The Internationalization of Brazilian Economics Research: An Empirical Approach to Comparing Mainstream and Heterodox Traditions in the 21st Century

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ABSTRACT: This study provides a comprehensive characterization of the thematic patterns and recent intellectual structure of internationalized Brazilian economic research and compares it with frontier research in the field. Our analysis considers the exceptionally pluralistic environment in which the discipline of economics is embedded in Brazil and examines mainstream and heterodox paradigms separately. In methodological terms, the analyzes rely on bibliometric data. Bibliometric data were extracted from the Scopus database, covering international publications by Brazilian authors and global frontier research between 2000 and 2022, totaling 5,444 and 13,233 documents respectively. The textual content was represented by a *bag-of-words* model and cluster analysis used the *k-means* algorithm and *cosine similarity* metrics. Our results show that Brazilian heterodox economics is more integrated with heterodox frontier research than Brazilian mainstream economics with the global mainstream.

Keywords: Brazil; Globalization of economics; Mainstream Economics; Heterodox Economics; Bibliometrics.

JEI: A23; A14; B40

Introduction

The internationalization of science refers to the process of integrating an international, intercultural, or global dimension into the purpose and functions of scientific research (RAZAEI et al, 2018). This type of internationalization manifests itself through the work and collaboration process of scientists in different countries and cultures, promoting the exchange of knowledge and ideas (KRABEL et al., 2012). In Brazil, the process intensified particularly from the 1990s onwards, with increased government support and incentives for international academic cooperation (LAUS & MOROSINI, 2005). These policies increased the mobility of researchers, professors, and students, both among Brazilian institutions and with foreign institutions, and this mobility had significant impacts on the internationalization of the academic sphere.

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There is a vast literature dedicated to understanding the process of internationalization of the discipline of economics in Brazil. Loureiro & Lima (1994) emphasize the role played by international influences in the formation of the discipline of economics in Brazil and conclude that the American model had a significant impact on the institutional framework. Fernandez & Suprinyak (2018 and 2019) investigate the beginnings of the *Associação Nacional de Pós-Graduação em Economia* (ANPEC) in the development, internationalization, and promotion of pluralism in the country's economic science. Suprinyak & Fernandez (2021) explore the actions of the so-called 'Vanderbilt Boys,' a group of economists from Vanderbilt University who played a significant role in modernizing Brazilian economics during the 1960s and 1970s. Considering empirical approaches, Issler & Pillar (2002) measure the international scientific production in economics of Brazilian researchers and departments, Faria et al., (2007a) analyze the internationalization of Brazilian academic economists in terms of their publications in international economic journals and Faria et al., (2007b) study the determinants of international citations of Brazilian economists in articles published in the main national economics journals in 1994 and 2004, finding that research in Brazil has become more open to international influence and more geographically dispersed

While historical contributions recognize the pluralistic peculiarity of Brazilian economic science, they lack empirical evidence regarding the process of internationalization of Brazilian research in economics. Empirical contributions, in addition to ignoring internationalization within the scope of heterodox perspectives, use bibliometric strategies that are unable to provide indicators regarding the characteristics of the thematic and intellectual insertion of Brazilians. Given this, questions about the intellectual profile of the inclusion of research by Brazilians in global research in economics remain open.

In this study, two questions are addressed: (i) what is the intellectual profile of the internationalization of economics in Brazil? And (ii) in which thematic cores are the international contributions of Brazilians situated in frontier global research Research problems are confronted using a bibliometric methodology applied to a sample of 5,444 academic articles with at least one Brazilian author that were published in foreign economics journals, and another containing 13,233 articles published in one of the top 5 economics journals.

To answer these questions, we will emphasize the pluralistic peculiarity of academic economics in this country and present the results comparatively, considering contributions from both mainstream and heterodox perspectives. Therefore, in line with the contributions of Colander et al. (2004), this work is based on sociological classifications for the concepts of mainstream economics and heterodox economics at the global level. Therefore, we will consider as "mainstream" the most prestigious economic theories, methods, and approaches in global economics academia at the present

time. These are taught and make up the research centers in the most renowned graduate programs in economics in the world. They are also published in the most impactful economics journals and have the most prestige in the field. It is important to note that these mainstream theories, methods, and approaches are not necessarily associated with specific schools of thought or economic traditions. In general, they share a mathematical formalism and are governed by the principle of modeling economic relationships and testing them with sophisticated statistical approaches (AKERLOF, 2020). However, they do not necessarily have to be intellectually consistent with each other.

Consequently, theories, methods, and approaches that are sociologically marginalized from the global mainstream will be considered heterodox. In general, heterodox perspectives on economics derive from specific economic intellectual traditions and their adherent economists identify with those traditions. This makes a heterodox economist identify more specifically than a mainstream economist, such as a post-Keynesian, Marxist, evolutionary Schumpeterian, Austrian, old-institutionalist, structuralist, developmentalist, or a particular variant of ecological, feminist, or sustainability economist, among other types.

1 Heterodox and mainstream tradition in Brazilian economics

Even before the institutionalization of economics as a discipline in Brazil, the hegemony of economic policy and public discourse has been challenged by mainstream and heterodox approaches. In the early years of the Republican period, the "*paperists*" and "*metalists*" helped to reproduce the historical debate over British monetary policy. In the 1930s and 1940s, Brazil was the scene of the famous "planning controversy" between Roberto Simonsen, an advocate of state interventionism to promote the industrialization of the country, and Eugênio Gudin, a liberal and vehement opponent of Simonsen's ideas. In the late 1950s, the accelerated rise of inflation brought the "monetarist" currents into conflict with the "structuralist" currents, who opposed the understanding and strategies to deal with price imbalances. When economics was finally institutionalized in Brazil in the 60's, there was already a wide range of perspectives in the economic debate.

During the 1960s, the growth of economics in Brazil was significantly supported by North American institutions such as the United States Agency for International Development (USAID) and the Ford Foundation (FERNANDEZ & SUPRINYAK, 2018). These organizations played a pioneering role in funding graduate programs focused on economics and encouraged their modernization. A critical moment in the institutionalization of economics academia in Brazil was the creation of ANPEC in 1973. According to Fernandez and Suprinyak (2019), ANPEC's adoption of a pluralistic approach was highlighted during its first year when it chose to host the heterodox program

at the University of Campinas (Unicamp), despite facing potential boycott and withdrawal by one of its esteemed members, the Getúlio Vargas Foundation.

Unicamp's economic program developed with a strong heterodox orientation. By the 1970s and 1980s, the university had become one of the most prestigious in the country, with an Institute of Economics founded primarily by heterodox economists (DEQUECH, 2018). At the University of Campinas, the study of Keynes is the culmination of a trajectory that began with Marxist criticism of CEPAL ideas in the 1970s. This criticism led to Kalecki and his version of the principle of effective demand, and finally arrived at Keynes and his closest followers (CARVALHO, 2008).

The Institute of Economics at the Federal University of Rio de Janeiro (UFRJ) also was a prominent source of heterodox thought in Brazil. The institute is known for its adoption of a post-Keynesian approach, heavily influenced by American economists Paul Davidson and Hyman Minsky (CARVALHO, 2008). This approach stands in contrast to neoclassical macroeconomics. Two notable events in the history of this school include a course taught by Paul Davidson at the Fluminense Federal University in 1987, which expanded the dissemination of post-Keynesian ideas in Brazil, and a seminar held at UFRJ in 1997, which brought leading post-Keynesian economists such as Nina Shapiro, Steve Fazzari, Philip Arestis, Gary Dimsky, and Jan Kregel to Brazil (ibidem). Old Institutional Economics also has representationAccording to Brites & Almeida (2023), Ramon Garcia Fernandez was the pioneer of this approach in Brazil during the nineties. The initial milestone would have been a Heterodox Microeconomics course taught in the Graduate Program in Economics at the Federal University of Paraná (BRITES & ALMEIDA, 2023).

