at the *Independence – 20 Years on* Conference of the Bank of England on September 28th 2017. See the sixteenth minute of the recording at https://youtu.be/0ZKU2TUAxvw (accessed on February 2nd 2018).

economic PhDs, and most individuals sitting on the decision committees also hold PhDs in economics from a set of elite institutions (Bea 2016; Lebaron 2012; Lebaron and Dogan 2016).

Why do they hire all these research economists? Our fourth point is that the same justification is repeatedly given: central bankers assert that sound policy must build on "cutting edge economic thinking" (Jean-Claude Trichet cited in Mudge and Vauchez 2016, 153). The website of the European Central Bank is categorical: "[T]horough analysis forms the basis for decisions in all policy areas" and "high-quality research with a strong conceptual and empirical basis is vital as it provides the ECB with the tools it needs to conduct its single monetary policy" (ECB 2016). Another stark example comes from the Bank of England who launched, in 2014, a strategic plan emphasizing "analytic excellence" and the development of a "single research agenda" as means to promote "the good of the people of the United Kingdom" (Carney 2014).

Lastly, the tighter relationship between central banking and economic science is not a one-way street where academia supplies researchers and new ideas, while central banks turn these resources into policy precepts. In other words, the function of economic research in central banks is not solely (and, today, perhaps not even primarily) directed toward producing results directly relevant to decision making. Central bank research also aims to contribute to the scholarly literature. We have a two-way, multilane boulevard.

Concretely, this two-way relationship takes at least two forms. First, central banks have huge visiting scholars programs (Mudge and Vauchez 2016) and have official collaboration networks with universities (Fase and Vanthoor 2000). Second, research economists hired by central banks are *expected* and *incentivized* to do scholarly research in addition to policy-oriented work. Fase and Vanthoor (2000, 24) summarize their discussion with the Richmond Fed:

> Basic research is regarded as important not only with a view to recruiting new economists, but also for extending the sounding board for the policy discussions in the FOMC.[5] The [Federal Reserve System] was under severe criticism in this respect in the 1970s, which is why the Reserve Bank of Richmond does less of the rather superficial policy analysis and more, deeper theoretical research.

Terms such as "basic" and "deeper" are standard ways to express a scientific ethos, a character now widely shared by central bankers. For instance, former Fed's Governor Gramlich explains: "[A]s a former academic, I should also stress that *research is in a sense its own reward* – it stimulates clearer thinking, better behavioral models, more-efficient data collection, and in general more knowledge about the way community processes work" (Gramlich 2001, our emphasis).[6]

In sum, a key characteristic of the scientization of central banks is a tightening of the relationship between central banking and economic science. Most importantly for us, central banks seem to have become key actors in the scholarly field of monetary economics. But how much so? How central are central banks today in the scholarly community? These questions are about 'degrees' or 'how much'. They call for quantitative methods. In what follows, we contribute to the literature on the scientization of economics by documenting the increasing centrality of central banks in monetary economics.

Since this article also has a methodological goal, our mode of exposition will be peculiar. First, we want to emphasize how the process of quantification is *exploratory*, in the sense that the initial question gets refined as we progress. By displaying this exploratory process, the rest of the article does not follow the typical structure of a quantitative article (conceptual background, data, method, results, analysis). Second, we will put particular emphasis on points of method, for instance, on data limitation

5 FOMC stands for Federal Open Market Committee. By statute, the FOMC is the decision body for the Fed's monetary policy.

6 There are numerous official discourses going in the same direction, e.g., Kohn (2004); Mester (2006); Mishkin (2007), Papademos (2007).

and on the necessity, when our goal is measurement, to draw sharp distinctions where there are in fact shades of gray.

How big in terms of brain power?

Researchers are an important input of science. If the research staff of central banks has grown vigorously, a necessary (but not sufficient) condition for central banks to transform into scientific powerhouses would be met. Quantitative empirical research can help us assess whether this condition is met.

Although we aim only at counting heads, it is not a trivial matter for at least two reasons. First, there is the issue of data accessibility. There are hundreds of central banks worldwide and we need data through time to assess whether their research staff has grown. It would be possible to collect much of this information with a lot of labor. Alternatively, we can focus on one institution and provide evidence that the pattern found for this institution is generalizable. Using this second strategy, we propose to use the US Federal Reserve. It is a reference in the world of central banks, especially for its research. And we have numerous testimonies from other central banks to the effect that they aim to emulate the Fed in terms of research prowess. For instance, an ECB manager recalled in 2015 the early days of research in his organization: "the plan was to do as well as the Fed; that's the plan; we were led by the US example and the Anglo-Saxon tradition that has a strong scientific tradition; that's the paradigm." (quoted in Mudge and Vauchez 2016, 156)

The second difficulty is to decide which heads to count. In a central bank, there are archetypal cases of employees doing mostly research and employees doing mostly other things, but the line between the two groups is blurry. It is however crucial to draw a line and to keep the same line through time for the temporal comparison to be meaningful. At the Fed, there are positions of 'research economists' at the

Board of Governors and at the twelve regional banks. These employees are certainly not the only ones doing mostly research at the Fed, but they are demarcated enough to be followed through time.

