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From Modelmania to Datanomics: The Top Journals and the Quest for Formalization

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The paper uses bibliometric data from JSTOR and Web of Science to assess the rise of mathematical and quantitative methods in economics between 1940 and 2017. My claim is that the top journals of economics have impacted the formalization of economics, since the publication of new models and methods in these journals has positive externalities on the network of economics journals in the sense that it opens new avenues for research such as new applications and extensions of the models and methods. Moreover, it is argued that the role of the top journals as gate-keepers of economic discourse is not only a possible explanation for the formalization of economics, but it also has implications for contemporary economics. More specifically, I compare three leading journals, *The American Economic Review*, *Journal of Political Economy* and *The Quarterly Journal of Economics* with economics as a whole and it is shown that the use of mathematical and quantitative methods has grown sharply between 1940 and 1980 and has remained constant thereafter. Analyzing separately theoretical and applied papers, the results indicate that while the proportion of applied papers has grown steadily in the three journals since 1955, the proportion of theoretical papers has grown sharply between 1940 and 1980, and has declined afterwards. Furthermore, I employ co-word analysis to investigate trends in economics between 1990 and 2017 using abstracts from fifteen journals, it is shown that the shift from theoretical to applied research has intensified in recent years.

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Introduction[1]

The formalization of economics has been widely debated and it is commonly held that the Second World War was a watershed in the history of economic thought.[2] The so-called "formalist revolution" (Blaug 2003), so the story goes, marks the transition *From Interwar Pluralism to Postwar Neoclassicism* (Morgan and Rutherford 1998). Others have approached the subject through an internalist perspective, highlighting different sides of this story. Ingrao and Israel (1990) argue that the history of general equilibrium theory is continuous in terms of its core (existence, uniqueness, and stability) and that one should "speak of shifts rather than radical changes or turning points" (1990, 289). Giocoli's (2003) reconstruction of the transformation of economics' image from a "system-of-forces" to a "system-of-relations", likewise, rejects the idea of a formalist revolution since this concept "brings with it the idea of a sudden modification, while the actual process took almost three-quarters of a century to complete" (2003, 6). Weintraub (2002) shows how the changes taking place in mathematics since the early twentieth century played a significant role in the transformation of the image of economics. Yet others argue that the formalization of economics "was already well under way in late Victorian England" in the works of Jevons and Marshall (Schabas 1989, 60). A further point of contention is the relationship between ideology and neoclassical economics (Lawson 2012; O'Boyle and McDonough 2017; Milonakis 2017).

The list goes on, but my goal is not to provide a comprehensive account of the formalization of economics. Instead, my argument is that regardless of the interplay between internal and contextual elements in the rise of mathematical and quantitative methods, there is yet another important side of this process, namely the role of economics journals in the dissemination of ideas. Hence, my goal is to offer an additional and complementary explanation to historians addressing the formalization of economics. Instead of focusing on the impact of specific authors (e.g., Hicks, Samuelson, Arrow, Debreu, von Neumann, Nash), institutions (e.g., Cowles Commission, RAND), or the political and economic context, which have certainly contributed to the phenomenon under investigation, I focus on a less discussed side of this story, namely that ideas do not gain widespread acceptance only because they are

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[2] I follow Backhouse's (1998) definition of formalization as comprising mathematization, axiomatization, and methodological formalism. I thus use formalization in a different sense than that associated with Hilbert's programme, i.e., I use it as a synonym of mathematical and quantitative methods since I address both theoretical and applied models and methods.

brilliant or because there are patrons favoring such ideas (Goldstein 1993). Hence, I assess the formalization of economics through the lenses of the sociology of the economics profession, focusing on the institutionalization of three top economics journals --- *The American Economic Review (AER), Journal of Political Economy (JPE), and The Quarterly Journal of Economics (QJE)* --- as gate-keepers of economic discourse and their impact on the dispersion of mathematical and quantitative methods post-1940. Given the leading role of these three journals, an empirical investigation of the content of the papers published in these outlets sheds some light on the formalization of economics as a whole. The top journals of economics influence research directly, since they are widely read and cited, but also indirectly since publishing in these journals affects researchers' tenure and promotions (Oswald 2007; Card and DellaVigna 2013; Fourcade et al. 2015).[3]

My working hypothesis is that given the prestige of these three top journals and the mutual influence they exert on one another, they have played a pivotal role in the formalization of economics. In particular, the co-evolution of formal content in these journals sheds some light on the idea that journals can be thought of as nodes in a network with ideas travelling across space. In this sense, the publication of new models and methods in these three journals has positive externalities on the other journals in the network, leading to debates, extensions, refutations, and applications. The perniciousness of the top journals' hegemony as gate-keepers of economic discourse has the unfortunate implication that researchers more often than not ask themselves what arguments and methods are more likely to be accepted in the top journals, rather than what is the most relevant question and the most appropriate method to answer it. Hence, in looking to the future of economics, one must reflect on the extent to which the dominant position of few journals and institutions may hinder the emergence of novel ideas.

The main contributions of the paper can be summarized as follows: Firstly, it is argued that the top journals were important players in the formalization of economics, but that this not only offers a explanation for the formalization of economics from a historical perspective, but it also has implications to contemporary economics. Secondly, I compare the co-evolution of mathematical and quantitative methods in three main journals --- AER, JPE, and QJE --- *vis-à-vis* the economics profession as a whole for the period 1940-2010. Thirdly, recent trends in economics are discussed using co-word analysis to investigate the abstracts of fifteen leading journals in 1990 and 2017.

The Hegemony of the Top Journals of Economics

[3] As Morin (1966, 403) nicely put it, "theirs not to reason why, theirs but to write or die". According to him, George Stigler estimated that publishing in a top journal in the 1960s was worth between $10,000 and $20,000 in increased lifetime earnings.

Recently there has been some debate on pluralism within economics and whether a process of de-formalization is underway. Economic theories are not conceived *in vacuo* and politico-economic conditions influence the topics and methodologies of economists. For instance, "[i]n the 1920s and the 1930s, the common ground for intellectual confrontation (not excluding controversy) was a renewed interest in the economy's cyclical fluctuations" (Ingrao and Israel 1990, 223). As Goldstein (1993) explains, for ideas and interests to translate into political outcomes they must be "politically salient" in the sense that there are shared beliefs between the political community and its sponsors. Regarding Keynesianism, she argues that "the decision whether governments should adopt Keynesian policies in the 1930s or 1940s was not settled by objective facts" (1993, 2), but rather it was a consequence of the political community's imperative to respond to the economic turmoil of the 1930s.

However, the effect of the economic and political context on the development of economic ideas seems to be smaller nowadays due to the greater homogenization of the methodology of economics and the concentration of economic discourse in few journals and institutions. Although the current crisis has led to speculations whether the time is ripe for changes, Aigner et al. (2018) show that comparing the content of papers published before and after the crisis there is no significant change except for an increase of discussions regarding financial instability. Yet, the explanations offered for instability seem to rely on standard arguments and there has not been a paradigmatic development in recent years as was observed in the decade following the Great Depression. Instead, "the financial crisis and its consequences have, by and large, been rationalized with reference to existing theoretical concepts [...] the financial crisis is seen by economists as a major external shock, unforeseen because of the limits imposed on rational behaviour by asymmetric information, and not as something intrinsic to the economic process" (2018, 18).

The absence of change in economics due to the recent crisis when compared to the Great Depression may be a consequence of the internal hierarchy of the economics profession and how economists relate to fellow social scientists. As Fourcade et al. (2015) have argued, economists live in a bubble and dialogue with neighboring sciences is virtually absent due to economists' self-proclaimed superiority with respect to other fields such as sociology and political science, a feeling fed by the very rise of formalism: "[Economics] is characterized by far-reaching scientific claims linked to the use of formal methods", contrary to sociology and psychology. Economics has risen to a dominant position in the hierarchy of the social sciences, and well-defined power relations exist both across the social sciences and within economics: "The authority exerted by the field's most powerful players, which fosters both intellectual cohesiveness and the active management of the discipline's internal affairs, has few

equivalents elsewhere". The authors argue that after the Second World War the "intellectual trajectories of the social science disciplines have diverged importantly" with economics embracing mathematical and statistical methods. The "insularity" of economics is said to be a consequence of its epistemological differences when contrasted with other social sciences, two crucial factors being economists' penchant for methodological individualism and formalism (2015, 90-93).

Within economics, an explanation of the lack of innovation may be the "'oligopoly' of U.S. institutions dominating leading journals in economics and economics research throughout the world" (Hodgson and Rothman 1999, 172). The authors argue that this concentration may reduce diversity in approaches, and that although economists will often diverge on policy issues, there is much more agreement about "fundamental theoretical and methodological assumptions - such as utility-maximisation and the ubiquitous, axiomatic-deductive method". Taking an evolutionary perspective of this process of concentration, they claim that "it may be difficult for further change to take place. 'Lock-in' may occur, where specific institutions defend specific, and possibly outdated, ideas and approaches". Although some level of concentration of personnel and resources is beneficial to innovation due to institutional scale, extreme levels of concentration as currently experienced in economics journals hamper the development of new ideas (1999, 180-183).

The idea that path-dependency helps to understand why economics is locked-in a paradigmatic core has also been discussed by Dobusch and Kapeller (2009). They claim that in the immediate post-World War II it is possible to observe a process of path formation which was open-ended in the sense that multiple equilibria could emerge, but that a number of individual contributors (Popper, Hayek, Friedman, Samuelson, Arrow, and Debreu), but also the Mont Pelerin Society, helped to stir economics away from the pluralism that characterized interwar economics. The authors discuss a number of "mechanisms and amplifiers" that help to understand the "interplay between the subject matter and the institutional and social structure of the scientific community in economics" (2009, 877), highlighting how citation metrics and the higher unity of mainstream economics when compared with heterodox economics may lead to a situation of lock-in. They argue that this dynamic "has become institutionalized in the 1960s onward by 'objective' quantitative measures, like citation indexes" and, as a consequence, the highest ranked journals "are very easily able to reproduce their top position, leading to a stable cluster of journals that mutually refer to one another and make it quasi impossible for new or dissident journals to succeed" (2009, 881).

