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Article

Advances in the mathematization process of Brazilian Academic Studies in Economics since the 1980s

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RESEARCH ARTICLE

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RESEARCH ARTICLE

Advances in the mathematization process of Brazilian Academic Studies in Economics since the 1980s

Mauricio Martinelli Silva Luperi^{1*}

Abstract: Looking at Brazilian economic discourse, in this article, we look at how mathematization of economics has advanced in the country in the last three decades. For this, we have classified into several categories all articles published in three major Brazilian economic journals (*Revista Brasileira de Economia, Estudos Econômicos, and Revista de Economia Política*) and the publications of ANPEC meetings from 1981 to 2010, according to the type of argument used. A total of 5,733 articles were analyzed. We attempt to see how mathematization of economic discourse developed, and found that there was an increased use of a formalized language from the mid-1990s onwards. Finally, to confirm our findings, we focus on the process of mathematization through the observation of a quantitative variable: equations per article.

Keywords: mathematization, process, discourse, Brazilian



RESEARCH GROUP OVERVIEW

The line of research that currently I work in investigates the possible influences of mathematics and physics in economic theory, potential problems generated by the mathematization process of economics, and their impacts in terms of prescribing policies on employment and income.

PUBLIC INTEREST STATEMENT

In this paper, more specifically, through the classification of 5,733 articles in six different categories, I seek to find what was the turning point in the production of economics papers in Brazil, in which the papers are most mathematized. For this, I analyze the population of articles from three major Brazilian magazines and National Association of Graduate (ANPEC) meetings since 1981. The date chosen for the research seems a bit late compared to surveys conducted in the United States and Europe on the subject. However, it is not late when we observe the fact that the first scientific journal of economics has emerged in Brazil only in 1947 and other two reviews have emerged only in 1971 and 1981.

1. Introduction

Applauded by most economists and criticized by some, the increasing use of mathematical language in economics beginning in the second half of the last century is unquestionable. Some excellent studies (e.g. Ingrao & Israel, 1990; Mirowski, 1989, 1999; Weintraub, 1991, 2002) have discussed this process as a whole or focused on specific points. Economists who defend this process generally assume it to be a natural evolution in the consolidation of the sciences and are currently not too concerned with justifying the need for formalization (an exception by the explicit request of editors of controversy, is Krugman, 1998; a more theoretical and less pragmatic defense of formalization found in Katzner, 1991).¹ On the other hand, the opposition to this approach has often written to criticize its limitations (see, among others, Gillies, 2004; McCloskey, 1991; Ward, 1975; Woo, 1986).²

The general acceptance of the mathematical formalization of contemporary mainstream economics is such that Colander, Holt, and Rosser (2004) believe the most liberal of these economists, who can concede any theoretical point of traditional economics, and suggest that what is not formalized is not economics.

Mathematization in the international academy was well explored in the article *The When, the How and the Why of Mathematical Expression in the History of Economic Analysis* by Mirowski (1991), wherein Mirowski suggests that there were major waves in the mathematization of economic discourse. The first occurred between 1870 and 1890 with the Neoclassical Revolution. Its main proponents (among them Léon Walras, William S. Jevons, Irving Fisher, Francis Y. Edgeworth, and Vilfredo Pareto), in large part engineers, simply adapted models derived from mid-nineteenth-century physics based on the principle of conservation of energy.³ The second occurred between 1925 and 1935, a process that can be attributed to a group of physicists, notably Jan Tinbergen and Tjalling C. Koopmans, who again changed the way academics worked with economics. Mirowski studied this process, analyzing the change in economic discourse in four of the chief contemporary journals: *Revue D'Économie Politique* (RDP), *Economic Journal* (EJ), *Quarterly Journal of Economics* (QJE), and *Journal of Political Economy* (JPE).

In his analysis of the second wave, Mirowski looked at qualitative data from articles published in these periodicals between 1887 and 1955. The author found that from 1887 to 1924, mathematical discourse in the journals studied followed very similar trends, with a growth rate close to zero. The journals rarely devoted more than 5% of their pages to mathematical discourse until 1924. The sea change in economic discourse happened between 1925 and 1936.