Tracking the number of research economists through time at the Fed, especially given its 13 branches, could be laborious. Fortunately, we can rely on two reports. The first report was made by Alan Greenspan in August 1993 as a response to an inquiry from the House Banking Committee. Greenspan offered a table with the number of persons employed by the Board and by the regional banks for four types of positions: officers, economists, statisticians and professional support staff (table reprinted in Auerbach 2008, 41). The first column of Table 1 reproduces Greenspan's numbers for the type 'economists'. The 360 economists represent less than half of the 730 positions counted in the 1993 table. It is thus crucial to count the same type of persons later in time.

Table 1: Number of staff research economists in the Federal Reserve System since 1993. See the text for the sources for each column

	1993	2003	2017
Board of Governors	189	220	392
Regional Banks	171	275	416
Total	360	495	808
Average annual growth rate:		3.2 % (1993-2003)	3.6 % (2003-2017)

The second report is from an article by Lawrence H. White (2005, 330) in which he presents data from Fed websites accessed in January 2003. Seemingly without being aware of Greenspan's report a decade earlier, he counts the same type of employees, explicitly identifying them as 'economists' that are neither visiting scholars nor consultants.

These two reports give the temporal depth required by the core question of this section, what remains for us is to count the research economists employed today by the Fed. Each of the 13 websites of the Fed (the Board and the twelve regional banks) has a page in its 'research' section with a list of 'people' that can be counted. Most of that counting is straightforward and can even be partially automated using a simple search on the relevant markup in the html source code.

There is however some amount of educated guess involved because the type 'research economist' is presented differently from one website to the next. For instance, should we count the employees listed as "policy professionals" and "supervisory policy analysts"? More importantly, should we count the more than hundred employees on the Board's webpage *Meet the Economists*[7] who have titles implying that they have managing duties (e.g., "chief," "director," "manager")? To validate that the needed judgment calls do not lead to arbitrary numbers, we used a procedure to check for intercoder reliability, i.e., the extent to which two persons coding a sample for a specific characteristic tend to reach the same conclusion. In late October 2017, both of us visited the 13 websites independently of the other to count the research economists. Our only rule was to count all and only the types of employees that the 1993 and 2003 exercises had probably counted. Since the previous reports did not say much about the procedure used, uncertainty was significant.

We came back with numbers close to each other. We both counted 392 research economists at the Board. For the regional banks, one of us reached 424 while the other stopped at 408. Since this difference is not big enough to warrant an in-depth analysis of what made us diverge, we report the average of our two results in Table 1.

With a measured average annual growth rate of more than 3 % since the early 1990s, staff economists at the Fed have more than doubled in 25 years. With around 808 research economists in late 2017, the

7 https://www.federalreserve.gov/econres/theeconomists.htm (last accessed February 2nd, 2018)

institution has a small army at its disposal. Yet, we would like to have a point of comparison. Is 808 economists a lot?

A basis for comparison is with the economists working on similar topics in academia. White (2005, 329) estimates that the 495 economists that he counts at the Fed in 2003 represent "27 percent more macro/money/banking economists than the top 50 US academic economics departments put together." This figure indicates that the Fed's research staff is, no doubt, 'big'.

It would be even better to be able to have the Fed economists as a ratio of all US economists with the relevant specialty (mostly monetary economics), but the denominator of this ratio is subject to even more uncertainty than the one surrounding the numerators reported in Table 1. Auerbach (2008, 142) reports that "[i]n 1992, roughly 968 members of the American Economic Association (the largest association for economists in the United States) designated 'domestic monetary and financial theory and institutions' as their primary field, and 717 designated it as their secondary field." If we take the sum to estimate that around 1700 US economists had the relevant specialty in the early 1990s, the numbers reported by Greenspan in the same period suggest that the economists in the Fed's staff amounted to around 21 % of the specialists in the United States.

What about today? Unfortunately, we cannot directly reproduce Auerbach's measurement because the fields into which AEA members classify themselves have changed.[8] We nevertheless attempted to circumscribe as best we can the relevant specialty, which corresponds to the union of the following three JEL codes: E3 (Prices, Business Fluctuations, and Cycles), E4 (Money and Interest Rates) and E5 (Monetary Policy, Central Banking, and the Supply of Money and Credit). The directory of members on the AEA website can be search by specifying these fields. The web interface is however limited in that the user can only search for 'JEL Primary', not for 'JEL Secondary', although members do report

8 It is probable that, in the early 1990s, AEA members used a previous version of the JEL codes, the classification system having been revamped exactly around that time. For a history of the JEL codes, see Cherrier (2017).

their secondary field. Since this last information is in the database, the way to circumvent the limitation of the interface is to manually complete the query string with 'JEL Secondary'. As of October 30th 2017, such a search in the AEA directory returns 1723 economists with the relevant specialty.

This number of specialist economists is surprisingly similar to the one arrived at by Auerbach in the early 1990s. Is it probably due to the fact that our procedure is not counting exactly the same type of heads. Yet, our selection of JEL codes is defensible. It thus seems that our number can be used to compute the relevant ratio: today, economists in the Fed's staff represent 47 % of the AEA members with the relevant specialty. Although the comparison can only be rough, we have strong evidence that the Fed's research staff has significantly grown in relative terms between the early 1990s and 2017, from 21 % to 47 % according to our indicator.[9] As we indicated at the beginning of this section, there is ample evidence that, during the same period, other central banks worldwide have been in catch-up mode relative to the Fed with respect to their research staff. We can thus tentatively conclude that the measured trend is not a US anomaly.

How big in terms of scholarly research output?