As argued by Kapeller (2010), citation metrics shape the perception of economists about the quality of papers and acts as a "self-fulfilling prophecy leading to a scientific elite, which is able to reproduce its position via the mechanics of citation ranking". It is a self-

reinforcing mechanism in that papers are perceived as being of high quality *a priori* because they are published in top journals or by an author who is often cited, and papers are cited because of the institutional credentials of the author or the journal. Therefore, citation metrics operate as a "conservation mechanism within science, but also have a societal role by indirectly influencing the public discourse and thus making them a 'hegemonial device'" (2010, 331-332). The author has shown that roughly half of the citations of the top thirteen heterodox journals are to orthodox journals. Thus, ironically, although many of these citations are critical of the ideas of mainstream economics, they end up by boosting up the citations (and consequently the rankings) of the very journals and ideas they intend to defeat. Citation metrics are decisive in tenure, promotions, and the distribution of resources among departments, and may be hazardous to the development of new ideas because they overestimate the quality of the dominant institutions due to the more fragmentary nature of heterodox economics with its many schools, which reduces the number of citations to heterodox journals, not to mention that heterodox economists tend to cite older papers than orthodox economists (which also negatively affects the ranking of heterodox journals), but also because heterodox economists dedicate considerable effort on criticizing the mainstream, which increases the citations of orthodox journals.

What is at stake is not only that to the victor go the spoil, but also that citation metrics favors the idea that any publicity is good publicity. If the top journals are gate-keepers of economic discourse and influence the direction of future research, one might be skeptical whether the current crisis and recent pleas for pluralism may lead to considerable changes in the economics profession. Indeed, this concern has been recently voiced by Akerlof (2017) in his panel address to the ASSA when a section was dedicated to the top five journals:[4]

> What I am worried about most of all is what we don't see. So, I am worried about the analysis that is never seen, that never becomes a paper. And it doesn't become a paper, because it can't become a paper. And it can't become a paper, because that's not what a paper in economics is all about.

That the ASSA dedicated a section where prominent economists have debated the "the curse of the top five" is highly symptomatic of the negative effects of the economics journals hierarchy. Whether or not they will continue to engage in the debate and help to bring the issue to the fore remains to be seen. The point though is that historically the top journals have been important players in molding economic discourse and the rise of mathematical and quantitative methods cannot be understood without taking into account the communication function of economics journals.

[4] The so-called "top five" are AER, JPE, QJE, *Econometrica* (Ecmca), and *Review of Economic Studies* (RES).

The Formalization of Economics, the Top Journals, and their Editors

Several papers have used citation analysis to investigate the concentration of economics journals and some of them have discussed the formalization of economics, the idea that journals form a communication network, and the extent to which editors influence the content published in the journals. This section overviews these issues since they are of importance for the present purpose. The literature has documented the increasing importance of empirical and mathematical methods, especially the former. The focus is usually on empirical papers, rather than papers that use econometrics, and there is no comprehensive work that addresses the formalization of economics using citation analysis; many of the papers are restricted to surveying a small sample of papers, and none of the papers examines the whole period from 1940 to 2010. Moreover, as far as I am aware no paper has argued that the top journals were important players in the formalization of economics. Yet, taken together these works provide some insight into the formalization of economics after the Second World War and complement my empirical analysis.

The Rise of Empirical and Mathematical Methods

In 1970 empirical methods were on the rise and, at the time, one third of the most cited economists were econometricians, while in previous decades the proportion of econometricians among the most cited economists was much smaller (Quandt 1976). Figlio (1994) has shown that whereas in the 1970s the top five journals published less empirical papers than journals ranked between sixth and tenth place, this gap has closed between the 1970s and the 1990s, when AER, JPE, and QJE started to publish more empirical papers than the second half of the top ten journals. One of the explanations offered for the increasing use of empirical methods is "the relationship between theoretical paradigm shifts and publishing patterns" (Figlio 1994, 185), in the sense that the development of a number of macroeconomic theories in the 1970s and 1980s may have led to several attempts to test such theories. The point raised by the author is important because it highlights that theoretical models may have spillovers over empirical applications that I have not taken into account. Therefore, while I address the evolution of theoretical and applied papers separately, they are not completely independent and further research would be necessary to investigate whether the development of theoretical models have influenced the rise of applied research.[5]

[5] The effect of empirical evidence upon theoretical models is likely to be less important, historically empirical evidence has had little effect in driving the content of theoretical models, yet one can not rule out that there might have been some instances in which empirical evidence not in accordance with the results of theoretical models led to the formulation of new theories that could rationalize such findings.

Aigner et al. (2018), analyzing the abstracts of the top 560 cited papers between 2001 and 2013, notice that the term *model** appears on average approximately once in each abstract and that this has increased after 2008.[6] Moreover, they argue that empirical methods are growing in importance given that terms like *theor** and *equilibri** have either stagnated or declined after 2008, while the occurrence of terms such as *data*, *estimat**, and test* has increased. Kim et al. (2006) have investigated papers with over 500 citations, showing a clear picture of the rise of econometrics, which accounted for 10% of highly cited papers between 1970-1974 and 22.9% in 1995-1999 if one classifies the papers according to its JEL primary code. Assessing the main contribution of these papers, instead of their JEL primary code, the proportion of theoretical (empirical) papers has fallen (risen) from 76.7% (13.3%) in 1970-1974 to 11.4% (60%) in 1995-1999.

Hamermesh (2013) classified over seven hundred papers published in AER, JPE, and QJE between 1963 and 2011. While the proportion of theoretical papers fell from 50.7% to 19.1% between 1963 and 2011, the proportion of empirical papers (using either borrowed or self-generated data) has increased from 47.8% to 63.9%. The most thorough investigation of the rise of empirical methods is Angrist et al. (2017). They analyze over one hundred thousand papers between 1980 and 2015 and show that not only did empirical papers become more common, but they have also grown in importance considering the outlets in which they are published and the share of citations that they reap.

Card and DellaVigna (2013) argue that there has been a decrease in the impact of papers that are mainly theoretical and econometrical after 1990, while papers in international, development and macroeconomics have gained momentum. Hence, while papers in econometrics (say a paper discussing the properties of an estimator) have decreased in importance, papers using econometrics (applied research) are on the rise. Comparing empirical and theoretical works, Johnston et al. (2013) have shown that the former are more cited than the latter, and this may be a further explanation for the increasing use of the empirical methods.

Stigler et al. (1995) investigate the role of journals in scholarly communication and the increasing use of formal methods between 1892 and 1990. Looking at the highest level of technique in five journals, there has not been much change between 1892 and 1922, with roughly 95% of the papers being classified as primarily verbal.[7] This figure drops to 80% in 1932-3, and continuously falls throughout the following decades such that by 1962-3 one third of the papers were primarily verbal and by 1989-1990 more than 90% employed either algebra, econometrics, calculus, or more advanced techniques. They recognize the difficulty in classifying papers according to the technique employed, but

[6] The wildcard operator * captures any word stemming from *model*.
[7] AER, Ecmca, JPE, QJE, and *Review of Economics and Statistics* (REStat).

argue that "[n]o faults of classification, however, could conceal the enormous movement toward mathematics in recent decades" (Stigler 1995, 342).

Fourcade et al. (2015, 102) have also documented "the dramatic rise of economics' engagement with mathematics and statistics in the post-World War II period" looking at the proportion of extra-disciplinary citations in the top five journals, which shows that developments taking place outside of economics are also an important explanation of its formalization. Kosnik (2015), likewise, documents that *model* is the most common word in articles corpus and highlights the increasing importance of mathematical methods and of the microfoundations literature in seven top journals from 1960 to 2010.[8] Using JEL codes, Kelly and Bruestle (2011) have shown that mathematical and quantitative methods and microeconomics account for approximately 37% of the publications in the top eight general journals (namely the top five plus REStat, *International Economic Review*, and *Journal of Economic Theory*) and this proportion has remained fairly stable between 1970 and 2007, while these two areas represented nearly 17% of the papers in economics as a whole in the 1970s and 13% in 2000-2007. The proportion of papers in mathematical and quantitative methods in the top eight general journals is more than twice the proportion of these papers in economics as a whole, which is further evidence that the main papers in this field tend to published in the top journals.

The Top Journals

Investigations into the communications network of economics journals are not new. Eagly (1975), for instance, argues that information exchange can be thought of as an "idea industry" with "vital importance for the progress of the discipline". Instead of focusing on the importance of individuals as "lighting-rods for the discipline, serving as liaison between the gods and mere mortals, or electric eels, serving to maintain the alertness of fellow economists who are swimming in the same waters", one should approach the production of ideas from a sociological standpoint because of the division of labour and interdependence of practitioners: "Information flows at many different levels must be taken into account" (1975, 878). His study shows how the top journals were already huge players in the 1960s. The author analyzes a network of 18 journals in 1961-4 and in 1970-1, highlighting the growing importance of American journals during the 1960s, when AER, JPE, and QJE were the three most central journals in the network. Using a measure to estimate the prestige of journals, he finds that QJE ranks first and AER ranks third in both waves. Moreover, QJE and AER have the higher "sending-receiving ratios" (the number of times a journal is cited compared to how many times it cites other journals), meaning that they are feeders of the network since this is a

[8] She uses the top five journals plus the *Journal of Economic Literature* and the *Journal of Economic Perspectives*

measure of "the journal's innovative role as a wellspring of seminal ideas in the discipline" (1975, 880).

Although "major theoretical contributions appear occasionally in journals outside the central core of the discipline" (Stigler et al. 1995, 334), it has been widely documented in the literature that the top journals reap a significant portion of citations even though they account for a small fraction of all papers. AER, JPE, and QJE "are the three most highly regarded general journals in the profession" and, although there are a number of methodologies to evaluate the prestige of journals, they invariably figure at the top of the list (Wu 2007, 59). Quandt (1976), likewise, has shown that in 1970 between 16% and 24% of the references in AER, JPE and QJE were to one another and that AER was the most prestigious journal.