Among the periodicals analyzed, this evolution was led by the QJE, which reached 25% of total pages with mathematical economic discourse. In the JPE, this process took somewhat longer, reaching the same level as the QJE only in the 1950s. The EJ and the RDP reached 20% after the World War II.

Inspired by Mirowski, we seek to verify how mathematization has advanced in the Brazilian academy. Given the more recent appearance of economics as a science in Brazil, we hypothesize that this process took place much later. As a result, although there have always been practical economists in Brazil, the economics as a formal course of study dates back only to the 1940s. At the graduate level, although there were some isolated initiatives in Rio de Janeiro and São Paulo at the start of the 1960s, it was only in 1966, with the seminal Itaipava Meeting, that the idea that would come to be the National Association of Graduate Studies in Economics—ANPEC (Loureiro, 1997) arose. For its part, the first annual ANPEC meeting would only be held in 1973. At the same time, the Brazilian Society of Econometrics—SBE, a defender of an exclusively formalized approach, was only created in 1979.

The questions we pose at the opening of this study are: Were there any inflection points in the study of economics within the Brazilian academy with respect to formalization? If there were, when did they occur and what were their causes?

We begin by presenting our definitions and methodology to later present qualitative data analysis. Finally, to test the robustness of our definitions, we use a quantitative variable, equations per article, to verify convergence with our qualitative analysis.

2. Methodology and Definitions

For this study, articles published in three of Brazil's main economic journals were analyzed: the *Revista Brasileira de Economia* (RBE), *Estudos Econômicos* (EE), and *Revista de Economia Política* (REP). Publications for ANPEC meetings held between 1981 and 2010 were also analyzed. A total of 5,733 articles were analyzed.

Our analysis was based on journals and conferences that feature a wide range of approaches. We decided not to study, despite its importance, the Congress of the Brazilian Society of Econometrics and the official publication of this entity, now called *Brazilian Review of Econometrics*, because it is assumed that from the beginning a mathematized approach is what should be defended. If our interest is in studying the process of mathematization of the Brazilian Academy of economy as a whole, it did not make sense to consider a group whose cutting, since its inception, is given by the defense-formalized approach, it is expected that the percentage of articles that formalized strand is 100% from beginning to end of the review period.

The RBE is the oldest business magazine in the country, having published its first volume in 1947, and the second oldest in Latin America (the first is *El Quarter Economic*, whose first issue was published in 1934). Currently their online publishing is facing more neoclassical articles, and it is assumed, therefore, to be more mathematized.

The EE was established in 1971 and is in principle a more plural magazine, i.e. their publications have articles both neoclassical and current as various visions of heterodoxy; plus it publishes articles from various fields in economics.

The REP was established in 1981 and publishes works of political economy within a pluralistic spirit. Under its editorial guidance publication of studies of pure economics that are too abstract is not considered, which allow us to suppose that in general the articles should be less mathematized.

The meeting of ANPEC is realized annually since 1973 and has been

'(...) In order to stimulate exchange between economists and professionals in related fields. (...) During the meeting, unpublished works selected by a team designated for this purpose are presented. The texts explore the frontiers of scientific knowledge in economics, politics, economics and econometrics. There is also concern with the discussion of the national reality, which is the subject of panels and breakout sessions, and issues of regional interest. The event also includes the participation of renowned international researchers.' (National Meeting of Economics, 2012)

Articles were classified in one of six categories:

- (1) articles without formalization and few (or no) data, fundamentally using natural language;
- (2) theoretical articles with argumentation primarily based on mathematics, with few or no data (articles with simulations were included here as well);
- (3) articles without formal modeling or econometrics but that use data (e.g. descriptive statistics) as the basis of their argumentation;
- (4) articles with prominent sections of formalized theory and that have at least some empirical data based on econometrics;
- (5) articles where econometrics are more prominent than theory (typically articles without theoretical models or with brief discussions of the model, but in which the argumentation is essentially econometric);
- (6) articles with a section of formalized theory with at least some empirical data based on descriptive statistics.

We consider descriptive statistics to be statistics using tables with percentage data, tables with absolute data, graphs with practically no statistical inference, etc.

The annual data collected from 1981 to 2010 refer to:

- (1) the number of articles per category;
- (2) the number of pages per category; and
- (3) the number of equations per year in each journal studied and in ANPEC meeting publications.