Establishing that the brain power of central banks has grown significantly in the last decades, both in absolute and relative sizes, does not say much about the extent to which central banks have become more important in the scientific field of monetary economics. It is possible, for instance, that most of these new researchers do only policy work, i.e., research with the primary goal of informing decision makers inside their organization. Under this hypothesis, central banks would indeed produce much more research, but not more work that is intended as scholarly contributions to economics. An

9 There is one consideration suggesting that our ratio, in fact, underestimates the growth in the proportion of monetary economists working for the Fed. Given that central bank research staff have moved closer to the science of economics, it is plausible that a higher proportion of them now sign up to the AEA, thus boosting the total count of monetary economists at the AEA in contrast to early 1990s. It is thus plausible that the true increase in the share of economists is even more extreme than what our data indicate.

alternative hypothesis is that a great chunk of the research effort of the staff is directed toward scholarly rather than primarily policy output.

According to the evidence provided in a previous section, we already know that research contributions in central banks nowadays are not only meant as direct aids to decision making. But to measure the *extent* to which central banks have become a significant voice in the scholarly literature, we turn to scientific journals. Our question can be put thus: Do scientific articles published by central bank staff represent a growing proportion of publications in the *relevant specialty*? This is a question about relative importance. Since Clarivate's Web of Science includes the affiliations of authors, we can potentially answer this question by identifying the authors affiliated to a central bank[10] and then compute the ratio through time of the number of articles with central bank authors to the number of all articles.

One issue stands in the way of this quantification: we need to define which publications are in the relevant specialty. An extremely permissive corpus would include all economics journals. We reject this option because central bank authors would be lost in the ocean of all economists. We do better to restrict ourselves to journals specializing in monetary economics. The problem now is that there are gray zones between monetary economics, general macroeconomics, financial economics, and so forth. Our strategy is to select journals based on the self assessment of central banks. A report on research at the ECB explains that the organization has "a point system that ranks journals into four groups [… that] correspond to standard journal rankings, with the exception that monetary-focused journals are given greater priority." (Freedman et al. 2011, 19) The accompanying footnote indicates the specialized and prioritized journals: "the *Journal of Monetary Economics* [JME] is placed in the top group and the

10 Concretely, we identified authors from central banks in our database mostly based on the field reporting institutions. The coverage of this field is extremely good: for our three main journals, 97.3 % of articles have at least one associated institution and this proportion is not declining as we move back in time (which is a rare property for bibliometric data). To further improve our coverage to 98.8 % of the articles, we used the email addresses of authors. When computing all proportions reported in this section, we excluded the small fraction of articles (or authors) without an affiliation.

Journal of Money, Credit and Banking [JMCB] and the *International Journal of Central Banking* [IJCB] are placed in the second group." These three journals thus seem like a relevant corpus to answer our question.

[Figure 1 around here. Caption: Fraction of articles in the three main specialized journals with at least one author working at a central bank]

Figure 1 indicates a clear positive trend toward publications authored by central bank staff. The progression is impressive: from around 15 % of the publications around 1980 to more than 50 % in our last recorded year (2015).[11] This indicator tells us that central banks are a lot more present in the specialized scientific journals than they were.

Can we trust this indicator? The first worry might be that we should not include the IJCB, which is both of recent origin (2008) and "an initiative of the central banking community."[12] It can be hypothesized that the recent impressive performance of central banks in Figure 1 is in great part due to the inclusion of this journal for the last eight years of our corpus. It is indeed the case that this journal has a higher percentage of articles signed by central bank staff (63 % over the eight years), but the number of its articles per year is so small that it has only a marginal impact on the general trend. Excluding it reduces the fitted average annual growth rate from 3.8 % to 3.6 % and the peak in 2015 from 52.5 % to 50.6 %.[13] Furthermore, it seems appropriate to interpret the creation of this journal has a further indication of the incursion of central banks into the territory of economic science: central banks federating their efforts to create a high-profile journal in their scientific specialization.

11 With such a strong trend, there is really no need for inferential statistics to assess whether we can reject the hypothesis that it is just noise around a stable mean (the p-value associated to this null hypothesis is smaller than 10^{-9}).

12 http://www.ijcb.org/about/purpose.htm, accessed January 12th 2018. It is "sponsored" by many central banks worldwide, see http://www.ijcb.org/about/sponsors.htm .

13 See Dietsch, Claveau and Fontan (2018, 89) for the same figure, but excluding the *International Journal of Central Banking.*

A second worry might be that our Figure 1 is mostly driven by the fact that the number of collaborations has increased. Since the average number of authors per article has steadily gone up, random sampling among a stable pool of authors would imply a positive trend for the share of articles with *at least one* author from a central bank. Two points must be made to address this worry. First, even if coauthorship was the main driving force for the pattern in Figure 1, it would still be strong evidence for the growing integration of central banks in economic science. Second, the composition of the pool of authors is not stationary: as Figure 2 indicates, the percentage of authors from central banks increases at only a slightly less rapid rate of 3 % than the rate reported in Figure 1.

[Figure 2 around here. Caption: Percentage of authors in the three main specialized journals working at a central bank]

A last worry is the converse of the first: perhaps we include too few publications. These three journals are arguably not the only journals specializing in monetary economics. Is the sharp increase in the share of articles robust to the addition of other journals?