The share of publications from United States/Canada based authors in these three journals has decreased from 92% between 1963 and 1993 to 83% in 2003-2011 (Hamermesh 2013, 164), however the "Americanization of the economics literature" is very much alive (Eagly 1975, 884). As an example of "the extent to which the US has become the center of economic research since World War II", among the 27 core journals of economics in 1986 only one was not published in English and roughly half of the citations to the core journals were concentrated in five journals: AER, Ecmca, JPE, RES, and REStat (Diamond 1989, 3-4).[9] After 1990, QJE has grown considerably in importance becoming the leader both in terms of median number of citations and considering the ratio of citations per paper, followed by AER and JPE (Card and DellaVigna 2013).

The most comprehensive study of concentration is Glötzl and Aigner (2017), who have shown that economics is very concentrated in terms of articles, journals, regions, institutions, authors, and paradigms. They report that the Gini coefficient of citations to articles has increased from 36.5 to 69.2 between 1956 and 2016, and that the Gini coefficient of citations to journals is even more concentrated, increasing from 67.9 to 85 in the same period. Moreover, the top five journals received 27.6% of all citations and published 71% of the top 100 articles between 1956 and 2016. The top five reached their peak in the early 1970s, when they reaped nearly half of all citations, and this proportion has been steadily declining. Yet, it is striking that in 2016 although papers in the top five amounted to 2% of all papers they still received roughly 22% of all citations. Moreover, while the number of journals has increased from 40 to 675 between 1956 and 2016, the top five journals' share of the top 100 articles has remained around 70% during the whole

[9] Diamond's list has been criticized by Burton and Phimister (1995) and Hodgson and Rothman (1999), who argue that citations are a crude measure of quality since there are many features that should be accounted for such as percentage of self-citations and their distribution over time. Though there are significant differences between their lists and Diamond's, the predominance of US journals is still observable.

period. On the geographical dimension, 49% of the papers were published in North America and these papers account for 73.5% of all citations between 1980 and 2014, with 18 out of the 20 most cited institutions being located in the USA. Furthermore, while the top 10 and top 100 authors have on average, respectively, 114.6 and 74 citations per article, reaping 3.6% and 15% of all citations, roughly one third of all papers have zero citations.

Aigner et al. (2018), similarly, show that among the 560 most cited papers between 2001 and 2013, 81.1% have their origin in the USA and 63.3% of these citations are to the top five journals. The prestige of these journals can be seen by their high number of citations; their median number of citations was around 200 in the period between 1990 and 2000, and AER, JPE, and QJE were the most cited journals (Card and DellaVigna 2013). Kim et al. (2006) list 146 papers written after 1970 with more than 500 citations, showing that in the 1970s and 1980s the main outlets were Ecmca (21.4%), JPE (12.4%), and AER (14.4%) and in the 1990s they were QJE (21.4%), JPE (15.7%), the Journal of Finance (14.3%), Ecmca (12.9%), and AER (8.6%). Overall, roughly 40% of these papers were published in AER, JPE, and QJE. Furthermore, 85% of the papers were written by researchers working in the USA. Siegfried (1994), analyzing the same journals as I do, has shown that between 1950 and 1989 there was a decrease in the share of papers published by authors affiliated with the four institutions the most published in AER, JPE, and QJE, however, Wu (2007) has updated his results for the period 2000-2003 showing a reversal in this trend.[10] Overall, the proportion of authors coming from the top four institutions in the three journals ranged from 13% in AER in the 1970s to 43% in QJE between 2000 and 2003.[11] Hence, not only is there a highly skewed distribution of citations favoring the top journals, but also a high concentration of authors affiliated with the top institutions.

The Role of Editors

A further issue in the formalization of economics concerns the role of editors in favoring particular lines of research. As an example, John Davis, editing the AER between 1911 and 1940, may have delayed the formalization of the journal while he was on board. Likewise, Keynes' dislike for econometrics may have affected the content of papers published in the *Economic Journal* while he was its editor (Stigler et al. 1995, 344).

Coats (1971) shows, however, that analyzing the content of papers in five journals between 1886 and 1959, one observes original differences between editorial lines fading

[10] In the 1980s these were MIT, Princeton, Chicago, and Harvard for AER, Chicago, Stanford, MIT and Harvard for JPE, and Harvard, Princeton, MIT and Stanford for QJE.
[11] In 2003 the top 4 were Stanford and MIT (in the 3 journals), plus Harvard and Princeton in AER, Chicago and Pennsylvania in JPE, and Harvard and Chicago in QJE.

throughout time with journals becoming more homogeneous regarding its distribution of contents.[12] His results suggest that "their editors were subject to forces beyond their control; that far from being dynamic academic entrepreneurs of the Schumpeterian type, they were merely passive recipients of a changing flow of manuscripts over which they exercised little or no editorial influence" (1971, 32). Yet, he notes that there is not sufficient information available to judge the extent to which editors may be considered "'gate-keepers' of the science in any but a passive sense of that expression. Nor can we readily discover what, if any, have been the effects of changes in the composition and functions of editorial boards" (1971, 39).[13]

Hodgson and Rothman (1999), likewise, note that to evaluate whether or not there is favoritism would require a comparison of rejected and accepted papers, and since no such data is available it is difficult to know the extent to which editors influence the content of publications. Nonetheless, they express concern about the high level of institutional concentration of editors and authors.

This issue has been more recently discussed by Colussi (2017), showing that 43% of the papers published in AER, Ecmca, JPE, and QJE between 2000 and 2006 were written by scholars connected to at least one editor of the journal. This is not to say that there is favoritism, for, as he argues, an alternative explanation is that top universities attract more talented and productive students, and they tend to become even more productive due to interactions with like-minded researchers. Be it as it may, there is little doubt that the network of economists has become a "small world" (Goyal et al. 2006).

Laband and Piette (1994) have argued that although editors may accept papers that would not be published otherwise due to their connections with authors, overall these relationships help editors to choose high quality papers. They thus do not discard that favoritism may happen in some cases, but their main claim is that due to competition among editors for high quality papers, editors use their network of relationships to gain information about high impact papers and that their main goal is to publish such papers rather than favor people from their network.

Even conceding that editors exert some influence on the content of publications, it may be argued that they are more likely to affect the topics that are chosen and who gets to be published, than the methods used. Moreover, it is difficult to disentangle whether editors are key actors in shaping the contents of papers, or if the very choice of who becomes the editor of a journal reflects lines of research that are gaining importance.

[12] AER, JPE, QJE, *Economica*, and *The Economic Journal*.

[13] For a more detailed investigation of Dewey's, Homan's, and Haley's editorships of AER see Coats (1969). The author argues that in spite of Dewey's desire to differentiate the outlet from JPE and QJE, there were no significant differences in these journals during his editorship. With respect to Homan, he notes that it is hard to estimate his accomplishments given the "rapid post-war growth and rising standards of the economics profession" (1969, 63).

Hence, the long run trends discussed in the present paper should be seen as part of a broader phenomenon: "[T]he pattern of home bias in top economics journals, together with the stability of rankings of top departments, is not just a coincidence of geography and authors, but stems instead from a particular form of social organization and control" (Fourcade et al. 2015, 100). Regardless of the inconclusive evidence on the issue of favoritism and the influence of editors in the publishing process, it should be clear from the discussion thus far that there is an excessive concentration of power in the top journals.

Data and Methods

Data

Annual data from JSTOR is used for the period 1940 to 2010. Different from other databases, JSTOR has the advantage that it covers the 1940s, however it contains a very small amount of papers published after 2010. The sample consists of 230,033 papers, out of which 16,300 were published in AER, JPE, and QJE.[14] Reviews, rejoinders, comments and such like were excluded.
Table 1 presents the number of papers in each journal by decade. Although JSTOR does not list all journals of economics, its database is quite large and taking together all journals other than the top three offers a fairly close description of the economics profession as a whole.

Table 1: Article Count by Decade

	1940s	1950s	1960s	1970s	1980s	1990s	2000s
American Economic Review	867	782	925	1463	1616	1598	1992
Journal of Political Economy	330	349	549	904	660	528	445
Quarterly Journal of Economics	347	410	500	543	567	464	461
Other Journals	6474	10126	17491	30706	40548	49296	59092

I have chosen to analyze AER, JPE, and QJE, instead of the top five, because Ecmca mostly publishes formal papers since its foundation and in the 1940s mathematical economists formed a small and isolated community. In this sense, it was the general journals who were mainly responsible for dispersing ideas to wider audiences since they are more accessible and more widely read. As to RES, I opted for not including it given the Americanization of the economics profession. It is not clear without further research the extent to which RES communicated with the top three American journals, even though ideas certainly crossed the Atlantic.

[14] AER's *Papers and Proceedings* is also included since JSTOR does not distinguish between AER's normal and special editions.

To further investigate recent trends in economics, abstracts from fifteen journals were collected from JSTOR, Web of Science, and manually from the journals' websites. Conference editions and special issues were excluded to avoid overestimating the importance of topics discussed in such issues. The criterion to choose the journals was to select the highest ranked journals according to IDEAS for which abstracts were available in 1990 and 2017, listed in Table 2. The journals were divided in general and field journals.