Primary information was collected at the libraries of the Getúlio Vargas Foundation in São Paulo (FGV-SP), the offices of the journals in question, at ANPEC headquarters and with DVDs of all ANPEC meeting publications through 2009.

Once the articles were classified, we defined an advance in the mathematization of economics in the Brazilian academy as an increase in publication of type *ii*, *iv*, and *v* articles. On the other hand, type *i*, *iii*, and *vi* articles were considered less mathematized.

Our definitions seek to address both qualitative and quantitative aspects. Thus, our analysis differs from that of Mirowski's (1991), who considers the analysis of quantitative variables, for example, the number of equations per page, an insufficient indicator of mathematization. Finally, we checked for a correlation between these types of variables with regards to the inflection point(s) in economic discourse.

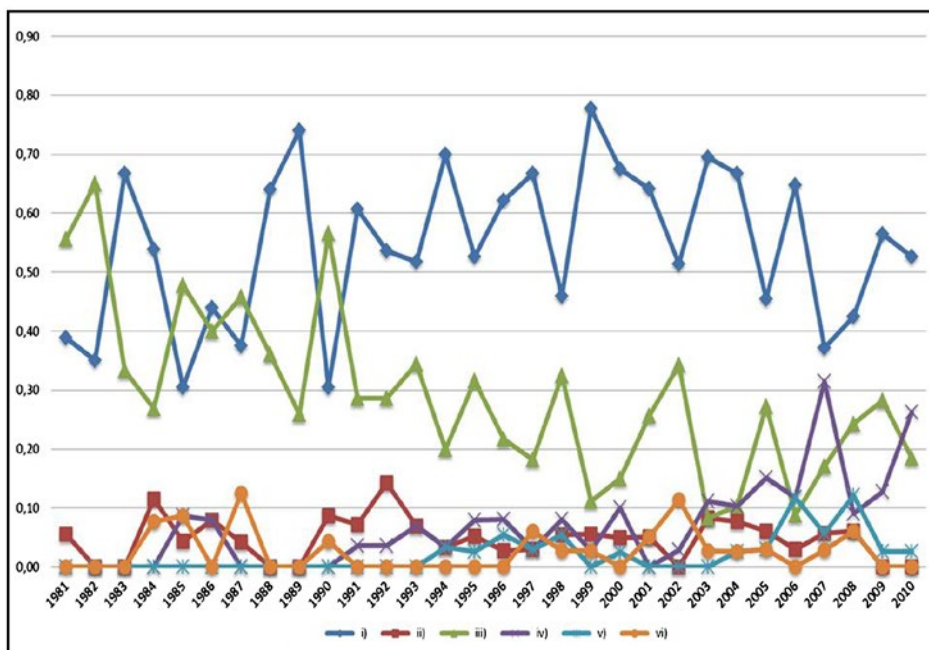
3. Quantitative Analysis of Qualitative Variables

Initially, we observed publications of each type of article in each journal and ANPEC meetings. Later, according to our definitions, we analyzed the aggregate data.

In Figure 1, we can see that type-*i* articles published in the *Revista de Economia Política* (REP) vary greatly in the 1980s, from 30 to 70% of publications at that time. In the 1990s, however, publication of these articles stabilized to between 50 and 70% until the mid-1990s, where it varies between 40 and 60%.

Figure 1. % Articles by type—REP.

Source: REP



We can see that there is a significant decline in the publication of type-iii articles beginning at the end of the 1980s. In this period, type-iii publications vary between 30 and 50%, and between 20 and 30% in the 1990s, stabilizing around 20% in the last decade.

On the other hand, we did not see significant variation in publication of type-vi articles, which held steady at 0–10% over the last three decades, and in several years represented 0% of publications. Type-ii articles remained stable at 0–10% of publications, indicating that only a small portion of published articles included basic formalized research.

Type-iv articles were virtually not published in the REP in the 1980s, but begin appearing at the start of the 1990s, representing about 7–10% until the turn of the century, when they grew to between 10 and 30% of publications. The most purely econometric articles (type v) grew from 0% in the 1980s to about 5% in 1994, stabilizing at 10% in the middle of the last decade.