Adding journals to our corpus should be done carefully for at least two reasons. First, there is the issue of the gray zone between monetary economics proper and adjacent specialties. Two journals that are *prima facie* good candidates for our corpus are the *Journal of International Money and Finance* (JIMF) and the *Journal of Banking and Finance* (JBF).[14] But, on closer inspection, both journals are significantly more in the gray zone than our original sample. JIMF presents itself as an hybrid between "international monetary economics" (highly relevant for us) and "international finance" (less relevant).[15] Even further toward the dark zone, JBF does not even list monetary economics or central

14 Thanks to Emmanuel Carré for inciting us to look at other journals.
15 https://www.journals.elsevier.com/journal-of-international-money-and-finance/, accessed January 19, 2018.

banking among its "main subjects".[16] By including these journals, we might thus capture publication dynamics that have little to do with central banking.

[Figure 3 around here. Caption: Annual number of articles in five journals]

Second, including journals that are booming in size can lead to misinterpretations if we only look at shares of publications. Figure 3 shows that some journals are growing a lot faster than others in terms of the number of published articles per year. The two main journals in our corpus (JME and JMCB) are growing slowly since the late 1970, their annual growth rate averaging at 1.7 %. The last journal in our corpus, IJCB, is growing fast (7.7 %), but started with only a few publications per year in 2008. The two journals that we introduced in the previous paragraph, JIMF and JBF, have different dynamics: they have grown at remarkable speeds for a long time (at respectively 4.4 % and 7.1 % per year). The dynamics of JBF since 2000 is most surprising: it has grown at an annual rate of 9.8 %, which implies that it has published in the last five years (2011-2015) as many articles as the four other journals combined.

With these annual growth rates and given that JIMF and JBF are not squarely specialized in monetary economics, we should not expect central banks to come to dominate these journals as they did in our corpus. A more appropriate metric, if we focus on these two journals, might be the *absolute* number of papers authored by central bank staff rather than their share of the total. Figure 4 shows the evolution of this number. It has been growing at a fast pace of 7.3 % per year since the 1980s, slightly faster than the two journals combined (6.9 %).

[Figure 4 around here. Caption: Number of articles in JBF and JIMF with at least one author working at a central bank]

16 https://www.journals.elsevier.com/journal-of-banking-and-finance/, accessed January 19, 2018.

Particularly relevant here is the comparison with the growth in the brain power at central banks (see the previous section). If we can use the annual growth rate in research staff at the Fed as a proxy for the growth of brain power across all central banks, we reach the conclusion that the annual growth rate in the published output of central banks in these two journals (7.3 %) is twice as large as the rate of their labor force (around 3.5 % based on Fed data). We also notice this increasing labor productivity if we take the five journals together: year on year, central banks manage to publish on average 4.9 % more articles in these journals.

How significant in terms of research impact?

Central banks have a growing research army, and this force is increasingly oriented toward scholarly publications. These two claims have been supported by quantitative evidence in the previous sections. Are these results sufficient to establish a more generic conclusion about a growing dominance of central banks in monetary economics? One reason to refrain from embracing such a conclusion at this point is that dominance is mainly about impact and we have not established impact so far.

In science, a standard metric of impact is citations (Garfield 1955, 109; Cole and Cole 1967, 379; Gingras 2016, 32–33). It is possible that, although central banks publish a lot in scholarly journals and increasingly so, their work is little used by other researchers. Articles sponsored by central banks might have little uptake. Conversely, are these articles noticed by the scholarly community and thus regularly cited?

To answer this question, we go back to our corpus of three specialized journals (JME, IJCB, JMCB) and study citation patterns. From the Web of Science again, we can retrieve the number of citations of each article in our corpus. We can thus assess whether articles produced by at least one central bank employee tend to be more cited than articles from elsewhere.

Citations are a type of impact that accumulates through time. An article published many years back has had more time to accumulate citations than a more recent paper. It is thus an unfair comparison to compare directly their number of citations. Since we want to compare documents published at different points in time (from 1976 to 2015), we use the standard procedure of normalizing the citation count of each article by the average number of citations of articles published in the same year. We call this ratio the 'normalized impact' of an article.

[Figure 5 around here. Caption: Sample distribution of normalized impact conditional on central bank authorship]

Figure 5 depicts the sample distributions of normalized impact conditional on whether or not the articles have at least one author from a central bank. A rightward shift of the distribution implies a higher probability of large impact. The figure indicates that publications from central banks have a larger impact. More specifically, the mean of their distribution is 15 % higher and the median is 33 % higher than the same statistics for the normalized impact of the other articles. But can this be accounted for by sampling error? What is the probability of having such a rightward shift in the distribution of the central bank subsample although the population distribution is the same regardless of the composition of authorship?

These are questions in inferential statistics. Because citation data are not distributed normally, these questions are typically answered with a Mann-Whitney-Wilcoxon test. The null hypothesis is that an article randomly selected from the central bank subsample is as likely to have a higher normalized impact than a randomly selected article from the subsample without central bank authorship. Given the pattern in Figure 5, our alternative hypothesis is that it is in fact more likely (one-sided test). The result of the test, with a p-value of 0.000005, tells us that the null hypothesis can be confidently rejected.

[Figure 6 around here. Caption: Comparison between mean and median citations of the two subsamples (with or without central bank authors). A bar above the origin signals that articles with at least a central bank author have the advantage in terms of mean or median citations in that year. A bar below the origin signals the opposite. The two gray, dotted, vertical lines are added to the data to signal what are called 'three chapters' in the main text. Citations in this analysis are not normalized by mean citations for the year.]