Table 2: List of Journals, IDEAS Ranking, and Number of Abstracts, 1990 and 2017

Journals	Ranking	Obs. 1990	Obs. 2017
General Journals			
Quarterly Journal of Economics	1	38	40
Journal of Political Economy	2	54	44
American Economic Review	3	55	115
Econometrica	6	52	62
Review of Economic Studies	8	40	51
Field Journals			
Journal of Financial Economics	4	22	121
Journal of Finance	7	70	63
Journal of Monetary Economics	10	40	33
Journal of Econometrics	12	30	83
The Review of Financial Studies	13	17	111
The Review of Economics and Statistics	14	97	72
Journal of International Economics	15	40	86
Journal of Labor Economics	16	22	28
Journal of Public Economics	18	48	119
Journal of Development Economics	21	52	71

Methods

The exercise consists of two steps. First I compute the proportion of papers that use mathematical and quantitative methods from 1940 to 2010 in AER, JPE, QJE, and for the rest of the journals listed in JSTOR - Table 1. Secondly, co-word analysis is employed using data from the journals listed in Table 2 for the years 1990 and 2017 in order to assess recent trends in economics.

In the first step, papers are classified as "formal" if they use mathematical and quantitative methods. Formal papers are divided into theoretical and applied papers. A paper is classified as theoretical if it uses mathematics, but not econometrics, and it is classified as applied if it uses econometrics, regardless of the extent to which it draws on economic theory.[15]

[15] The expression "applied" has multiple meanings and one may argue that an econometrical paper may not necessarily be applied if it is not based on economic theory. Conversely, a theoretical paper (say a paper in game theory) may be defined as applied if it has policy implications, for an introduction to the history of the concept

To compute the proportion of applied papers, I select all articles that contain at least one of the following expressions: *panel data, time series,* or *cross section*, as well as those that use the words data* and regress*. Given that several papers use data, but not necessarily econometrics (especially in the 1940s and 1950s when there was a significant number of empirical works, but econometrics was still unusual), and since the word regress* can have different connotations, I require that both words be used. This allows to minimize the number of articles erroneously classified as applied. The wildcard operator * allows for truncation. For example, writing *model** in the search engine yields the number of papers that use words such as *models, modeling,* and *modelling*. As a proxy to estimate the proportion of theoretical papers, I select all articles that use either the word *model** or *equation**, but do not use any of the words selected in the previous step, i.e., I select all papers that use models or equations but do not use econometrics.

A potential objection to this approach is the risk of false drops, i.e., a paper that uses one of the expressions but is not necessarily theoretical or applied, however my results are very close to other papers that have investigated similar journals.[16] Furthermore, I have cross-checked by adding a number of words to ensure that the choice of expressions is a good proxy for the phenomenon under investigation, and the results only changed marginally. Adding the words *optimiz*, theorem, nash* and *general equilibrium* to the query to capture theoretical papers and adding *structural equation(s)*, *simultaneous equation(s)*, *least squares*, *estimator*, *cointegration,* and *maximum likelihood* to capture applied papers only changes the results by roughly 2 p.p. for the period as a whole.

In the second step I use co-word analysis to assess the centrality of the three journals in the network and to further investigate recent trends in economics by analyzing what words appear more often in abstracts in two waves: 1990 and 2017.[17] Since in the first

"applied economics" see Backhouse and Biddle (2000). However, I follow the customary distinction between applied and theoretical depending on whether or not a paper uses econometrics.

[16] Although Stigler et al. (1995), Backhouse (1998), and Hamermesh (2013) do not include AER's papers and proceedings, and the former also includes Ecmca and REStat, my results are very close to theirs. Backhouse (1998) reports an increase from 20% to 40% in the proportion of papers that use mathematics (but not econometrics) between 1940 and 1960, which is the same result I have found. Since Hamermesh (2013) classifies papers as empirical (thus it also includes papers that use data, but not econometrics), my results are virtually identical to his for the years 1993, 2003, and 2011, but lower for the years 1963, 1973, and 1983. This is not surprising considering that in the earlier years there was a high number of empirical (but not econometrical) papers, while in the last three decades it has become less common to find empirical papers that do not use econometrics. One may object that I have not excluded AER's *Papers and Proceedings*, however as a check I have deleted all papers using the expression *papers and proceedings*, which also drops papers published in AER that cite papers from the special edition, and the results only changed by roughly 1 p.p..

[17] Generic words like paper and study were excluded, and a number of words were replaced such as equilibria by equilibrium, empirical framework by empirical, regressor by regression, subgame perfect equilibria by game, etc. Furthermore, the words quasi natural experiment, regression discontinuity design and natural experiment were replaced by experiment, hence experiment refers both to actual experiments and quasi-experiments, since both methods are equivalent as far as my argument is concerned, i.e., these methods usually do not draw on economic theory to a large extent. The thesaurus file with all modifications is available upon request.

step all papers using econometrics are classified as applied regardless of the extent to which they draw on economic theory, it is not clear whether the importance of theory has been growing or declining once one takes into account that applied papers also use theory. Therefore, I investigate the abstracts of the fifteen journals listed in Table 2.

Using the VOS (visualization of similarities) mapping technique, co-word maps were built for 1990 and 2017.[18] The size of the words is determined by the number of documents in which they appear, and there is a link between two words if they co-occur in a document. Since I use a distance-based map rather than graph-based map, the distance between two words reflects how strong is the link between these two words, where the strength of the link is determined by the frequency of documents in which they co-occur. Furthermore, the position of words is determined by their relatedness with all the other words in the map. In this sense, the centrality of a word is a measure of its importance since the more often a word appears in conjunction with all the other words, the more central is its position in the map. Hence, both the size and the position of words are measures of their importance and they capture different attributes. The map also uses clustering techniques to group words based on their relatedness.

More specifically, the maps are constructed applying VOS to a similarity matrix, which is a co-occurence matrix normalized by the total number of co-ocorrences of words. The similarity matrix is normalized using the association strength a_{ij} of words i and j ($i < j$) given by

$$a_{ij} = \frac{mc_{ij}}{c_{ii}c_{ij}}$$

Where m is the number of documents, c_{ij} is the number of documents in which words i and j co-occur, and c_{ii} and c_{ij} are the number of occurrences of i and j. Considering that the weighted sum of the squared Euclidean distances between all pairs of concepts is given by

$$E(x_1 \dots x_n) = \sum_{i<j} a_i \|x_i - x_j\|^2$$

Where the vector $x_i = (x_{i1}, x_{i2})$ denotes the location of word i and $\|\cdot\|$ is the Euclidean norm. The position of the words in the map is then determined by minimizing their Euclidean distances subject to the constraint

[18] For details about technical implementations of VOSviewer see van Eck and Waltman (2007, 2010)

$$1/n(n-1)\sum_{i<j} a_i \left\| x_i - x_j \right\|^2 = 1$$

Results

The Top Journals and the Quest for Formalization

Figure 1 shows the proportion of formal papers taking the top three journals together. There was a sharp increase in the proportion of formal papers between 1940 and 1980, such that by 1976 this proportion reached 90%, remaining stable thereafter. Furthermore, the figure also shows that while theoretical papers were much more common than applied papers in the first decades, since 1960 applied papers have been growing faster than theoretical ones, increasing its share of publications. Indeed, in the early 1990s the proportion of papers using econometrics becomes larger than the proportion of theoretical papers, which has been falling since the early 1980s. While in 1940 only 28% of the papers were formal, and there were roughly twice as many theoretical (19%) than applied papers (9%), by 1955 the proportion of theoretical papers more than doubled (55%) while the proportion of applied papers nearly did not change. After 1955, however, the importance of econometrics steadily increases reaching its highest value in 2010 (69%), while a mild growth is observed among theoretical papers between 1955 and 1983, when it reaches its peak (60%), and, after 1983 its importance has been continuously decreasing, with its level in 2010 (30%) returning to its 1948 level. Therefore, theoretical papers follow an inverted-U trajectory while applied research exhibits a positive trend for the whole period.

Fig 1: Formalization in the Top 3 Journals by Applied and Theoretical

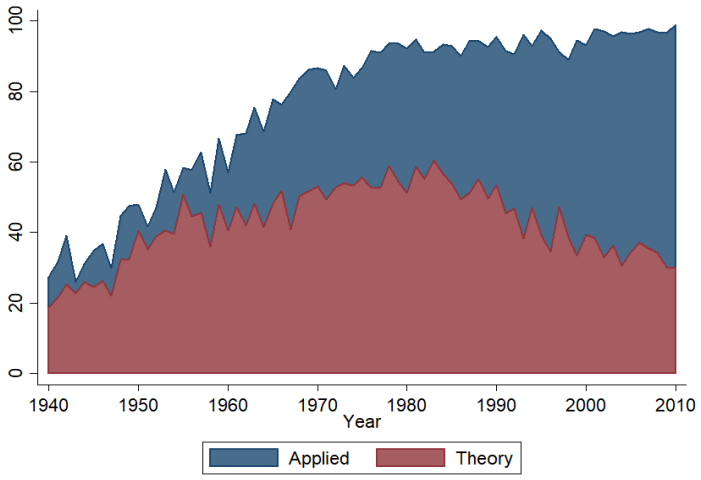


Figure 2 shows the level of formalization in each of the three journals, while Figures 3 and 4 show, respectively, the proportion of theoretical and applied papers in these outlets. The same pattern discussed for the top three journals has been observed in each

of the journals. Indeed, the series are remarkably similar and this is an indication that the journals mirror one another,i.e., that they communicate.