In the REP, we saw a more accentuated decline in type-iii article publications, which we considered less mathematized as compared to econometric articles. This type of article is based on descriptive statistics.

On the other hand, we saw an increase in two types of articles that, according to our definition, are considered more mathematized: type iv (formalized economic theory with econometrics) and type v (econometrics with little or close-to-no formalized economic theory).

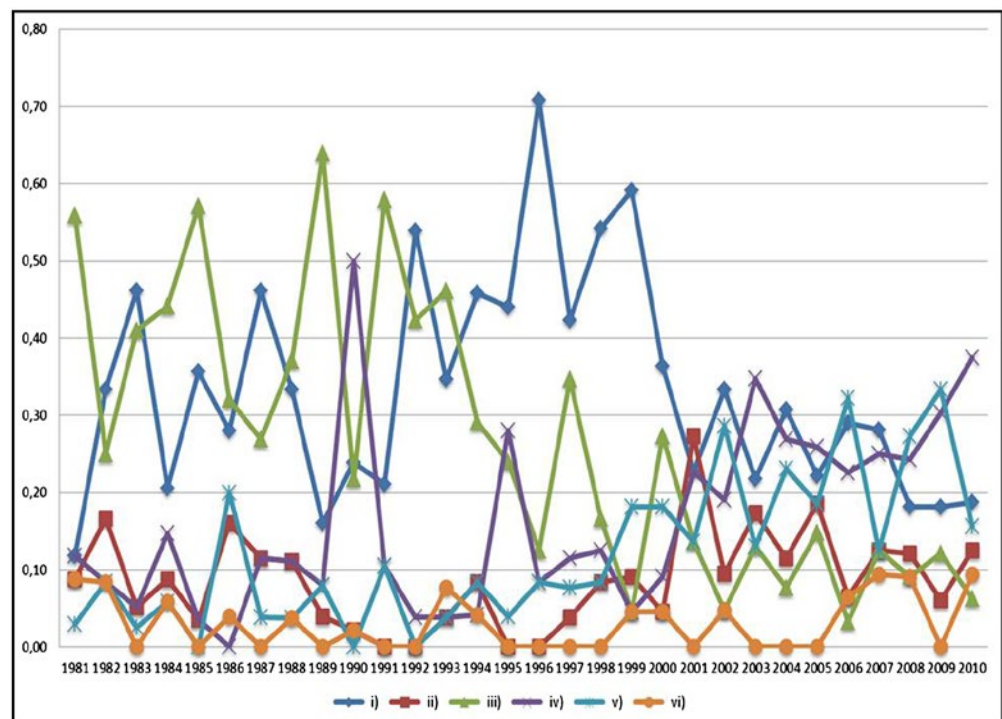
Thus, we see a certain advance in the process of mathematization in the REP. However, to quantify this advance, we need to compare it with other journals and ANPEC meetings, which we do below.

Let us now turn to article types in the journal *Estudos Econômicos* (EE).

In *Estudos Econômicos* (EE), as we can see in Figure 2, type-i articles vary between 20 and 40% of the total in the 1980s, with a high in the 1990s, when they represented 40–60%, falling significantly

Figure 2. % Articles by type—EE.

Source: EE



until the middle of the last decade to between 20 and 30%, stabilizing around 18–20% of total publications. Although the EE follows a trend similar to the REP in the 1980s and 1990s, publication of type-*i* articles declines more sharply in the last decade as compared to the later decades. Note that publication of this type of article in the REP varies in the 1980s and 1990s, representing 30 and 70%, and 50 and 70%, respectively, of articles, while since the middle of the last decade, they represent between 40 and 60% of total publications. Meanwhile, the EE, despite having a considerable growth in the publications from the 1980s to the 1990s (between 20 and 40% to between 40 and 60%, respectively), at the turn of the century, began to fall significantly, following a trend of stabilizing at levels well below those of the REP's at 18–20% (EE), compared to 40–60% (REP) of publications.

With regards to type-*iii* articles, in the EE we see a slightly steeper decline than in the REP (approximately 20% in the last decade) beginning at the end of the 1990s, though it follows the same trend. In Figure 2, we can see that this type of article represented 30 to 60% of total publications in the 1980s, falling to 30–50% by the mid-1990s and to around 10% at the end of that decade, stabilizing at this level.