The articles with authors from central banks thus tend to have more impact over the period covered by our corpus (1976-2015). Is there also a temporal pattern to this higher impact? Figure 6 is meant as a tool to detect such pattern. It reports two measures of central tendency for the distribution of raw (that is, not normalized) citations: the mean and the median. The values reported in the Figure are:

$$y = \log(M(\text{cit}_{\text{cb}}) / M(\text{cit}_{\text{not cb}})) \quad (1)$$

where 'log' stands for the natural logarithm, M is the measure of central tendency used (either the mean or the median), cit_{cb} stands for the citations of articles with a central bank author and $\text{cit}_{\text{not cb}}$ for the citations to the rest of the sample. How should each bar be interpreted? Take the value $y = -1.15$ for the logarithm of mean ratio in 1976. Because it is negative, it indicates that articles with *no* central bank author have more citations on average. The extent of this advantage is given by the absolute value of y: $e^{1.15} = 3.16$, which means that average citations for the subsample without central bank employees is more than three times the average citations for articles with central bank staff (the actual means are respectively 23.9 and 7.6). The ratio of medians is similar in that year (ratio of 4 in favor of the subsample without central bank authorship; the actual median values being 4 and 1 respectively). If we take the year 1991 instead, the situation is pretty much reversed: the subsample with central bank authors has the advantage in terms of impact, by a factor of 3.76 for the mean value (means of 71 versus 18.9) and by a factor of 4.36 for the median value (30.5 versus 7).

The historical pattern in Figure 6 can be roughly divided in three chapters. From 1976 to 1984, visual inspection of the Figure leads us to believe that the subsample with central bank authorship tends to have *lower* impact. Then, from 1985 to 1999, relative impact fluctuates dramatically from year to year. With hindsight, we can say that this chapter was transitional because, since 2000 (the third chapter), articles from central banks have a clear lead.

Is this story supported by statistical testing? Yes. Running the appropriate Mann-Whitney-Wilcoxon test on each chapter gives us results compatible with this story. For the corpus between 1976 and 1984, we ran a one-sided test, the alternative hypothesis being that the articles *not* authored by central bank staff tend to have a greater normalized impact. The p-value of this test is 0.069, which gives a mild reason to reject the null hypothesis. For the second chapter (the transitional chapter from 1985-1999), a two-sided test gives a p-value of 0.2, definitively not low enough to warrant the claim that the two distributions are not identical. Finally, a one-sided test on the last chapter (2000-2015) gives us strong reasons to reject the null hypothesis in favor of the claim that articles from central banks tend to have more impact ($p = 0.0002$). For instance, the mean normalized impact of this subsample is 23 % higher than the same measure for the other subsample.

A story about the evolution of impact is emerging, which could be summarized thus: from a situation in the late 1970s and early 1980s when central bank authors tended to produce articles with less impact, we have transitioned to a situation since the early 2000s where the impact per article of central bank employees in the scholarly literature tends to be higher than other authors.

Some scholars with a strict interpretation of statistical testing might worry that our p-value of 0.069 for the first chapter of our story is not low enough to warrant the claim that central bank authors in the early 1980s were generally less impactful than other authors. A blunt reply to this criticism is that it

suffers from "the cult of statistical significance" (Ziliak and McCloskey 2008): we should not blindly follow conventions such as a significance level of $\alpha = .05$ in assessing empirical hypotheses.

If we are willing to be a little more technical, we can provide a subtler answer to the scholars worrying about the first chapter of our story. Here is this alternative answer. P-values are meant to give the probability of type I error, that is the probability of rejecting the null hypothesis while it is true. We should also consider the probability of type II error, that is not rejecting the null hypothesis while it is false. Since the sample in this first chapter of our story is not big – i.e., there are only 117 articles from central banks – our test plausibly suffers from weak power. We can thus make the hypothesis that it is improbable to strongly reject the null hypothesis in chapter 1 even if one subsample comes from a population with a higher impact. Can we support this hypothesis?

Here is one way. Imagine that the data generating process for the two subsamples in chapter 1 (1976-1984) is the same as in chapter 3 (2000-2015), but with only two differences. First, the identities of the two samples are swapped such that articles *not* from central banks become more impactful (i.e., our alternative hypothesis for chapter 1 holds). Second, the sample sizes are the ones of chapter 1. The question is now: what is the probability that a one-sided Mann-Whitney-Wilcoxon test on these data return a p-value lower than what we got (i.e., 0.069)? In other words, knowing that the alternative hypothesis is true in this case, what is the probability that we will indeed accept this hypothesis given that we require a p-value lower than the one we got from our actual test? To answer this question, we ran a Monte-Carlo simulation (10,000 repetitions, sampling with replacement). The probability of accepting the alternative hypothesis (i.e., the power of the test) turns out to be around 0.49, which means that being more demanding implies that we would commit a type II error in more than half of the cases. For instance, if we set the significance level at the usual $\alpha = .05$, the probability of this error rises to 0.58. In short, this simulation exercise indicates that given the sample size of the corpus in

1976-1984, it is improbable to have a really low p-value even if one subsample comes from a population with a higher impact.[17]

We should not get lost in technical details. The analysis in this section supports the story of central banks becoming (more) dominant in the scholarly community on monetary economics: the balance of relative impact, measured by the distribution of citations, is now tilting in favor of articles from central banks while the opposite was likely true in the late 1970s and early 1980s. This is a noteworthy trend, but we should not radicalize its significance. The *extent* of the shift must be considered. We are not talking about central banks starting from a state where they were not cited at all to a situation where only articles from central banks get attention. If we take the relationship between *mean* citations as a (rather limited) indicator of the extent of relative impact, the picture is the following. For articles published between 1975 and 1984, the ones authored by at least one central bank employee have had, on average, only 63 % of the citations to the other group of articles. In contrast, the same ratio has grown to 123 % for articles published between 2000 and 2015. This shift is clearly big enough to be worth mentioning.