Mainstream economics also has broad support in Brazil. An historical initial movement, led by Eugênio Gudin and Otávio Gouveia de Bulhões, established the orientation of the first official university, founded in Rio de Janeiro in 1946 (LOUREIRO & LIMA, 1994). This institution sought to develop within the framework of the so-called "modernization tendencies" prevalent in industrialized countries (ibidem, p. 368). This period was characterized by the rejection of "mixed" curricula and the focus on mathematics, statistical methods, and economic theories (ibidem). A "mainstream" tradition has been implemented in Brazil as part of a second important movement, the systematic sending of Brazilian professors to doctoral courses at foreign universities, especially in the United States, since the late 1960s. This initiated the process known as the 'Americanization of discipline' (ibidem).

Largely due to its historical process, Brazil currently represents a unique and distinct instance of historical pluralism in economics (HODGSON, 2019). In contrast to the global trend, heterodox economists in Brazil hold tenured positions at the country's leading universities and have access to primary sources of research funding (DEQUECH, 2018). Furthermore, most nationally distributed

journals accept submissions employing heterodox methodologies and divergent approaches coexist harmoniously in most economics departments offering graduate programs (FERNANDEZ & SUPRINYAK, 2019). This exceptionality is explained in the literature within the domains of the institutions regulating the economics academy in the country (FERNANDEZ & SUPRINYAK, 2018 and 2019; DEQEUCH, 2018)).

The current scenario stands for the maintenance of this historical pluralism. During the 2017-2020 quadrennium, the Graduate in Economics had 67 programs recommended by the Coordination for the Improvement of Higher Education Personnel (CAPES). Of these programs, 21 were academic master's programs, 28 offered both master's and doctoral programs, 1 offered only a doctoral program, and 17 offered a professional master's program. In total, this group of programs included 95 graduate programs (CAPES, 2022). Among these programs, 54 were affiliated with the National Association of Centers for Postgraduate Studies in Economics (ANPEC), distributed among programs in economic theory, development economics, and applied economics (ANPEC, 2023).

Among the programs associated with ANPEC, Fernandez and Suprinyak (2019) estimate that only 27% of all graduate programs in economics in Brazil are purely mainstream programs. These include programs at Getúlio Vargas Foundation (in São Paulo and Rio de Janeiro), the University of São Paulo at its various campuses, the Federal University of Pernambuco (UFPB/PIMES), and others. The predominantly heterodox group is slightly more represented, with 32.6% of the programs. These include the University of Campinas (Economic Theory and Economic Development), the Federal University of Rio de Janeiro, the Fluminense Federal University, and others. Plural degree programs represent the majority with about 40.4%, including the University of Brasília, the Federal University of Minas Gerais, the Federal University of Rio Grande do Sul and others. This illustrates the pluralistic environment that characterizes academic economics in Brazil.

2. Methods and Procedures

Bibliometrics emerged from scientometrics, aiming to quantitatively treat written discourse and related behavior (LAWANI, 1981). Thus, encompasses techniques to quantify written communication (LAWANI, 1981; IKPAAHINDI, 1985) and it is used to analyze scientific publications, including production, dissemination, and impact aspects (ARIA & CUCCURULLO, 2017). To fulfill its purpose and be useful for scientific mapping, bibliometric analysis must be organized around a mathematical model capable of representing a document. For the purposes of this work, we will assume the representation known as "bag-of-words," a method employed to represent textual data as a set of words, disregarding grammar and the order in which words appear. This

approach involves segmenting the text into individual words and counting the frequency of each, thus creating a "bag" of words that can be used for analysis and comparison of different texts (DIODATO, 2013).

As explored by Huang (2008), in the "Bag-of-words" approach, words are counted in each bag, where each represents a dimension in the resulting data space, and each document is transformed into a vector with non-negative values in each dimension. The frequency of each term is its weight, indicating that terms that appear more frequently are more relevant and descriptive for that document (HUANG, 2008). Following the derivation expressed in Maltaca and Almeida (2022), let us represent $D = \{d_1, \dots, d_n\}$ as a collection of documents and $T = \{t_1, \dots, t_n\}$, as a collection of distinct terms that appear in D. If we represent a document as an m-dimensional vector t_d then the frequency of term $t \in T$ in document $d \in D$ can be denoted $t_d(d, t_1), \dots, tf(d, t_m))$. Huang (2008 apud Maltaca e Almeida, 2022) notes that the most frequent terms are not always the most informative. In fact, terms that appear frequently in a small number of documents but rarely in others tend to be more relevant and specific to that cluster. To account for this, we transform the basic term frequency equation$t_d d(d, t)$) into the tfidf (term frequency-inverse document frequency) measure. This measure weights the frequency of term "t" in document "d" with a factor that reduces its importance relative to its presence in the entire document set and is denoted by$t_{didif}(d, f) = t_f(d, t) \times \log(|D|d_f(t))$, where $df(t)$. The quantity of documents containing the term "t" is represented by this value. The weight of term "t" in document "d" can be represented by the notation w_t, d.

In accordance with the specialized literature, the bag-of-words approach should be used as a preliminary procedure before applying clustering algorithms, given the need to select appropriate distance or similarity measures, which can significantly affect the quality of the clustering results (HUANG, 2008). Thus, according the guidelines expressed in Madani (2015), the clustering process involved tree mathematical steps: (i) we measured the similarity between research papers using metrics such as cosine similarity, in line with the results found by Zahrotun (2016); (ii) we applied a clustering algorithm such as k-means, which we compared with hierarchical clustering to group research papers based on their similarities; and (iii) the quality of the clusters was evaluated using metrics such as *silhouette score*, a commonly used clustering evaluation tool that measures the quality of clustering by calculating the relative compactness and separability of clusters (DUDEK, 2020)[2].

[2] It ranges from -1 to 1, where a score closer to 1 indicates that the data point is well-matched with its own cluster and poorly matched with neighboring clusters (Ibidem). On the other hand, a score closer to -1 indicates that the data point is poorly matched with its own cluster and well-matched with neighboring clusters. A score of 0 indicates that the data point is on the boundary between two clusters (DUDEK, 2020).

The attributes of a specific document are interconnected through the document's own attributes (such as author, keywords, publication date, country, or journal). These connections between different attributes can be represented through $Document\ X\ Attribute$ matrices (ARIA & CUCCURRULLO, 2017). Again, following a derivation present in Maltaca and Almeida (2022), we can define an $m \times n$ co-occurrence O where its columns represent the attributes whose co-occurrence we wish to analyze. Typically, in Maltaca & Almeida (2022) and in this study, the rows of the matrix represent the documents, and O is a binary matrix. If we let oki denote the element in the k-th row and i-th column of O, then $O\ k_i$ is equal to 1 if object i appears in the document corresponding to the k-th row of O and 0 otherwise. Let C be the co-occurrence matrix of objects $1, \dots, n$, a symmetric and non-negative $n \times n$ matrix where its elements c_{ij} are in the i-th row and j-th column of C. For $i \neq j$, c_{ij} is equal to the number of co-occurrences of object i. For all i and j, we have that $C_{ij} = \sum_{k=1}^{m} O_{ki}O_{kj}\ O.T$hus, we conclude that $C = O^T O$, where O^T is the transpose of O.

In accordance with the methodological procedures outlined by Maltaca & Almeida (2022) we used the Strength of Association to normalize distances, which is a direct similarity measure. This is a method is a normalization method that considers the co-occurrence frequency of two items (e.g., documents, authors, or keywords) in the same reference list, as well as the total number of references in which each item appears. The resulting association strength values are then used to construct a weighted network, where the weight of each edge represents the strength of the association between the two connected items. It is defined as $\sum_{j}^{n} = 1, j \neq i\ cij$ or as $si = \sum_{n}^{k} = 1\ O_{kij}$ both equivalent to $S_A(C_{ij}S_iS_j) = \frac{C_{ij}}{S_iS_j}$. This metric reflects the ratio between the observed frequency of objects i and j appearing together, and the frequency that would be expected if their occurrences were statistically independent. Note that the subscript values for matrix O are swapped because the number of columns varies between C and O. A direct similarity measure determines the similarity between two objects i and j by taking the number of co-occurrences between i and j and adjusting this number for the total number of occurrences and co-occurrences of i and j and the total number of occurrences and co-occurrences of j.