Fig.2: Formal Papers by Journal (%)

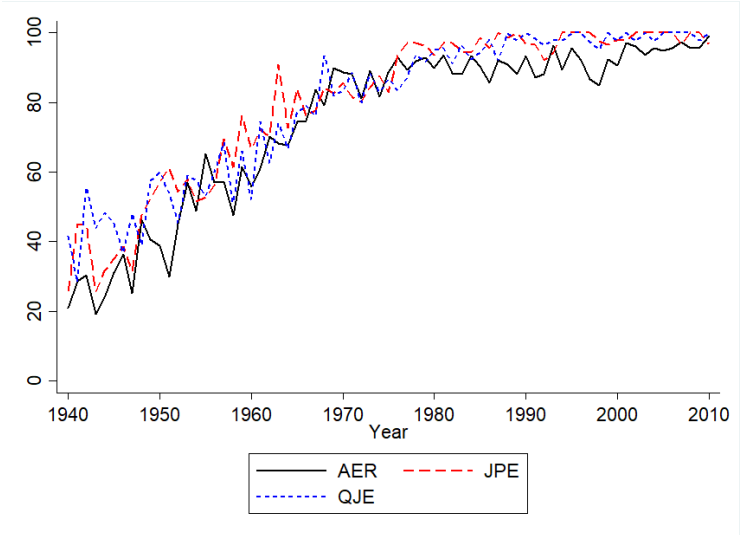
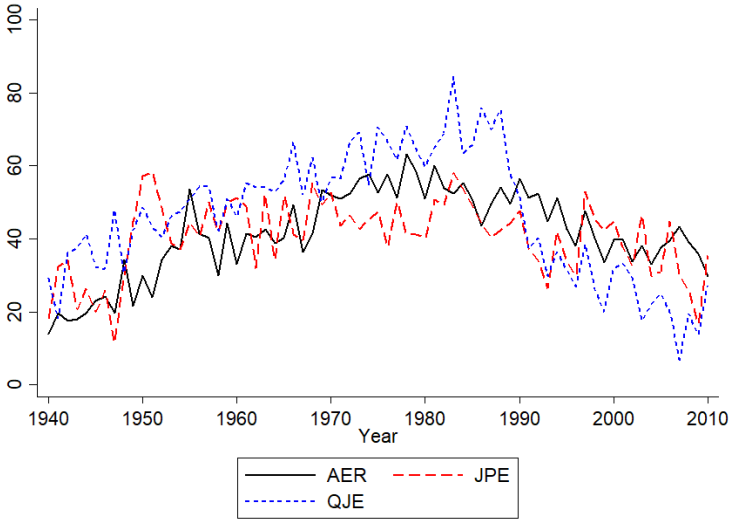


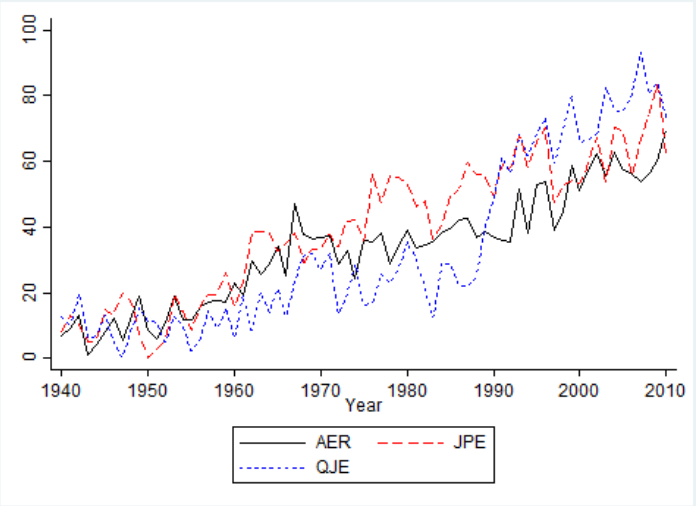
Fig.3: Theoretical Papers by Journal (%)



The most important differences concern QJE. As can be seen in Figures 3 and 4, QJE was the journal with the highest proportion of theoretical papers for most part of the period under analysis. In fact, by 1983 84% of the material published in this journal made no recourse to econometrics. However, in the 1980s there is a sharp increase in applied research and a pronounced decline in the proportion of theoretical papers. Indeed, QJE lagged behind AER and JPE until the late 1980s, when it became the journal with the

highest proportion of applied papers. Interestingly, this observed increase in the trend's slope coincides with its consolidation as the most important journal.[19]

Fig.4: Applied Papers by Journal (%)



Comparing my results with Kim et al. (2006), one sees a clear relationship between the proportion of applied papers and the number of citations received by a journal. The authors have shown that while in the early 1970s AER and JPE led the list of journals that published highly cited papers, reaping respectively 20% and 23.3% of papers with over 500 citations, in the early 1990s the proportions were AER (5.7%), JPE (25.7%), and QJE (20%), and after 1995 QJE assumed the first position. My results help to explain their findings, since my computations show that while in 1970 the proportion of econometric papers in AER, JPE and QJE was, respectively, 37%, 33%, and 27%, by 1990 this figure changed to 37%, 49%, and 48%, and in 1995 QJE became the journal with highest econometrical content. Therefore, considering that empirical papers are more cited than theoretical ones (Johnston et al. 2013), QJE's rapid ascension in the ranking of journals in the late 1980s is consistent with the sharp increase in its share of applied research.

My results also corroborate a common narrative of the history of United States postwar economics in terms of Harvard/MIT versus Chicago, with Cambridge mostly as theoretical leader and Chicago (for whom theory already existed, namely price theory) mostly focused in finding empirical evidence to counter Cambridge ideas. My results can be read along these lines, since it was shown that QJE was somewhat more theoretical than the other outlets, while the incidence of applied work was higher in JPE. Naturally, alternative narratives which are still to be written are possible.

[19] Card and DellaVigna (2013) have shown that between 1985 and 1995 QJE has moved from fourth to first place in the ranking of journals.

The fact that the top journals move in unison indicates that the explanations offered in the literature do not wholly explain the phenomenon under investigation. As important as the Cold War might have been, for example, it leaves unexplained what is the mechanism leading to the quick and virtually identical adoption of formal methods in the top three journals, while the same process happened much slower when considering all journals of economics. As shown in Figures 5 and 6, the economics profession as a whole has lagged behind the top three journals, but, ultimately, has followed the same trend. My interpretation is that there are spillovers between the top journals and that ideas quickly spread in the journals at the core of the network of journals, and, with some delay, these ideas also spread to the network of economics journals as a whole.

Fig.5: Formal Papers, Top 3 x All Other Journals (%)

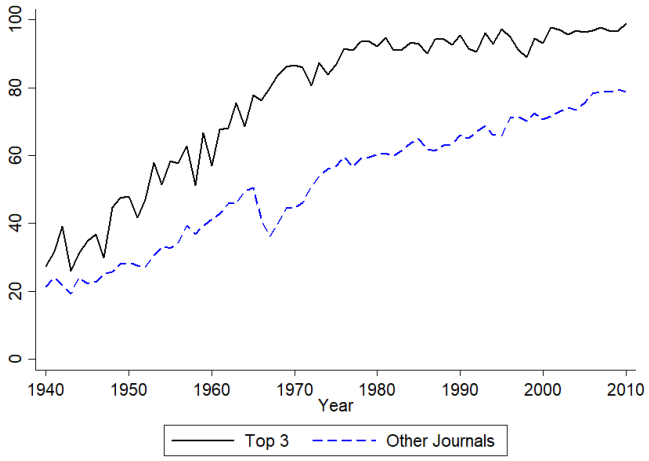
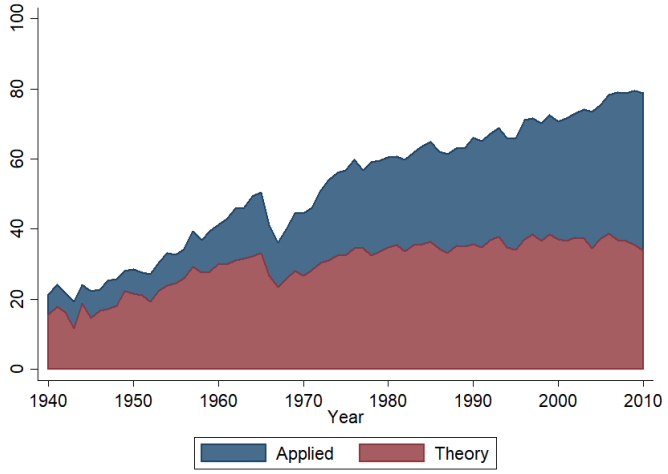


Fig.6: Formal Papers, All Journals Excluding Top 3, by Applied and Theoretical (%)



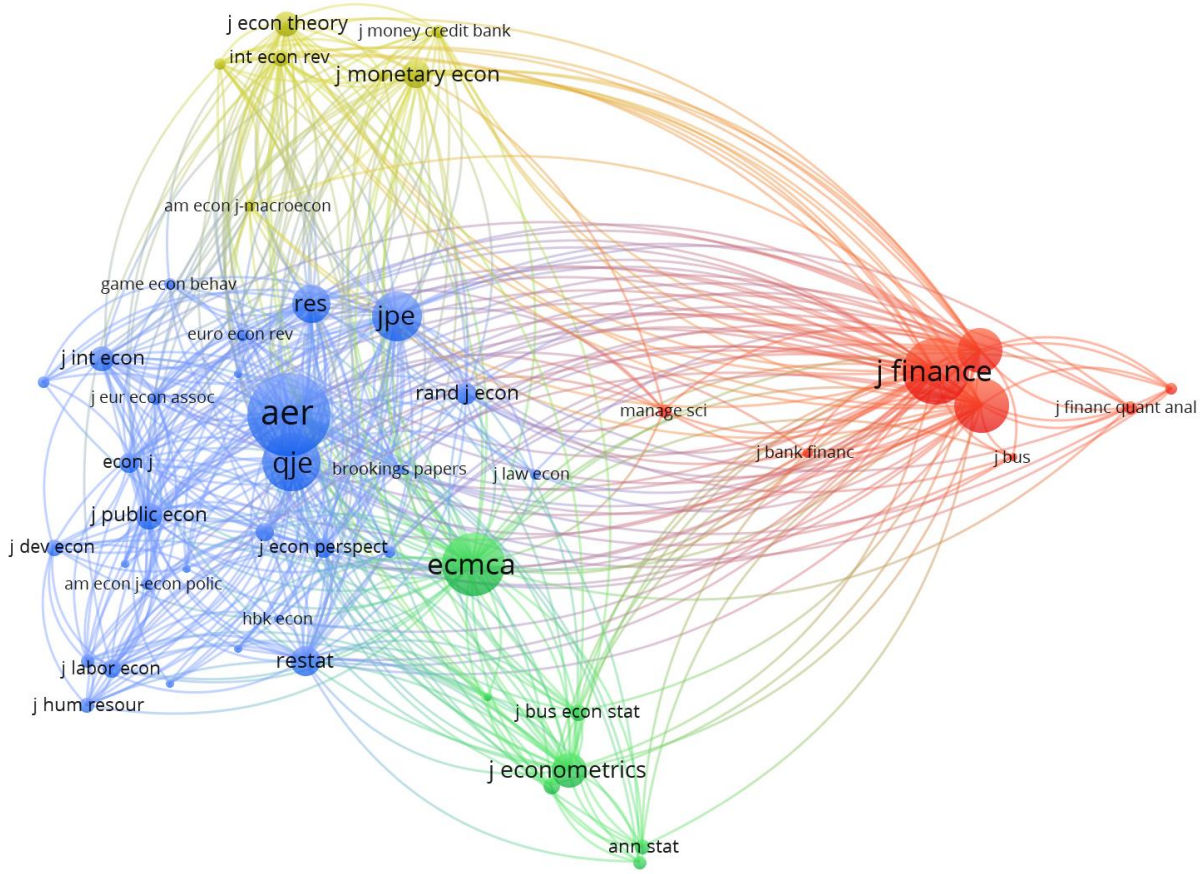
For the economics profession as a whole, the share of applied papers only becomes higher than theoretical papers in the early 2000s, roughly ten years later than the top three journals. Moreover, although the share of theoretical papers is flat since the 1960s