Conclusion

Already in 1993, Milton Friedman worried about what he saw as the dominant position of the Fed in US economics:

> [H]aving something like 500 economists is extremely unhealthy. […] it is not conducive to independent, objective research. […] [T]he location of the economists in the Federal Reserve has had a significant influence on the kind of research they do, biasing that research toward

17 If we run a similar Monte-Carlo simulation on the sample sizes of chapter 2 (1985-1999), the results are quite different. Around 85% (instead of 49%) of the runs give p-values that are lower than the one produced by our test (p = .2). It is thus probable that, in this case, our failure to reject the null hypothesis is not due to the weak power of our test.

> noncontroversial technical papers on method as opposed to substantive papers on policy and results. (Friedman cited in Auerbach 2008, 142)

This article has not assessed whether the situation is "unhealthy," we started this assessment elsewhere (Dietsch, Claveau, and Fontan 2018, chap. 4). What we have done here is to supply evidence that the worldwide dominance of central banks in the science of monetary economics has steadily increased since Friedman voiced his concerns in the early 1990s. Central banks have swelling research armies, they publish a growing share of the articles in specialized scholarly journals, and these articles tend to have more impact today than the articles produced outside central banks.[18]

At a methodological level, we mean to advocate that some research questions in organizational history call for quantitative methods. More specifically, our point is that this quantification must insert itself in a broader research protocol, which supplies qualitative information on the organizational context. Knowledge of this context first suggests what could be worth quantifying. It then gives interpretive thickness to the numbers. For our case, the context includes a general process of scientization of central banking and, more narrowly, a clear will by many central banks to be leaders in research. In this context, the stark progression in the dominance of central banks indicated by our numbers signals that central banks have been enormously successful in their attempt to be indispensable 'scientific' organizations.

18 Some aspects of the centrality of central banks in economic science have been left unexplored here. First, the growing share of central bank staff among monetary economists might be due to the an exiting of academic economists from the specialty. Second, the growing impact (in citation terms) of central bank research might be due to the fact that researchers from central banks disproportionally cite each other now. Third, there is also an aspect of dominance in science that we have not measured: scientific dominance implies gatekeeping, i.e., being in a position to decide what counts as publishable research (e.g., through editorial board membership or referee work). These are questions for future quantitative research. Here is a first result about gatekeeping: among the 33 editorial board members of the Journal of Monetary Economics in August 2017, only 8 had never been on the payroll of a central bank (although they had all 'visited' one) while 16 were still employed by a central bank, mostly the Fed (Dietsch, Claveau, and Fontan 2018, chap. 4).

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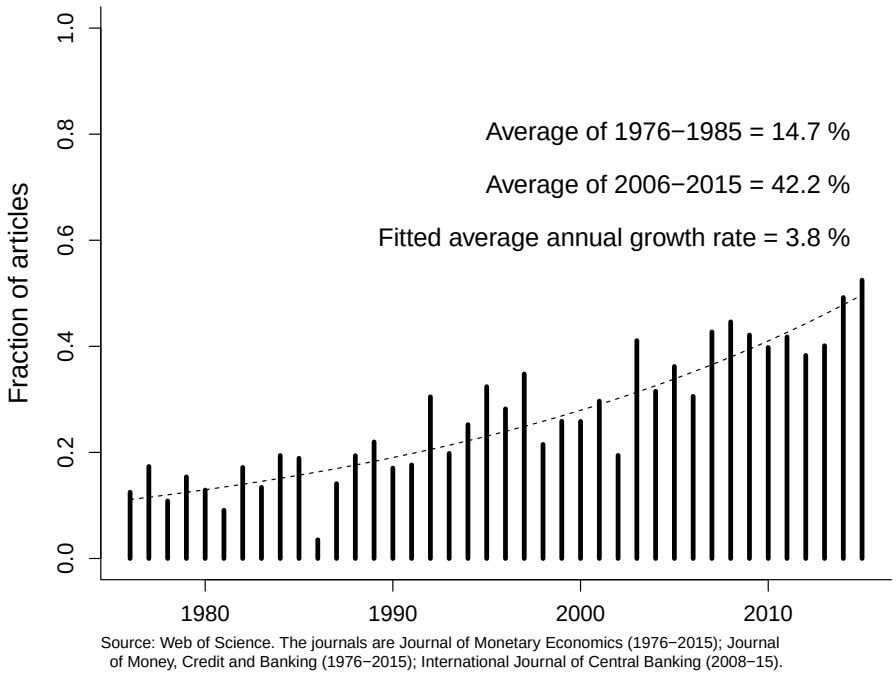

Figure 1: Fraction of articles in the three main specialized journals with at least one author working at a central bank