Co-citation analysis is based on the idea that two papers are related if they are both cited by a third paper. According Maltaca & Almeida (2022) This can be calculated using the formula Bcocit number of bibliographic pairs between documents: $Bcocit = A \times A$, where A is a matrix (Document x Cited Reference), but in this case, the b_{ij} elements represent the number of co-citations between documents i and j. Finally, co-occurrence analysis is a technique used to extract the conceptual structure of a model by creating co-occurrence networks of clustered words and terms. These

networks are derived from keywords, titles, and abstracts found within a set of documents. The measure for this analysis is calculated using the formula $Bcoc = D \times D'$, where D represents a matrix of $Documents\ X\ Words$. The words in this matrix are obtained from the keywords, titles, and abstracts of the articles. The bij elements indicate the number of co-occurrences between words i and j (MALTACA & ALMEIDA, 2022).

We adhered to the principles outlined by Maltaca & Almeida (2022). Thus, the visualization of these results was achieved using the technique developed by Waltman, Eck, and Noyons (2010), which maps co-citations and co-occurrences simultaneously. Finally, it was used the co-word analysis proposed by Callon et al. (1983) to estimate the strength of association between information in the textual data of the document sample based on the interactions of key terms. To better interpret the results, strategic longitudinal diagrams were used to categorize the identified themes. The strategic diagram is a two-dimensional space constructed by tracking themes according to their centrality and density classification values, using the median to classify clusters along two axes: Centrality (x-axis) and Density (y-axis). Thematic areas are used to show conceptual evolution. Thus, a visualization approach is proposed to graphically represent the thematic evolution of the studied area (COBO et al, 2011).

The bibliometric data for this article were extracted from the *Scopus* database, chosen for indexing all major economics journals. Other databases, including Web of Science, PubMed, and Cochrane, were consulted but discarded. Web of Science indexed fewer documents than Scopus during the selected period, while PubMed and Cochrane were deemed outside the study's scope. The main sample was filtered from an initial sample of 1,445,252 documents extracted from the Scopus database, including documents with at least one Brazilian author. Filters were applied to refine the sample, including restricting to the "Economics, Econometrics and Finance" category, reducing the number to 15,807 documents.

The sample was then restricted to only academic articles, reducing the number to 12,014 articles. A language filter was applied to include only articles published in English, resulting in 8,960 articles. The period of analysis was chosen as 2000-2022, resulting in a sample of 8,200 articles. Two additional filters were applied to narrow the scope of the sample in terms of the journals it includes. The first filter removed national journals from the analysis, resulting in 6,678 articles. The second filter removed journals not listed as economics journals in the IDEAS/RePEc platform, yielding the final sample for this paper, comprising 5,444 articles. In the second part of the procedure, a more in-depth analysis of the sample was conducted to identify the contributions of the articles within the field of Economics. The journals in which the articles were published were used as a criterion to differentiate between mainstream and heterodox approaches, using the *Heterodox Journal Quality*

Score (HJQS Index). The data was fitted to models using *R* language software *RStudio,* version 2021.9.0, and the *bibliometrix* package. The *biblioshiny* interface was employed to generate graphs.

3. General characteristics of the sample

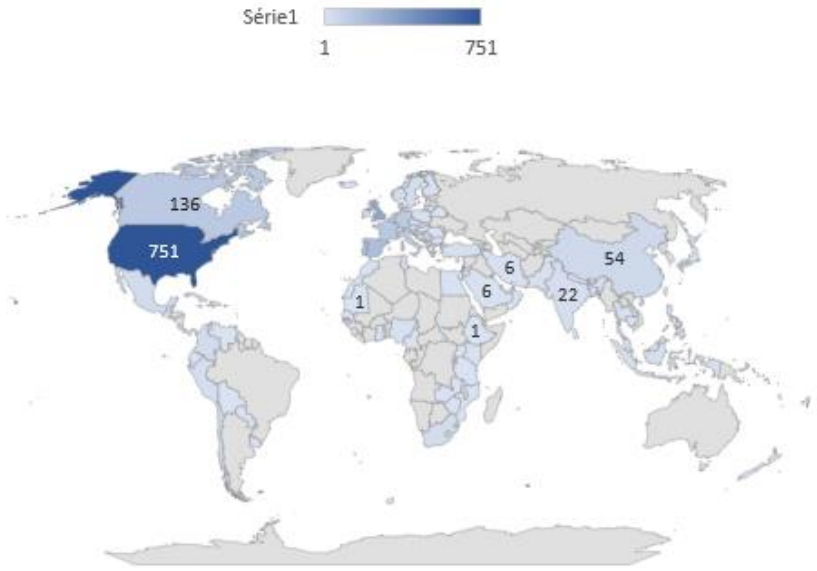
Each document received an average of 17.07 citations. the sample also contains information about the documents' content, including 8208 keywords plus (ID)[3] and 12505 author's keywords (DE). A total of 10,787 authors contributed to the sample, with 784 single-author documents and an average of 3.02 co-authors per document. International co-authorships account for 38.21% of the sample, distributed in partnerships with 100 countries. The journals with the highest frequency of publication (over 40 publications during the specified period)[4] can be organized into groups such as environment and sustainability (*Environment, Development and Sustainability*, Resources, Conservation and Recycling and *Marine Policy*), economics and management (*Economics Bulletin* and *International Journal of Production Economics*), natural ecosystems (*Ecological Economics*, *Energy Economics* and *Resource Policy*), applied economics (*Applied Economics*, *Applied Economics Letters* and *Economics Letters*), development and poverty (*World Development*), macro, monetary and banking economics (*Journal of Economic Studies* and *Journal of Banking and Finance*), Latin American studies (*Latin American Research Review*), formal theoretical economics (*Economic Modeling*, *Journal of Mathematical Economics* and *Economic Theory*), and heterodox journals (*Cambridge Journal of Economics*, *Structural Change and Economic Dynamics*, *Journal of Economic Issues* and *Journal of Post Keynesian Economics*).

Figures 1 and 2 illustrate the most important cooperation partners, taking into account mainstream and heterodox approaches.

[3] The use of Keyword Plus in bibliometric studies helps to visualize the structure of scientific fields and to study the structure of knowledge in scientific fields (GARFIELD, 1990). It is a feature of the Web of Science that automatically identifies common words or phrases in article titles and adds them to the article record as Keyword Plus terms (ibidem). These terms are intended to capture important concepts that may not be included in the keywords assigned by the author of the article (ibidem).

[4] The exact order in which they appear is: Environment, Development and Sustainability (160), Economics Bulletin (154), International Journal of Production Economics (151), Resources, Conservation and Recycling (137), Marine Policy (108), Ecological Economics (103), Applied Economics (98), World Development (91), Energy Economics (87), Applied Economics Letters (78), Economics Letters (77), Journal of Economic Studies (77), Journal of Post Keynesian Economics (60), Journal of Banking and Finance (59) , Resources Policy (57), Latin American Research Review (55), Cambridge Journal of Economics (53), Quarterly Review of Economics and Finance (53), Economic Modeling (50), Structural Change and Economic Dynamics (50), Journal of Mathematical Economics (47) and Economic Theory (46)

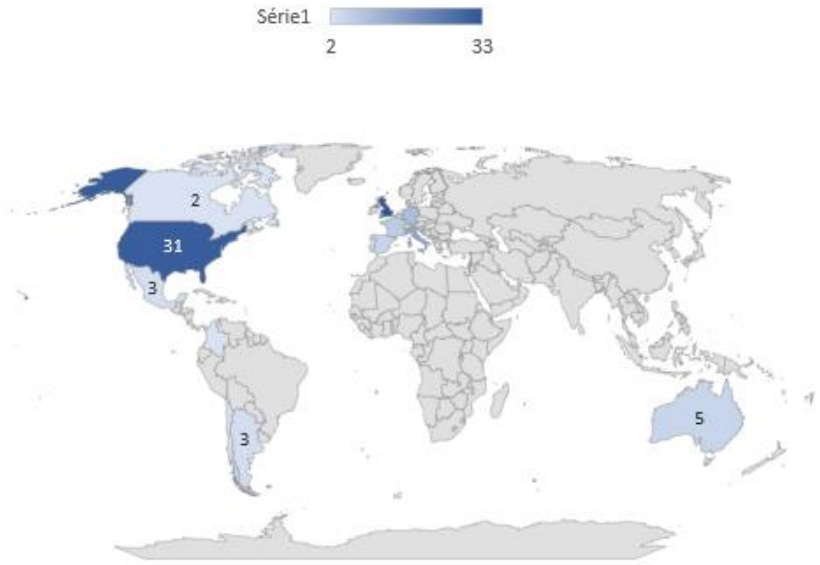
Figure 1– Collaborative efforts with Brazil (Mainstream Tradition)



Countries		Collaboration occurred
BRAZIL	USA	751
BRAZIL	UNITED KINGDOM	321
BRAZIL	SPAIN	195
BRAZIL	PORTUGAL	177
BRAZIL	FRANCE	140
BRAZIL	CANADA	136
BRAZIL	GERMANY	133
BRAZIL	ITALY	122
BRAZIL	NETHERLANDS	79
BRAZIL	CHINA	54
BRAZIL	CHILE	51
BRAZIL	MEXICO	38
BRAZIL	COLOMBIA	37
BRAZIL	DENMARK	35
BRAZIL	SWITZERLAND	34

Source: Outlined by the author.