and the inverted-U shape observable for the top three is not so clear for economics as a whole, it should be noted that the share of theoretical papers decreased from 39% to 34% between 2006 and 2010. Hence, it seems that the same trend observed for the top journals is happening in economics as a whole, albeit with some delay. It seems plausible to conjecture that the top journals lead the process and the other journals follow them, but that it takes some time for ideas to travel from the core of the network to journals that are not in the core, one possible explanation being that it takes time for people that do not publish in the core journals to learn the new methods.

Figure 7 shows the citation practices of the 19 journals in 2017.[20] The figure illustrates the centrality that AER, JPE, and QJE occupy in the network. The leaders in citations are AER (4175), Journal of Finance (2898), Ecmca (2670), QJE (2349), Journal of Financial Economics (2192), and JPE (1908). Though one may counter-argue that AER publishes a higher number of papers than most other outlets and that papers have a tendency to cite more often papers from the outlet where they are published, even excluding AER from the dataset the journal still leads the ranking with 3557 citations. On the other hand, when Journal of Finance, Journal of Financial Economics, and The Review of Financial Studies are excluded from the database, their number of citations reduces to less than 500. Therefore, although financial journals are highly cited, they are mostly cited by like-minded outlets and they are not as influential as the core journals.

[20] The 15 journals listed in Table 2 plus The Journal of Human Resources, Journal of Economic Literature, Journal of Applied Econometrics, and The RAND Journal of Economics

Fig.7: Citation Network of 15 Journals, 2017



Considering that journals constitute a communication network where each journal is a node, and since AER, JPE, and QJE form the core of this network, the increasing use of mathematical and quantitative methods in each of these journals is likely to have had positive externalities on the rest of the network. Therefore, from the perspective of the sociology of the economics profession, the leading role of these three outlets may help to explain why some ideas got accepted by the scientific community and others did not. If knowledge is socially constructed, and the terms of debate are negotiated by researchers, than the top journals are an important forum where conversations take place, if not the most important locus. It was through making their appearance in the top three journals, I conjecture, that ideas that once belonged to a small community of mathematical economists (e.g., the econometric society and its journal Econometrica) reached larger audiences.

Likewise, the top journals seem to have played an important role in the recent increase in applied work at the expense of theoretical work, e.g., the rise of quasi-experiments and experiments after 1990. Although in 1990 the top journals still relied heavily in theory, as will be seen in the next subsection, while field journals made much more extensive use of econometrics, a possible explanation of the rise of 'datanomics' after

1990 is that quasi-experimental methods were legitimized as a central tool in the economist's toolkit not least because some of the would-be seminal papers using such methods were published in the top three journals (e.g., Angrist and Krueger 1991, Card and Krueger 1994, Angrist and Lavy 1999), thus bringing to the fore a new way to approach econometrics which draws much less on economic theory. In that connection, it should be noted that Ashenfelter, who advised David Card and Angrist and was one of the first promoters of quasi-experimental methods, was the editor of AER starting in 1985 (Panhans and Singleton 2017), and Esther Duflo is currently the editor of AER. Moreover, QJE went through changes in its board of editors in the 1980s which helps to explain the increase in applied work in the outlet.

Recent Trends in Economics (1990-2017)

Table 3 summarizes the main findings from comparing the abstracts of the fifteen journals listed in Table 2 in 1990 and 2017. The ten concepts included in the table are concepts related to either theoretical or applied works, which is the main focus of this paper, while words that can be used both in theoretical or applied papers (e.g., cost and price) are not included in the table, but are included in the co-word maps. Overall, one notes that terms such as data, effect, estimation, and impact have become much more common while terms as model, equilibrium, theory, and behavior have lost importance between 1990 and 2017. Looking at the general journals, in 1990 six out of the ten terms listed are typical of theoretical research, namely equilibrium, behavior, game, theory, agent, and choice, while in 2017 only preference, agent, and equilibrium are associated to economic theory. Moreover, equilibrium has dropped from the second position to penultimate, while effect and data have increased their importance in roughly 10 p.p. In 1990, impact, policy, and estimation were not among the list of 10 relevant concepts and in 2017 they were used in, respectively, 14%, 12%, and 11% of the abstracts. Looking at field journals, although they are much more empirical than the general journals in both waves, one notes a similar trend. The proportion of abstracts using the term model has decreased between 1990 and 2017, while terms associated with applied research have gained importance in recent decades. Moreover, the proportion of abstracts using the term policy has increased from 8% to 13% between 1990 and 2017.

Table 3: 10 Relevant Concepts, 1990 and 2017 (%)

General Journals				Field Journals			
1990		2017		1990		2017	
Model	50	Model	47	Model	43	Model	37
Equilibrium	19	Effect	27	Effect	27	Effect	33
Effect	18	Data	27	Data	24	Data	31
Data	16	Impact	14	Evidence	13	Evidence	22
Behavior	11	Preference	13	Test	11	Country	14
Game	11	Policy	12	Country	10	Impact	14
Theory	11	Agent	12	Estimation	9	Risk	13
Agent	10	Estimation	11	Stock	8	Policy	13
Choice	9	Equilibrium	11	Empirical	8	Estimation	12
Evidence	9	Evidence	11	Hypothesis	8	Shock	12

Figures 8 to 11 present the co-word maps with approximately the 40 most common expressions. Apart from the more general remark about the increasing use of words related to applied works relative to words with a theoretical connotation, the position of the words in the map sheds much light on the changing use of data in recent decades. In the four maps, the red cluster contains most of the theoretical terms while most of the terms associated to applied research are in the blue cluster. Notice that in the general journals in 1990 (Figure 8), the blue cluster contains words associated both with theoretical works (e.g. theory and behavior) and with applied research (e.g. empirical and regression). Moreover, the word data is in the center of the blue cluster, and it is quite close to the terms hypothesis, theory, and behavior. Therefore, in 1990 there was a strong connection between applied work and economic theory in the general journals. Apart from that, the red cluster mostly contains words that reflect economic theory (e.g., rationality, equilibrium, agent). In 2017 the picture is rather different (Figure 9). Now, the blue cluster where data is located does not contain any expression related to theoretical research. This does not mean that applied research is completely divorced from economic theory, for there are links between expressions in the blue and the red clusters, and one can observe some terms in the red cluster such as application, empirical, and estimation, but it does indicate a substantial reduction in the relationship between theory and applied research. Since the distance of the terms is determined by their relatedness, the fact that in 2017 the blue cluster does not contain any term that is clearly associated with theory, whereas in 1990 there were a number of theoretical concepts in the blue cluster, indicates that applied papers draw much less on economic theory in 2017 relative to 1990. Moreover, while in 1990 the word choice was quite central, in 2017 the word policy occupies a central position in the map, and the word experiment appears in the 2017 map, but not in the 1990 map.