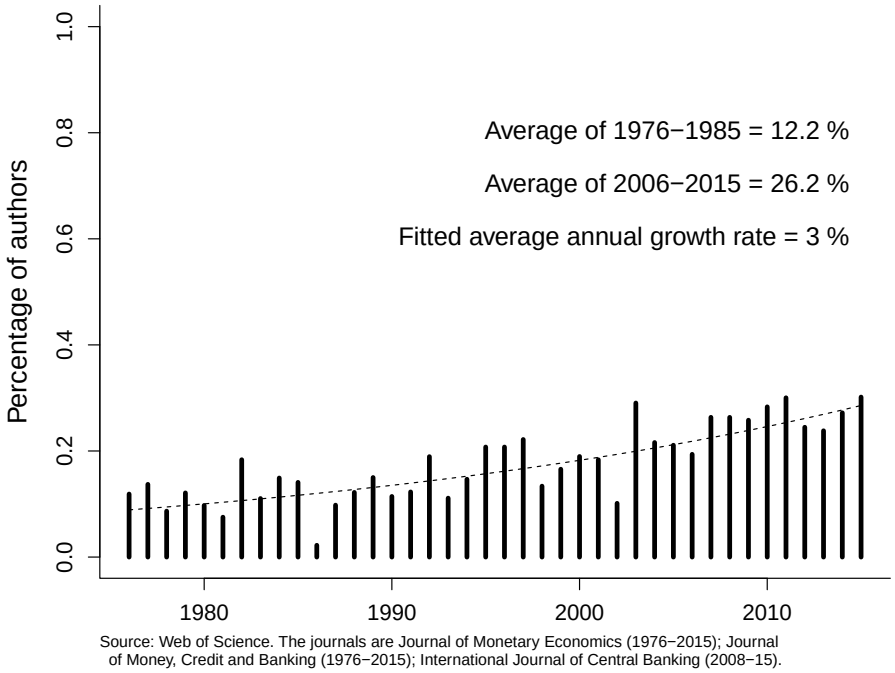

Figure 2: Percentage of authors in the three main specialized journals working at a central bank