Figure 2– Collaborative efforts with Brazil (Heterodox Tradition)



Countries		Collaboration occurred
BRAZIL	UNITED KINGDOM	33
BRAZIL	USA	31
BRAZIL	ITALY	15
BRAZIL	GERMANY	10
BRAZIL	FRANCE	7
BRAZIL	AUSTRALIA	5
BRAZIL	SPAIN	5
BRAZIL	ARGENTINA	3
BRAZIL	MEXICO	3
BRAZIL	AUSTRIA	2
BRAZIL	CANADA	2
BRAZIL	CHILE	2
BRAZIL	COLOMBIA	2
BRAZIL	NETHERLANDS	2
BRAZIL	PORTUGAL	2

Source: Outlined by the author.

4. Comparative co-citation analysis

This study compares co-citation networks and thematic maps of mainstream and heterodox articles to the top five journals of each approach. At this level of analysis, the type of internationalization of Brazilian economics is measured by its adherence to what has been developed at the frontier of mainstream and heterodox economics during the same period. As argued by Colander et al (2004) and Wei (2019), due to the restriction of economics education, the most innovative findings in economics (or the knowledge frontier in economics) are concentrated in the main journals of this discipline. From this comparative perspective from the Brazilian contributions and top 5 journals, it will be possible to determine, through the use of clustering algorithms, which segment of frontier research Brazilian contributions are most concentrated in, according to density and centrality criteria.

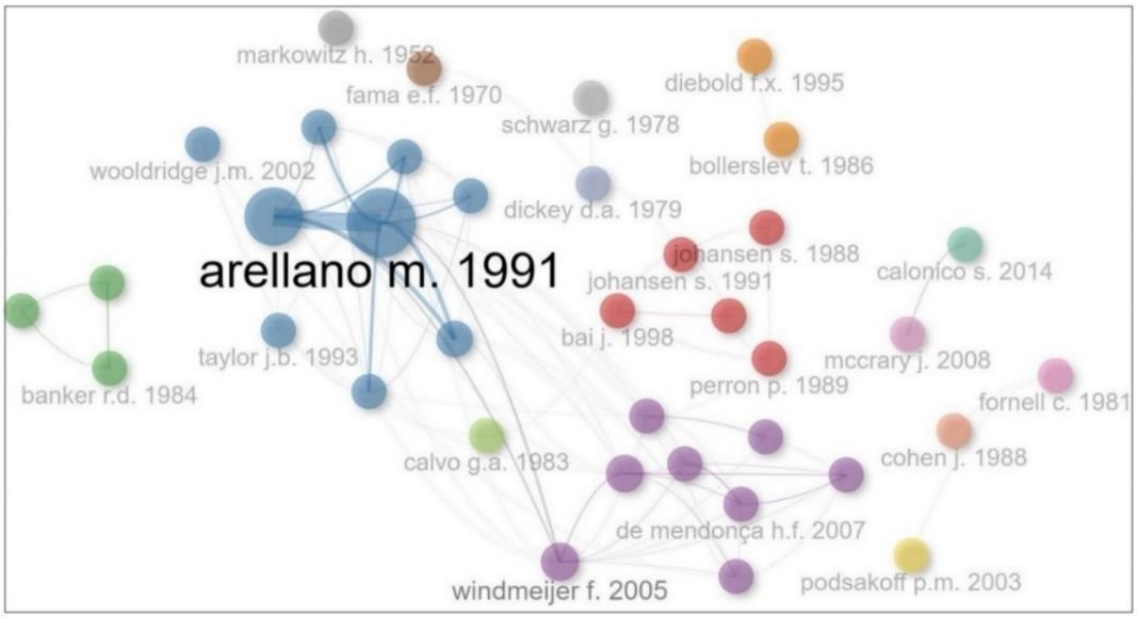
The mainstream journals listed (according to the *Scimago index*) are: *Quarterly Journal of Economics*, *Journal of Political Economy*, *American Economic Review*, *Review of Economic Studies*, and *Econometrica*. The heterodox journals listed (according to the HJQS index) are *Cambridge Journal of Economics*, *Journal of Economic Issues*, *Journal of Post Keynesian Economics*, *Review of Radical Political Economics*, and *Review of Political Economy*. These rankings provide insight into the most prestigious and influential journals in the fields of mainstream and heterodox economics. The *Scimago index* ranks journals based on their scientific impact, while the *HJQS index* ranks journals based on their influence in the field of heterodox economics.

Figures 3, 4, 5 and 6 show the compared co-citation networks. Co-citation analysis examines the relationships between academic articles based on the frequency with which they are cited together by other documents (CHEN, 2012). It is a way to identify the intellectual structure of a field and detect research frontiers (ibidem). The network is constructed by identifying all pairs of articles that are cited together in each set of articles and then connecting these pairs with a link. The strength of the link between two articles is determined by the number of times they are cited together (ibidem).

4.1 Mainstream Tradition

The estimated co-citation networks considering Brazilian mainstream contributions (Figure 3) present six main clusters.

Figure 3 – Brazilian Mainstream co-citation network (2000-2022)



Source: Outlined by the author.

The most evident of them (Blue Cluster) highlights complementary contributions in the field of theoretical econometrics (ARELLANO & BOND, 1991; WOODRIDGE, 2002) and applied econometrics (TAYLOR, 1993). Arellano & Bond (1991) presents specification tests for dynamic models estimated by the GMM method in panel data and proposes a serial correlation test based on GMM residuals. Woodridge (2002) explores the application of the GMM method for estimating problems with cross-sectional, time series, and panel data and discusses the advantages of the robustness of moment estimators. In both cases, the results legitimize the use of GMM with some reservations. Taylor (1993) addresses the practical application of econometric research on monetary policies. Theoretical econometrics and applied macroeconomics are also presented in the purple cluster, which highlights the contributions of De Mendoça (2007), who analyzes the use of the basic interest rate in Brazil after the adoption of the inflation target and evaluates the credibility of this monetary regime; and Windmeijer (2005), who presents a finite sample correction for the variance of efficient two-step linear GMM estimators. De Mendoça (2007) concludes that the strategy adopted in Brazil was not efficient in developing the necessary credibility for the inflation targeting regime. Windmeijer (2005) shows that the estimated standard errors of the efficient two-step GMM estimator can be considerably biased downwards in small samples and proposes a corrected finite sample variance estimate, which can be used to obtain more accurate inferences. This is confirmed through a Monte Carlo study using a panel data model (ibidem).

The examination of the red cluster presents similar results. In this domain, canonical contributions to time series econometrics are grouped together. Johansen's contributions (1988 and

1991) present results on maximum likelihood estimators and likelihood ratio tests for cointegration in Gaussian vector autoregressive models. Pierre Perron's contributions (1989) highlight an innovative approach to testing the unit root hypothesis against stationary trend alternatives, taking into account the analysis of the relationship between cointegration vectors and error correction models. Together with Jushan Bai, he presents a new approach to testing the unit root hypothesis against stationary trend alternatives (BAI & PERRON, 1998).