Fig.8: General Journals, 1990

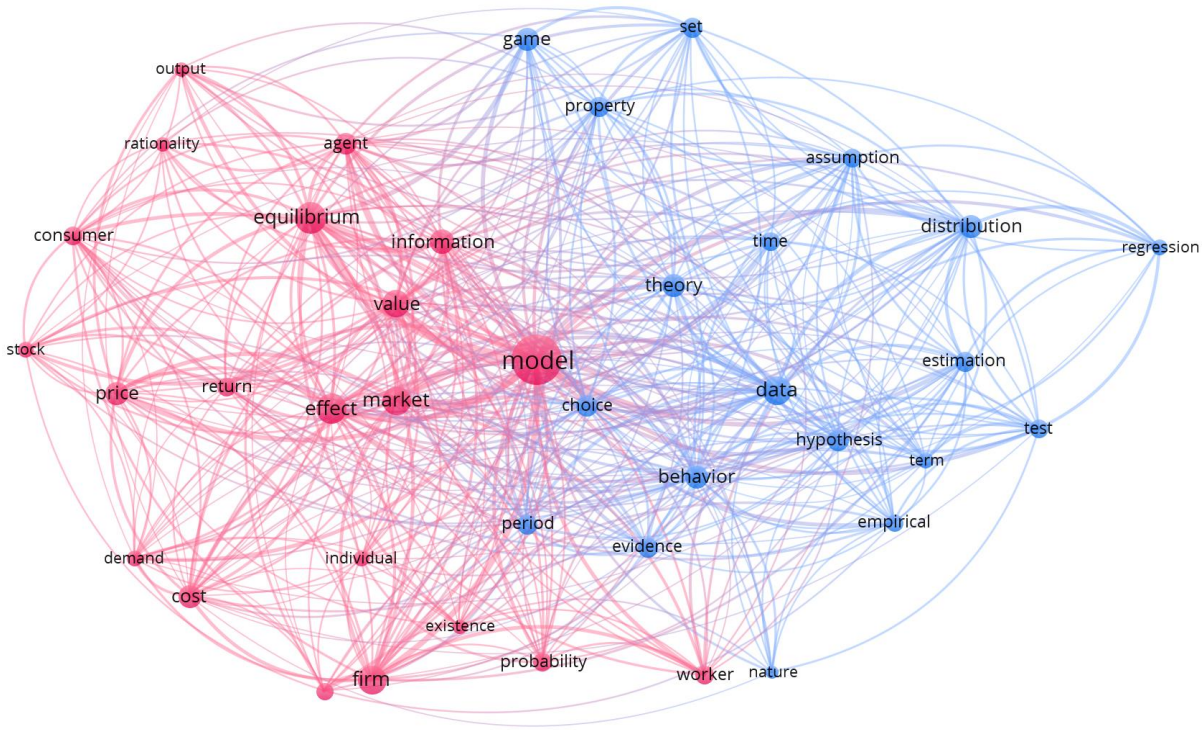
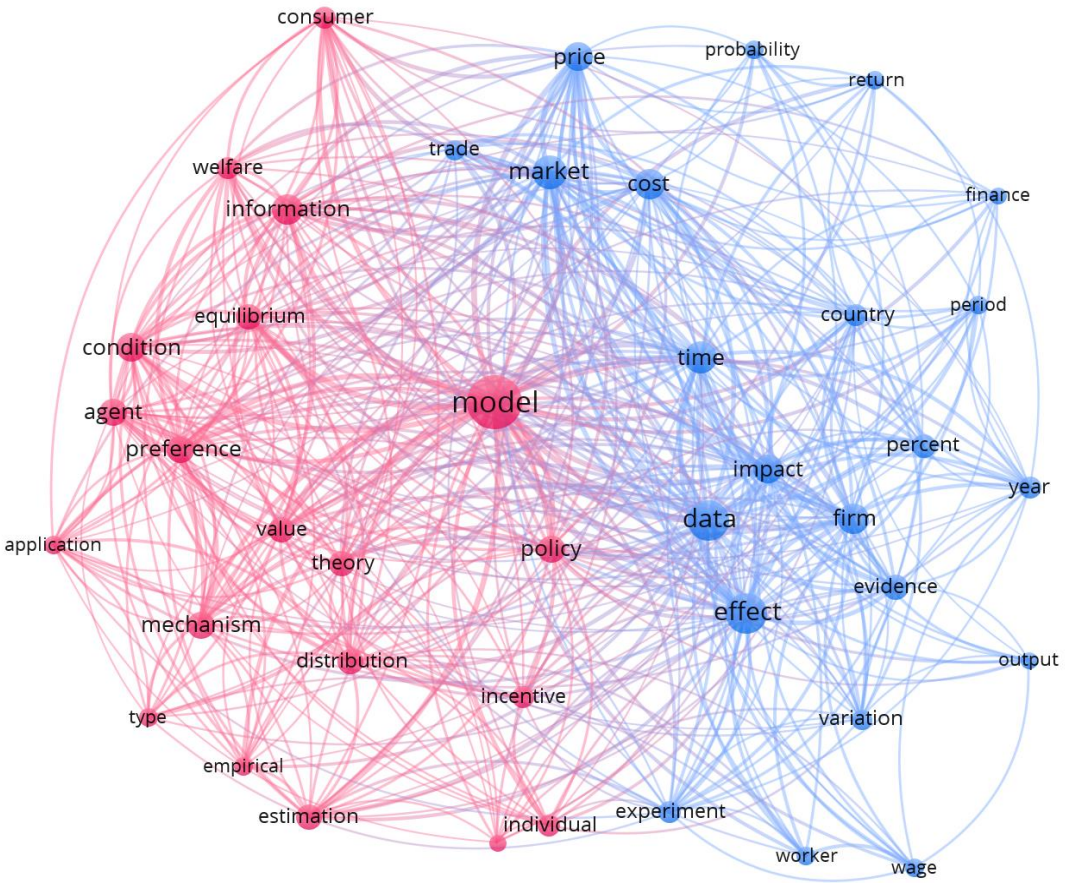


Fig.9: General Journals, 2017



Looking at field journals (Figures 10 and 11), one sees that although theoretical terms are much less prevalent than applied ones, similar changes can be observed. The most striking difference is that while in 1990 the terms data and model belonged to the same cluster, in 2017 the words are no longer in the same cluster, which clearly points at a decreasing relationship between applied work and theory. Moreover, the word model occupies a less central position in 2017 and the words evidence and data have grown in importance, both in terms of their frequency and their centrality. The word equilibrium appears in the map in 1990, but not in 2017, while the words policy and experiment can be seen in the latter, but not in the former. Notice also that the words behavior and individual, which are typical of microeconomics parlance, are much closer to the word experiment in the 2017 map than to the word model, which suggests that individual behavior has been more often studied empirically than analytically. Finally, in 2017 there is also a green cluster which reflects the increase in the number of papers published by financial journals. Given that papers in finance use a different vocabulary than other journals in economics, words such as shock, risk, and return are grouped in a separate cluster in 2017. These changes indicate that although field journals traditionally relied much less on theory than general journals, they have also drawn much less on economic theory in 2017 relative to 1990. The comparison between general and field journals reveals that both groups are considerably more homogeneous in 2017 than they were in

1990, hence the decline of theory and the rise of applied methods is observable across the journals under investigation.

Whither Economics?

In the last decade there has been much talk about the so-called 'empirical turn' in economics. Like every proclaimed 'turn' or 'revolution', the expression suggests an unwarranted paradigmatic revolution à la Kuhn which is hardly identifiable in any period of the history of economics. As my results suggest, there has been a steady increase in the proportion of econometric papers for many decades rather than an abrupt change. Likewise, there has been a considerable increase in theoretical models in the aftermath of the second world war, but the process was more gradual than the expression formalist revolution suggests.

The idea of an empirical turn is problematic, moreover, because it ignores that economics was quite empirical before the rise of mathematical and quantitative methods. In the 1940s, for instance, nearly half of the papers in the three journals used the word data, and in the interwar period there was a wealth of empirical work. Thus, the first point to notice is that although there has been an increasing use of econometrics in recent decades, one should keep in mind the changing uses of data throughout the twentieth century. This issue has been thoroughly debated in a recent issue of HOPE edited by Backhouse and Cherrier (2017) entitled *The Age of the Applied Economist: The Transformation of Economics since the 1970s*. [21]

[21] Practitioners, likewise, have discussed the limitations and advantages of Randomized Controlled Trials and the changing role of economic theory, see Deaton and Cartwright (2017) and Jackson (2017)

Fig.10: Field Journals, 1990

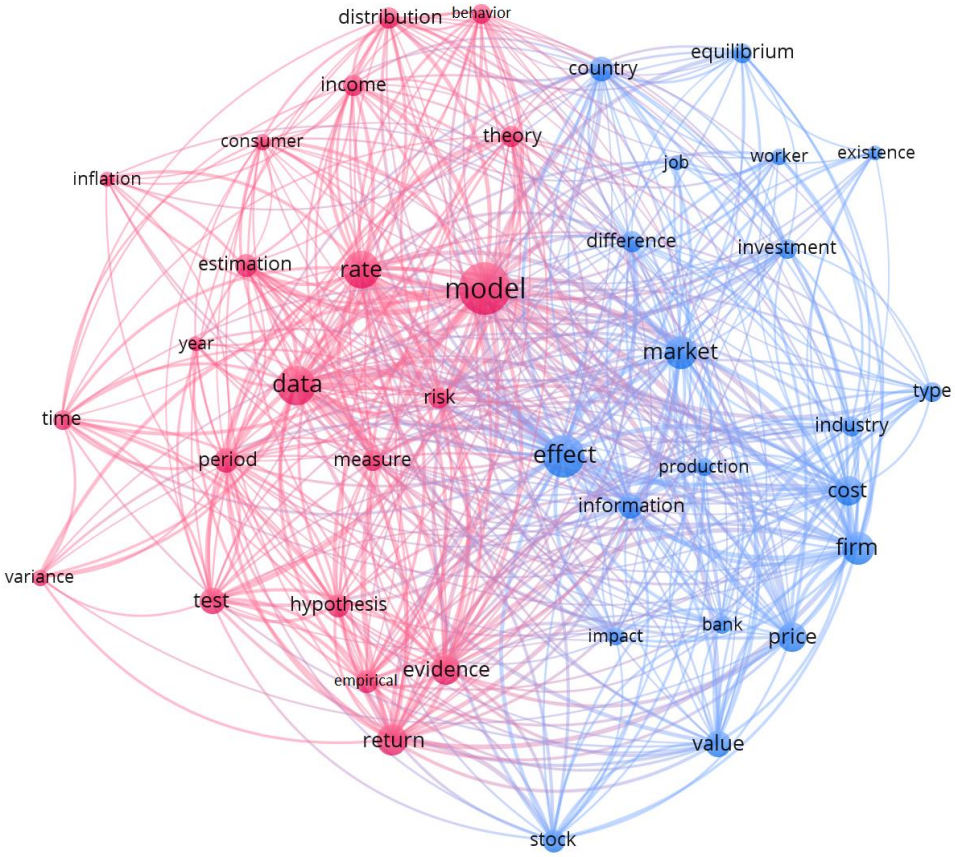
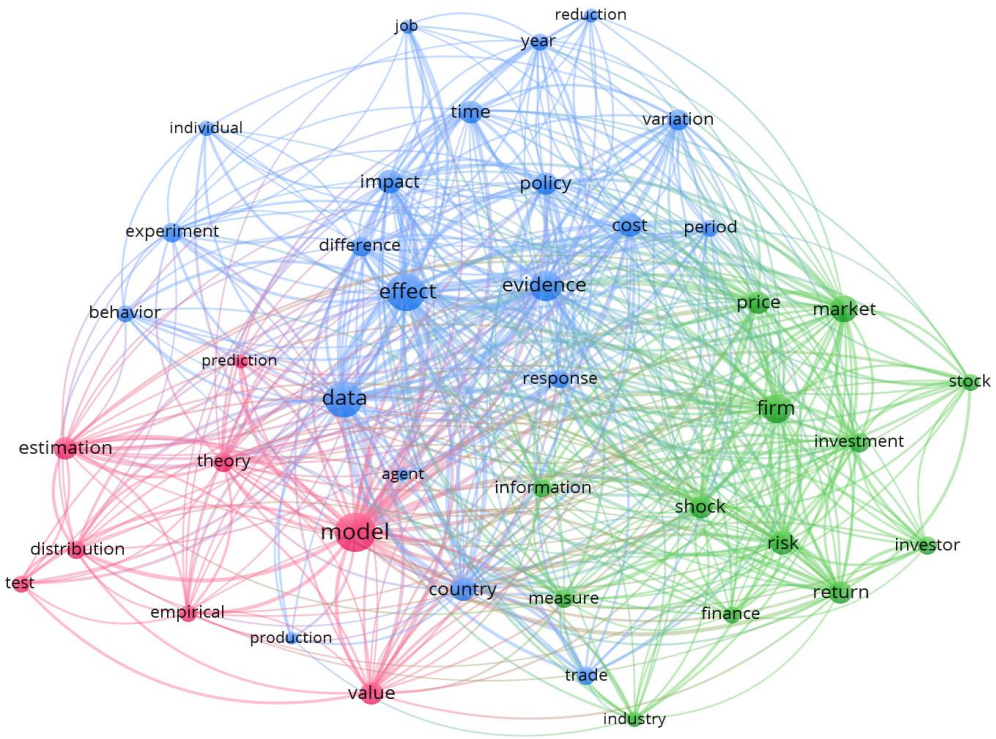