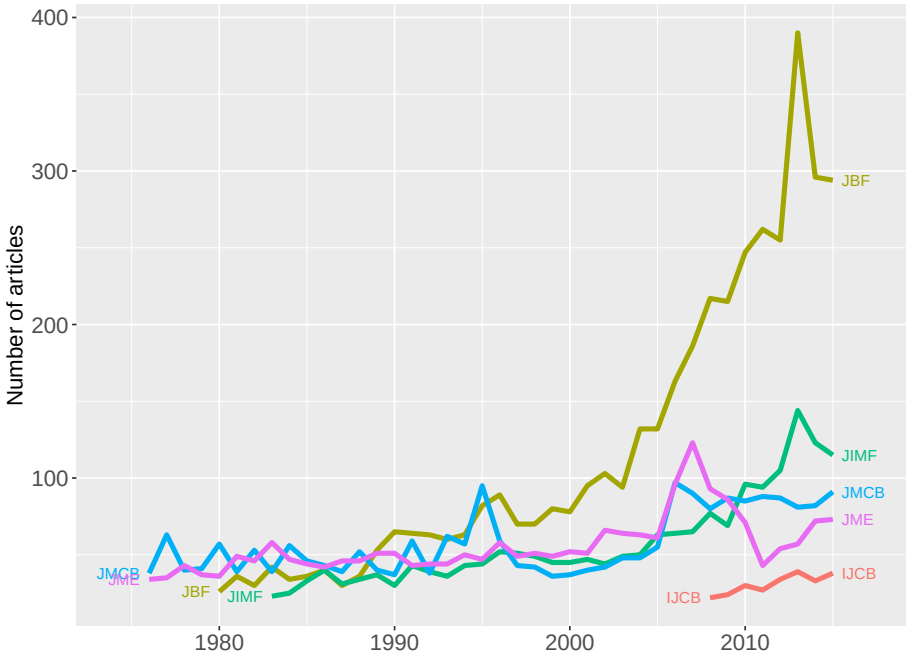

Figure 3: Annual number of articles in five journals

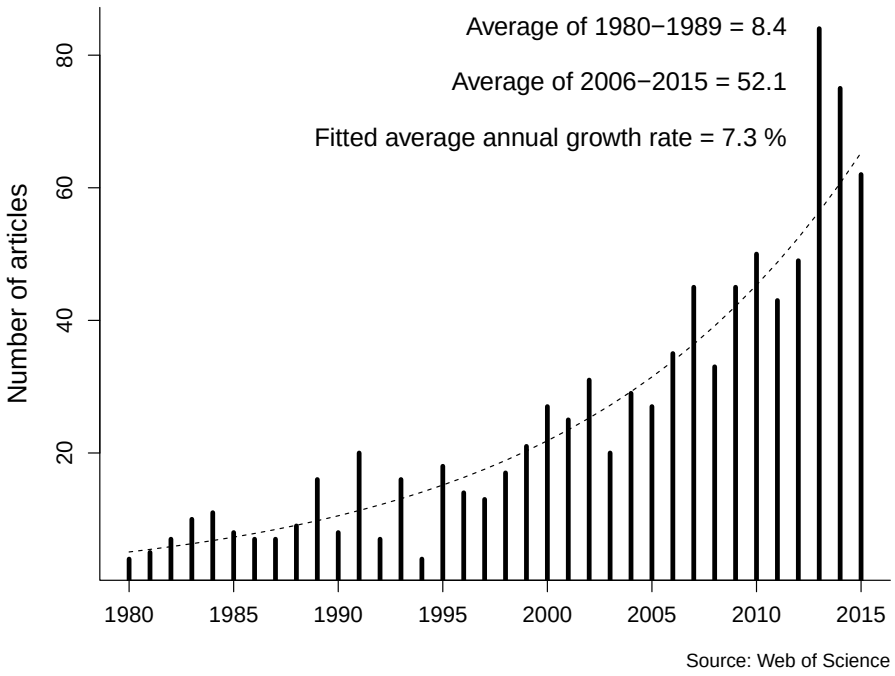

Figure 4: Number of articles in JBF and JIMF with at least one author working at a central bank

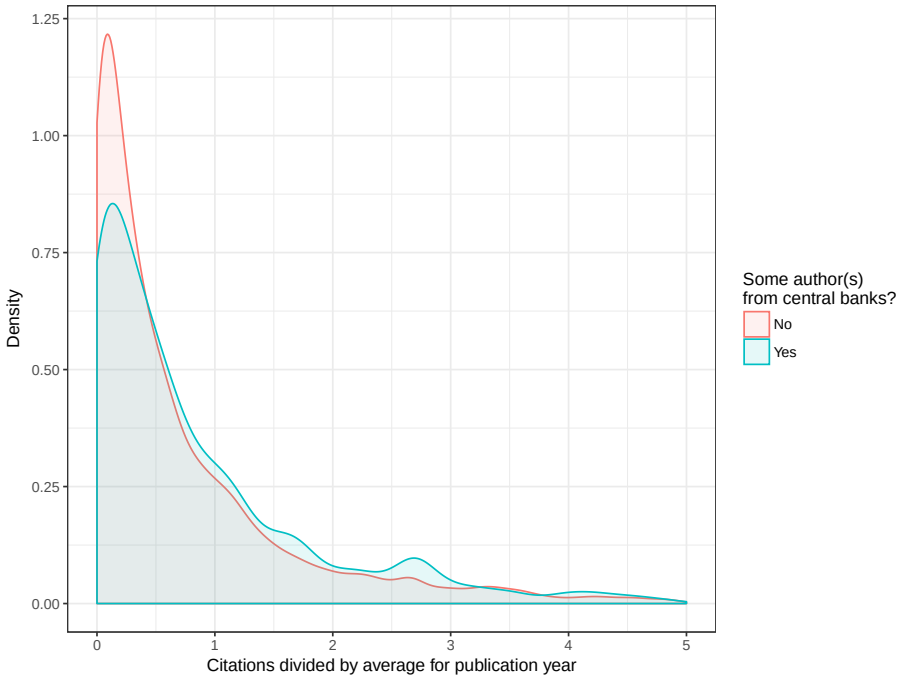

Figure 5: Sample distribution of normalized impact conditional on central bank authorship

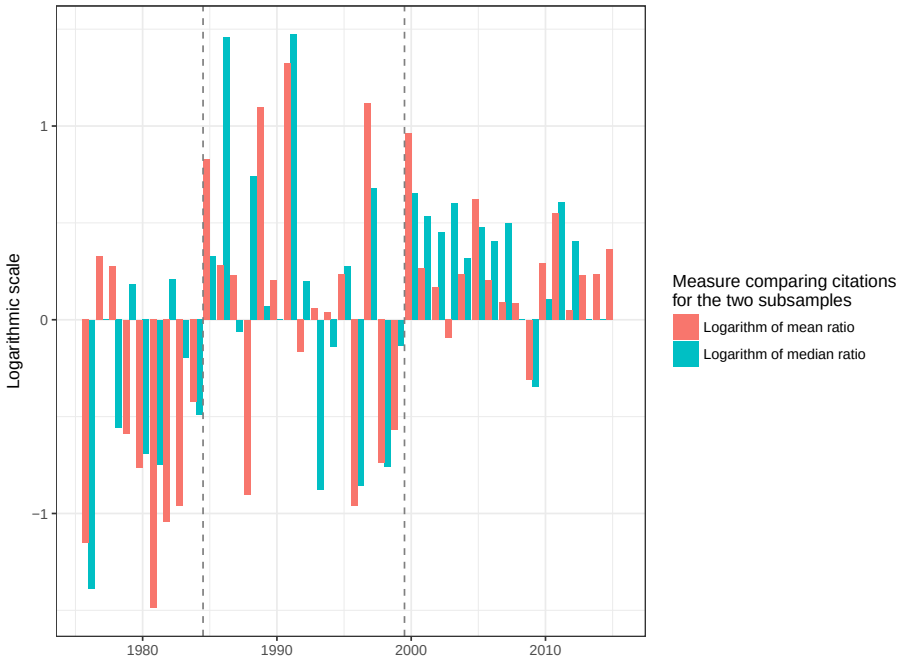

Figure 6: Comparison between mean and median citations of the two subsamples (with or without central bank authors). A bar above the origin signals that articles with at least a central bank author have the advantage in terms of mean or median citations in that year. A bar below the origin signals the opposite. The two gray, dotted, vertical lines are added to the data to signal what are called 'three chapters' in the main text. Citations in this analysis are not normalized by mean citations for the year.