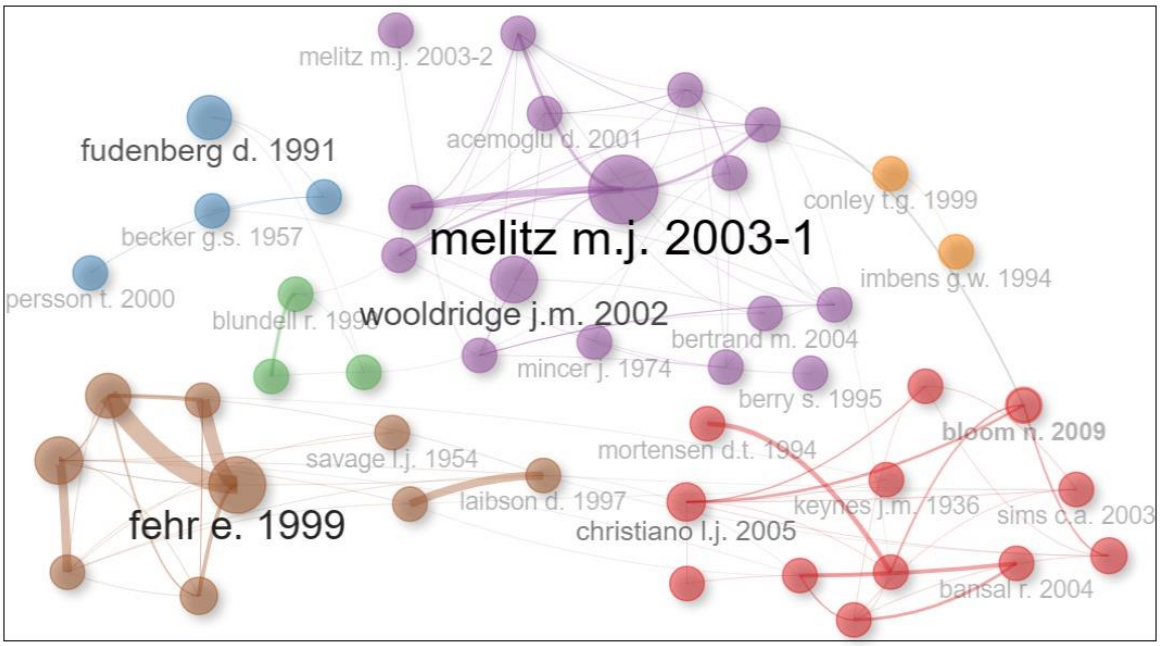
In these domains, Johansen's approach (1988) showed promising results when dealing with Gaussian data, offering robust estimates and reliable test statistics. Johansen (1991) shows that the asymptotic distribution of the maximum likelihood estimator is mixed Gaussian. Perron (1989) presented three canonical contributions: (i) allowing for the presence of a single change in the trend function under both null and alternative hypotheses; (ii) demonstrating that standard tests can fail to detect the unit root when there is a break in the trend function; (iii) and providing a convenient representation of sample moments of the time series under analysis. Bai & Perron (1998) develop a theoretical framework for testing and estimating change points in regression models, relating them to obtaining convergence rates and with the limiting distribution of estimated parameters.

Figure 3 illustrates three smaller clusters. In the orange cluster, canonical contributions of theoretical econometrics are grouped. They are: Bollerslev (1986), in the domain of his three most important contributions: (i) a proposal for a generalization of the ARCH model; (ii) A theoretical and formal derivation of the stationarity conditions and autocorrelation structure of the GARCH model; and (iii) an empirical comparison of the performance of the GARCH model with the ARCH model applied to the analysis of inflation rate uncertainty; and Diebold & Mariano (1995), who introduce and evaluate explicit tests of the null hypothesis considering the absence of difference in accuracy between two competing forecasts. These tests have broad applicability as they can be adapted to various accuracy measures.

In the light green cluster, contributions are grouped around Calvo's classic article (1983), in which he proposes a more analytically tractable staggered pricing model. This model presents microeconomic foundations and assumes that demands are derived from agents' utility maximization. The study demonstrates that the equilibrium path can be determined using essentially graphical techniques and analyzes welfare implications related to monetary and fiscal policy. From this classic essay derives Calvo's famous pricing rule, one of the pillars of modern new-Keynesian macroeconomics and DSGE models. Finally, the dark green cluster highlights Banker (1984), whose contributions lie in proposing an innovative method for estimating the most productive scale size (MPSS) using integer value data in the data envelopment analysis (DEA) method.

A shared reference between the estimated mainstream Brazilian co-citation network and the global mainstream (Figure 4) is Woodridge (2002).

Figure 4 – Global Mainstream co-citation network (2000-2022)



Source: Outlined by the author.

In the global sample, the reference shares the same cluster (purple) with Bertrand et al (2004), who analyse difference-in-differences (DD) estimates. Both contributions highlight the importance of productivity differences in economic analysis. Additionally, Melitz (2003) sheds light on the importance of the institutional environment and its relationship with economic development, a characteristic shared with Acemoglu et al. (2001), who investigate the colonial origins of comparative development. In the brown cluster, Fehr & Schmidt (1999) and Laibson (1997) fall within the field of behavioral economics. Fehr & Schmidt (1999) focus on the issue of fairness and equity in economic interactions, proposing a theoretical model that incorporates people's concern for equity to explain observed behavior. Laibson (1997), on the other hand, explores the issue of hyperbolic discounting of the future by consumers. The hyperbolic discounting model suggests that people tend to value rewards more in the present than in the future, resulting in inconsistent intertemporal decision-making behaviors.

The blue cluster highlights the classic game theory manual written by Drew Fudenberg and Jean Tirole (1991), along with the book by Gary S. Becker (2010) and Person et al. (2000). Both works are rooted in microeconomic and policy analyses. In the red cluster, contributions are grouped around Keynes' General Theory (1936). The article by Mortensen & Pissarides (1994) develops an

endogenous model of job creation and destruction and incorporates it into the matching approach to balance unemployment and wage determination. The other works in this cluster have a particular interest in economic uncertainty. Bloom (2009) analyzes the impact of uncertainty shocks on the economy, showing that an increase in uncertainty can lead to a temporary pause in investment and hiring by firms. Bansal and Yaron (2004) propose a model that explains the main phenomena of the asset market using consumption and dividend growth rates, includes a small long-term predictable component in consumption and dividend growth rates, as well as fluctuating economic uncertainty. Finally, Sims' (2003) article presents a new theory called "rational inattention," which shows that actions can depend on observations only through a communication channel with finite capacity. This theory has important implications for understanding human behavior in situations where there are limitations on cognitive capacity or information availability.