Fig. 11: Field Journals, 2017



The changing character of applied economics involves too many elements to be summarized here, yet one important point that complements my account is that within econometrics there has been a change from models to methods after 1990 (Panhans and Singleton 2017). As the authors show, there has been a paradigmatic shift from the Cowles econometric approach to quasi-experimental methods, which has grown considerably in importance since 1990. This shift, they explain, has its origins in the disarray of the simultaneous equations approach in the 1980s with its contested reliance on economic theories based on the optimization of agents or firms. The larger availability of panel data and longitudinal surveys from the 1960s onward was a necessary, but not sufficient explanation of this shift, and the changing character of applied economics must account for "a confluence of trends that fed into the stabilization of the 'credibility revolution'", such as the suitability of quasi-experimental methods "to meet the demands of patrons of economic research, particularly policymakers" due to their intelligibility (2017, 131). In the 1950s, Marshak, Koopmans, and Haavelmo made important contributions in general economic theory and theoretical econometrics, advancing considerably Frisch's and Tinbergen's program defined by the "subordination of measurement to model building and academic priorities" (2017, 150). Hence, the early decades of econometrics are marked by a close connection between economic theory and econometrics. Quasi-experimental methods, on the other hand, have economic implications and may orient public policy, but economic theory takes a much less important role:

> [Q]uasi-experimental design represents a subtle but significant reorientation of the role of economic theory in applied work on two levels. Rather than objects belonging in an economic model, the question itself is framed around a specific historical intervention, and the intervention replaces the role of a model in the empirical practice (2017, 145).

Stafford (1986) has shown that the proportion of empirical papers (in labor economics) with a meaningful theoretical section has nearly doubled between 1965 and 1983, hence not only have theoretical papers grown in importance in the aftermath of the Second World War, but also there has been an increasing use of theoretical models within econometrics. Nonetheless, as reported by Biddle and Hamermesh (2017), the proportion of microeconomic applied papers in the top five journals that draw on economic theory has risen from approximately 40% in 1951-1955 to 80% in the period from 1973 to 1977, but has fallen in the subsequent period such that this figure was around 60% in 2007-2008. Thus, while there is a larger proportion of theoretical models underlying applied papers nowadays than in the early 1950s, the extent to which theoretical models are used in econometrical papers has fallen considerably in recent decades. "If the typical thesis of the eighties was an elaborate piece of price theory estimated by non-linear maximum likelihood on a very small number of observations,"

remarks Deaton (2007), "the typical thesis of today uses little or no theory, much simpler econometrics, and hundreds of thousands of observations." My results point in the same direction, with applied works becoming increasingly more detached from theory after 1990. Thus, not only theoretical papers have become less common, but also their importance in orienting applied research has decreased after 1990.

If the 1940s and 1950s mark the rise of formalization, and in the early 1970s Leijonhufvud (1973, 328) rightly (and ironically) pointed that "status is only to be achieved by making 'modls'", in the 1980s it was measurement, rather than theory, which was on a clear ascent.[22] Thus, in a letter to Science, Leontief (1982, 104-107) complained of economists "irresistible predilection for deductive reasoning [...] economic journals are filled with mathematical formulas leading the reader from sets of more or less plausible but entirely arbitrary assumptions to precisely stated but irrelevant theoretical conclusions." To him, not only mathematical economics fell short from practical relevance, but also econometrics, which relied heavily on aggregate data that were of little use "to advance, in any perceptible way a systematic understanding of the structure and the operations of a real economic system" while "masses of concrete, detailed information contained in technical journals, reports of engineering firms, and private marketing organizations are neglected." He was critical of the excessive deductivism of economics and skeptical of the possibilities of interdisciplinary research. The "splendid isolation in which academic economics now finds itself", he argued, was likely to continue

> as long as tenured members of leading economics departments continue to exercise tight control over the training, promotion, and research activities of their younger faculty members and, by means of peer review, of the senior members as well. The methods used to maintain intellectual discipline in this country's most influential economics departments can occasionally remind one of those employed by the Marines to maintain discipline on Parris Island.

This brings me back to the main point of the paper. The hegemony of the top journals and their effect in shaping economic discourse is not only an element that helps to explain the formalization of economics from a historical perspective, but it has unfortunate implications for the future of economics. Researchers should not ask themselves what kind of argument and method is more likely to be accepted in the top journals before choosing the topic they deem more relevant or interesting. The pernicious incentives provided by the hierarchy of journals may hinder the emergence

[22] AER's 1972 editorial captures the dissatisfaction of readers of the journal as to the prevalence of theoretical articles: "Articles on mathematical economics and the finer points of economic theory occupy a much more prominent place than ever before, while articles of a more empirical, policy-oriented, or problem-solving character seem to appear less frequently." The editor went on to argue that this tendency was not due to the journal's preference for such articles (Borts 1972).

of novel ideas. Whether or not one should welcome the shift from theory to application is a matter of debate and ultimately of how one understands the role of the economist, but the most relevant question is not whether the changes in recent decades in economics are beneficial, instead what is at stake is what are the drivers of these changes. In this sense, if my argument that the top journals are gate-keepers of economic discourse is accepted, then there is much to be questioned about why should a small number of journals have so much power in determining what is acceptable as legitimate practices of economists.

Conclusion

Debreu starts his presidential address to the American Economic Association claiming that as "the Second World War was drawing near its resolution, economic theory entered a phase of intensive mathematization that profoundly transformed our profession" (Debreu 1991, 1). To him, economics benefited from this process by becoming "open to an efficient scrutiny for logical errors". This happened by incorporating new tools developed by mathematicians such as convex analysis, fixed point theory, and the theory of integration and of nonstandard analysis. By becoming more abstract, economists could solve some long-standing riddles such as the integrability problem and consumer choice under uncertainty. Yet, and perhaps surprisingly, he ends his presidential address by muddying the water as to the desirability of this process: "Ceteris paribus, one cannot prefer less to more rigor, lesser to greater generality, or complexity to simplicity; but other things are not equal, and in the estimate of many members of our Association the cost of that mathematization sometimes outweighs its benefit" (1991, 3-5). Thus, he argues, any evaluation of the pros and cons of the formalization of economics requires understanding how and why it happened.

The answer to such question obviously involves a number of elements and historians of economic thought have widely debated this issue. Hopefully, this paper has contributed to this investigation by shedding some light on one aspect of this process. As I have tried to show, there is an institutional side of this story that should be accounted for: the formalization of economics benefited from the vehicles that promoted the rise of such ideas. In this sense, the most important journals form the core of a communication network and they influence the diffusion of certain ideas throughout the whole network of the economics profession. The co-evolution of formal content in the three journals I have investigated is remarkably similar, both in terms of theoretical and applied research, which suggests that ideas quickly spread in the core of the network. Comparing the three journals with the other economics journals, one notes that the top journals led the process, and that the rest of the network followed the same pattern, albeit with some delay. Moreover, using co-word analysis it has been shown that

between 1990 and 2017 applied research has become more dissociated from economic theory. Thus, not only strictly theoretical research been losing importance since the early 1980s, but more recently theory has also become less important in orienting applied research.

Further research would be necessary to better understand the role of the core journals in shaping economic discourse, examining in more detail how ideas spread from the top journals to the economics profession as a whole, how and when these outlets came to occupy a central position in the network of journals, and whether or not the editors of journals favor certain lines of research. Yet, my contribution was a first step in showing the role of the top journals in the formalization of economics by acting as vehicles that diffused such ideas. In this sense, there may have been a 'standing on the shoulder of giants effect' through which the publication of papers in these journals led to extensions, revisions, applications and discussion in the other journals. Moreover, I have found some evidence of the rise and death of theory and the continuous increase of applied papers between 1940 and 2017. Finally, I have argued that my findings are relevant not only to shed some light on the formalization economics from a historical perspective, but also to assess the contemporary state of economics. What will the next chapter of this story be remains to be seen, but given the hierarchy of the economics profession there seems to be little doubt about who is going to write it.

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