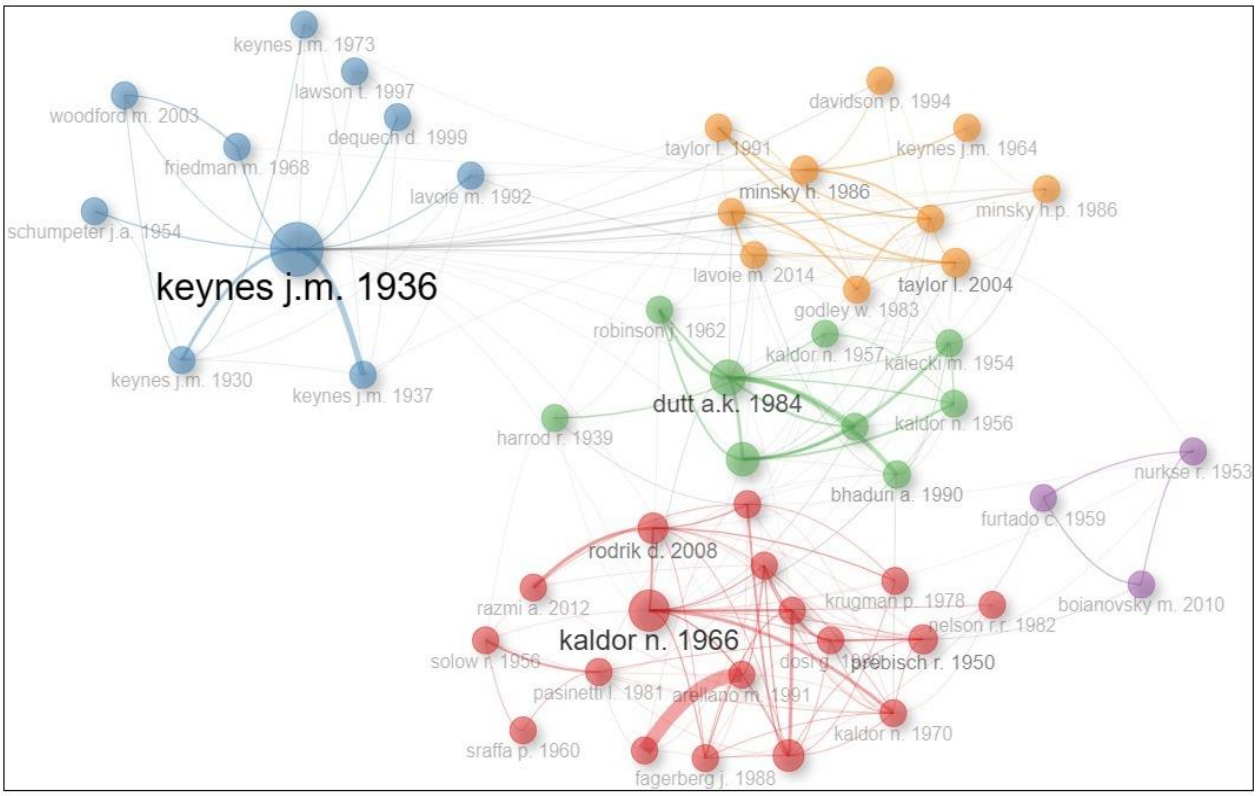
The yellow and green cluster concentrates contributions to the field of theoretical econometrics. The articles by Conley (1999) and Angrist & Imbens (1995) present similar contributions by addressing issues of spatial dependence and identification of local average treatment effects. Both propose robust methods of estimation and inference. Conley (1999) introduces a spatial model of dependence between agents using an economic distance metric. Angrist & Imbens (1995) emphasize the need for valid instruments and adequate conditions to identify local average treatment effects. Finally, Blundell & Blond (1998) propose two linear estimators for the dynamic error components model that improve the properties of the standard first-difference GMM estimator. Through asymptotic efficiency comparisons and Monte Carlo simulations for the simple AR(1) model, they demonstrate that the proposed estimators perform better than the usual first-difference GMM and nonlinear GMM estimators.

When comparing the co-citation networks at the Brazilian and global levels, although theoretical econometrics is present in both networks, most of the specific econometric methods identified in the networks show significant differences between them. Brazilian researchers associate through the citation of canonical texts in the field of time series econometrics and dynamic panel data, while global econometrics-focused clusters emphasize approaches related to causal inference and difference-in-differences studies. In the field of empirical macroeconomics, the Brazilian network indicates a focus on studies on the credibility of fiscal and monetary policies, while the global network shows greater interest in research addressing issues such as stock market uncertainty and labor market-related issues. The global intellectual structure also includes references on behavioral economics, applied microeconomics, and game theory, elements not found in the Brazilian network.

4.2 Heterodox Tradition

The Brazilian co-citation network of heterodox documents (Figure 5) has five clusters.

Figure 5 – Brazilian Heterodox co-citation network (2000-2022)



Source: Outlined by the author.

The blue cluster includes influential contributions to 20th century economic thought, such as Keynes (1930, 1936, and 1937) and Friedman (1968), which provide the basis for the deterministic debate of macroeconomics in the 1960s and 1970s. Woodford (2005) reexamines the foundations of monetary economics, showing how interest rate policy can be used to achieve an inflation target. Schumpeter (2006 [1954]) offers a comprehensive view of the evolution of economic theory throughout history. Lawson (1997) and Dequech (1999) focus on critical issues related to the limitations of neoclassical economic theory. Finally, Lavoie (1992) proposes an alternative theoretical framework to neoclassical economics based on post-Keynesian and Kaleckian economics.

The green cluster presents canonical references in post-Keynesian dynamic macroeconomics, including its Kaleckian and neo-Kaleckian strands. It groups classic texts of Harrod (1939), Kalecki (1954), and Robinson (1962) with seminal contributions of Dut (1984), examining the interaction between growth and income distribution in an underdeveloped economy, and Bhaduri & Marglin (1990), who develop a macroeconomic framework to analyze the relationship between wages and

unemployment. The red cluster focuses on economic development, emphasizing regional issues and constraints to the economic growth of developing economies. Sraffa (1960) presented a solution to the value problem framed in classical terms, determining relative prices and one of the two distributive variables. Solow (1956) is a major reference in economic growth, with his model often used to study the relationship between economic growth and income inequality, as well as the role of institutions and governance in promoting economic growth.

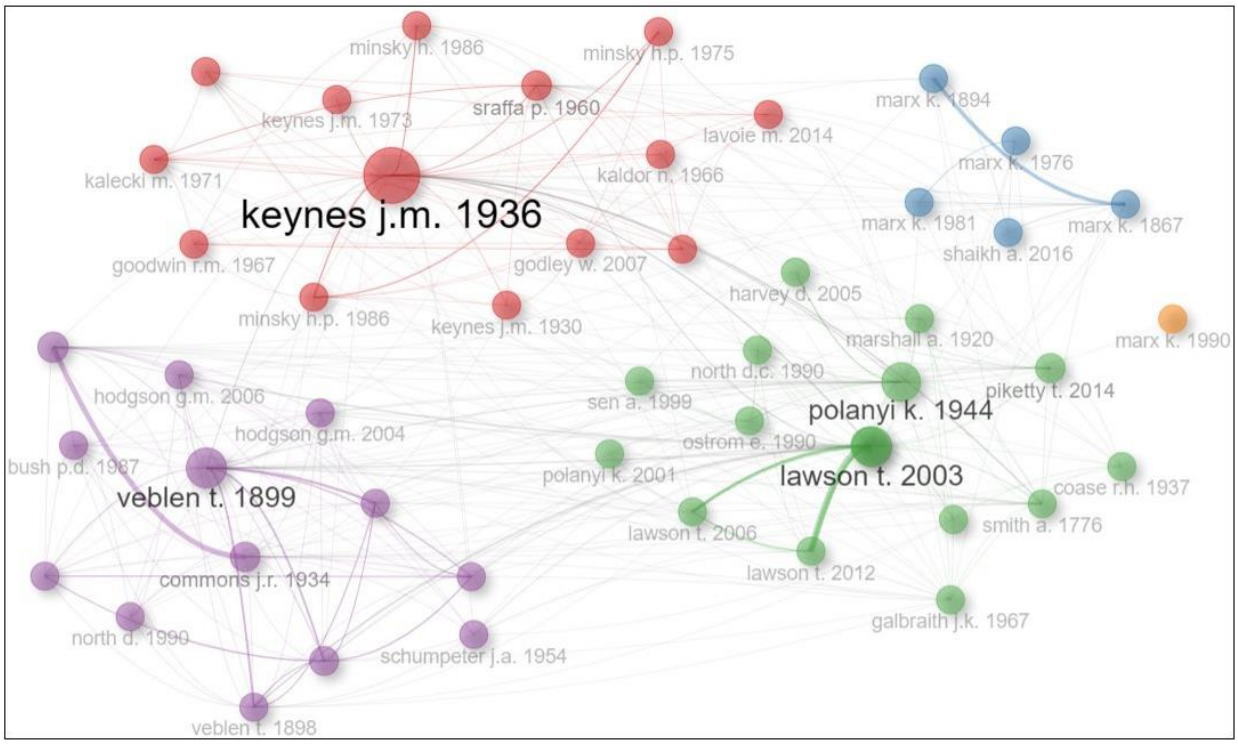
Another perspective on economic growth (red cluster) is presented by Nicholas Kaldor, who discusses the reasons for the slow economic growth of the United Kingdom (KALDOR, 1966) and addresses the problem of regional inequalities within countries (KALDOR, 1970). In Kaldor (1970), the concept of "efficiency wages" is examined, demonstrating how they tend to fall in regions where productivity increases faster than average. Rodrik (2008) presents a robust argument that currency undervaluation stimulates economic growth, especially in developing countries. Rozmi & Blecker (2008) tested the 'fallacy of composition' in 18 developing countries that specialize in manufacturing, finding that most developing countries compete with other developing countries. The purple cluster indicates an interest in economic development topics, focusing on the structuralist perspective of Celso Furtado and the "problems of underdevelopment." Classic references such as Furtado (2020 [1959]) and Nurkse (1953) are co-cited. Boianovsky (2010) discusses the contribution of Celso Furtado's interpretation of development and underdevelopment.

The estimated global co-citation networks for the heterodox bias sample are shown in Figure 6 and indicate the division of the field into four distinct traditions. The purple cluster highlights the seminal contributions of Thorstein Veblen, in The Theory of the Leisure Class (2017 [1899]), and John R. Commons (1934), co-cited along with articles by Geoffrey Hodgson (2004 and 2006), introducing the Old Institutional Economics approach. The red cluster highlights the presence of a post-Keynesian tradition, emphasizing the seminal contributions of Keynes (1930, 1936, and 1973), Kalecki (1971), Sraffa (1960), Kaldor (1966), Goodwin (1967), Minsky (1975 and 1986), and Marc Lavoie's Post-Keynesian Economics textbook (2014). The blue and yellow clusters demarcate the strong presence of a critical and Marxist tradition in global heterodoxy, grouping together texts written by Karl Marx, including the three volumes of Capital and editions of the "Marx & Engels Collected Works," co-cited with Anwar Shaikh's *Capitalism: Competition, Conflict, Crises* (2016).

Finally, the green cluster highlights a segment focused on Polanyi's economic anthropology (1944 and 2001), emphasizing the relationships between economy, society, and culture, alongside Tony Lawson's critical ontology perspective (2003, 2006, 2012). Lawson argues that ontological issues are central to distinguishing heterodoxy from orthodoxy (Lawson, 2003) and advocates for criteria that are not variable commitments to specific substantive theories, policy measures, or

analytical techniques to distinguish the various traditions that make up modern heterodoxy (Lawson, 2006). In *Ontology and the Study of Social Reality* (2012), Lawson argues that social reality can be understood through characteristics such as social relations, positions, and powers, emphasizing the importance of a "strong" form of emergence and the category of "process organization" in understanding social reality.

Figure 6 – Global Heterodox co-citation network (2000-2022)



Source: Outlined by the author.

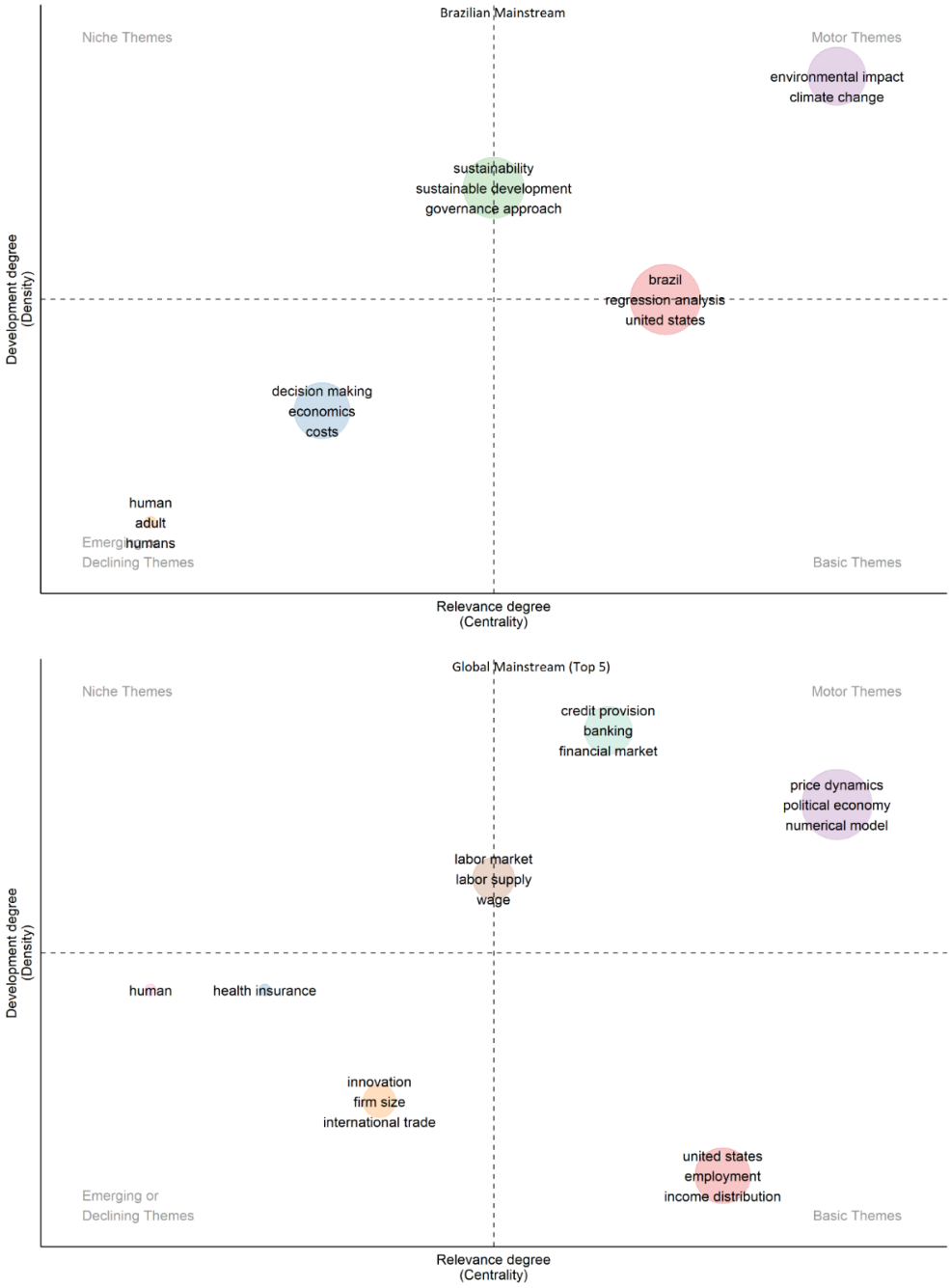
It is clear from the comparative examination of the Brazilian and global heterodox networks that the Brazilian ones are mostly located in the red cluster of the global network, which designates a post-Keynesian economic tradition. In Brazil, this tradition is even segmented into its neo-Kaleckian, post-Keynesian, and Sraffian approaches, while globally they all integrate into the same cluster. Brazilian interest in studies involving economic development and problems of underdevelopment does not have global representation, while original institutionalist, Marxist, and critical realism and economic anthropology-focused traditions do not appear in Brazilian networks.

5. Comparative Thematic Analysis

In a theme, the keywords and their connections draw a network graph called the thematic network. Each thematic network is labeled with the name of the most important keyword in the associated theme (usually by the most central keyword in the theme) (COBO et al. 2011). Figures 7 and 8 show the estimated thematic maps compared for the mainstream and heterodox bias approaches, respectively. The terms in the upper right quadrant have high density and high centrality and are therefore considered prominent topics (or engines) in that domain; the terms in the upper left quadrant have high density and low centrality, indicating well-developed internal features associated with low importance, and are therefore considered niche topics; the lower right quadrant contains the topics with high centrality and low density, indicating that they are still poorly developed despite their importance to the research; finally, the lower left quadrant groups topics with low density and low centrality, indicating that they are emerging or declining topics.

In the mainstream Brazilian context (Figure 7), there is a strong focus on environmental and climate change issues. However, these themes do not appear on the global mainstream frontier, which focuses on monetary and banking economics, price dynamics, and economic policy. Studies involving the US are basic themes in both cases, but more central in Brazilian contributions. The basic themes in Brazilian mainstream contributions also include studies on Brazil and regression analysis, while at the frontier there are macroeconomic themes of employment and income distribution. In both mainstream Brazilian and global frontier, some themes are situated between niche and motor themes. In Brazilian contributions, these involve “sustainability”, “sustainable development”, and “governance approach”, while in the mainstream frontier, they involve “labor market”, “labor supply”, and “wages”. Among emerging or declining themes, Brazilian mainstream research presents “costs” and “decision making” as emerging, while studies involving human development and human capital are declining. In the global mainstream frontier, studies involving “health” are emerging and close to becoming a relevant niche, while studies on international trade and innovation are becoming obsolete. As can be observed, Brazilian mainstream internationalized research presents no convergence with frontier research in the field, being strongly concentrated in environmental economics, with a focus on climate change and sustainability.

Figure 7: Compared thematic maps (mainstream bias)

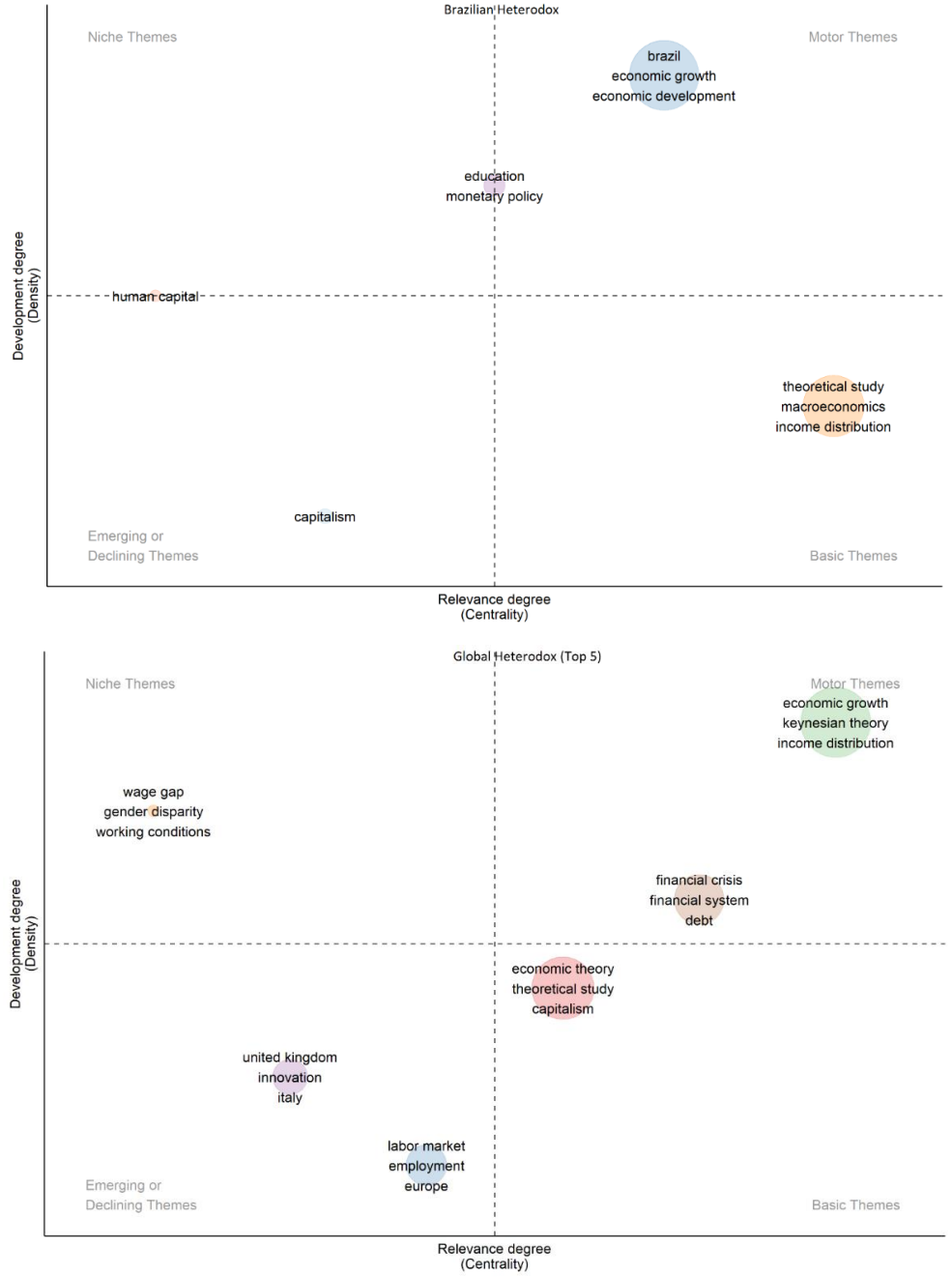


Source: Outlined by the author.

A distinct panorama, however, is presented by Brazilian heterodox research in relation to the frontier of economic heterodoxy (illustrated in figure 8). First, we see the centrality of research on economic growth both in the Brazilian community and at the forefront of global research, as evidenced by its high density and centrality in both maps. However, in Brazilian research, the centrality and density of the "economic growth" theme is associated with studies that include Brazil, as well as with research in the field of economic development. On the heterodox frontier, economic growth is accompanied by "income distribution," a basic (fundamental) theme in the Brazilian tradition, and "Keynesian theory," signaling the centrality of the post-Keynesian tradition. "Financial

crisis," "financial system," and "debt" continue to be the motor themes on the heterodoxy frontier, albeit with lower values for density and centrality. Theoretical studies are fundamental themes in both maps, while critical studies of capitalism, fundamental at the frontier, are regressive in the internationalized research of Brazilian heterodox economists. The frontier sample also shows "innovation," "employment," and "Europe" as emerging or declining themes. In summary, the internationalized research of Brazilian heterodox economists presents considerable convergence with frontier heterodox research.

Figure 8: Compared thematic maps (heterodox bias)



Source: Outlined by the author.

6. Concluding Remarks

This article considered the pluralistic exceptionalism that characterizes the discipline of economics in Brazil and analyzed the international publications of Brazilian economists in both mainstream and heterodox paradigms. Our comparative analysis highlighted two dimensions of this internationalization, namely: (i) the intellectual patterns of internationalization, and (ii) the degree of convergence of these patterns with frontier research patterns.

In the first dimension, we focused on the intellectual profile of the different traditions by examining frequently cited publications together and estimating thematic maps for Brazilian contributions. This allowed us to understand how the fields are interrelated, identify significant patterns and important topics in each tradition. At this stage, we found that the Brazilian mainstream tradition focuses on issues related to the environment, sustainability, and climate change and showed that these contributions are interrelated only in methodological terms, such as the frequent use of econometric analyses of time series and dynamic panels, based mainly on the use of modeling involving Generalized Method of Moments (GMM), Autoregressive Conditional Heteroskedasticity (GARCH), and maximum likelihood estimators (MLE), with no mention or reference to canonical or non-canonical documents that refer to specific schools of thought.

Regarding the Brazilian heterodox tradition, our study revealed that the most prominent themes are economic growth and development, accompanied by studies related to Brazil itself. In contrast to the mainstream tradition panorama, we observed that the interconnections between heterodox studies manifest predominantly in terms of theoretical associations, with co-citation clusters clearly highlighting the different post-Keynesian approaches, including Minskyan, Kaleckian (neo and post), and Sraffian traditions, accompanied with less emphasis by references to developmentalist structuralist thought, with a particular focus on the tradition inspired by the work of Celso Furtado.

In the second dimension, we showed that the intellectual patterns of the Brazilian mainstream are not representative of the patterns found at the global mainstream economics frontier, which is mainly dedicated to topics such as monetary economics, banking, price dynamics, and financial markets and whose interrelationships, despite also being structured around methods and not schools of thought, are structured around distinct methods and analyses, with a focus on causality studies and difference-in-differences modeling. In contrast, the patterns of international publications by Brazilian heterodox economists showed strong convergence with global frontier heterodox patterns, centered on discussions about economic growth and income distribution. It is important to note that, both at

the mainstream and heterodox frontiers, there are themes that did not present significant results in the estimates for Brazilian production. At the mainstream frontier, these themes include a focus on institutions, behavioral economics, and theoretical microeconomics. At the heterodox frontier, the themes include social anthropology based on Karl Polaniy, critical realism based on Lawson, original institutionalism in the traditions of Veblen and Commons, and Marxist-inspired critical economics.

However, this study has some limitations. The main one is related to the very nature of bibliometric studies, which present several potential flaws, ranging from those arising from the choice of possible omissions related to the choice of the database, mainly involving the breadth of coverage of publications, to failure in the accuracy of citation data. Secondly, our proposed index for internationalization may present a high degree of arbitrariness, as is characteristic of qualitative indices.

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