On the other hand, we did not see significant variations in publication of type-*vi* articles, which remained around 0–10% over the last three decades, over many years representing 0% of publications. The same occurred with type-*ii* articles, which remained stable with a slight decline by around 10% of publications in the 1980s. Again, as in the REP, we can see that articles published in the EE with basic formalized research are a minority.

Type-*vi* articles in the EE began in the 1980s from around 10% of publications, remaining at that level until the end of the 1990s, when they increased to 20–30% of the total in this journal. The same trend is observed for type-*v* articles, which indicates an advance in mathematization of economics in this journal, according to our definitions.

Next, we look at the trends in the *Revista Brasileira de Economia* (RBE), hypothesizing intuitively that this journal will follow the opposite path, considering the types of articles published, from the REP.

In Figure 3, we can see that type-*i* articles published in the RBE in the 1980s range from 10 to 30% of the total, below both the REP and EE. In the RBE as with the other journals, this type of article where natural language is prevalent, increases in the 1990s were to 20–40% of total publications. However, at the end of the decade, there is a significant decline in acceptance of less-mathematized articles, with type-*i* articles falling to 0–10% at the start of the last decade and reaching 0% in the last three years. Like with the EE, there is a downward trend in publication of type-*i* articles in the RBE, though it is much more radical.

With regards to type-*iii* articles, we can see in Figure 3 the same downward trend in publications as in both the REP and EE. In the 1980s, articles based on descriptive statistics represented 10 to 30% of publications, falling to approximately 10% in the 1990s and to near 0% of RBE publications in the middle of the last decade.

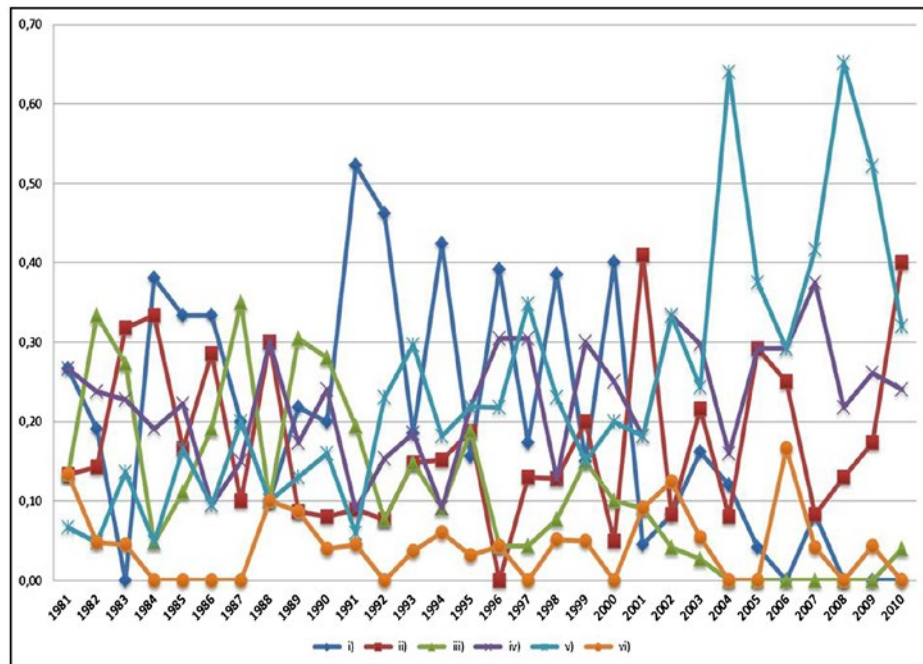
On the other hand, we did not see major variations in the publication of type *vi* articles, which have remained around 0–10% over the last three decades.

Type-*ii* articles, with basic formal theory, represent between 10 and 30% of publications in the 1980s, 10–20% through the end of the 1990s, and return to 1980s levels in the last decade.

Type-*iv* articles have tended to remain at approximately 20% of publications in the 1980s and 1990s, increasing to 20–30% in the RBE in the second half of the last decade.

Figure 3. % Articles by type—RBE.

Source: RBE

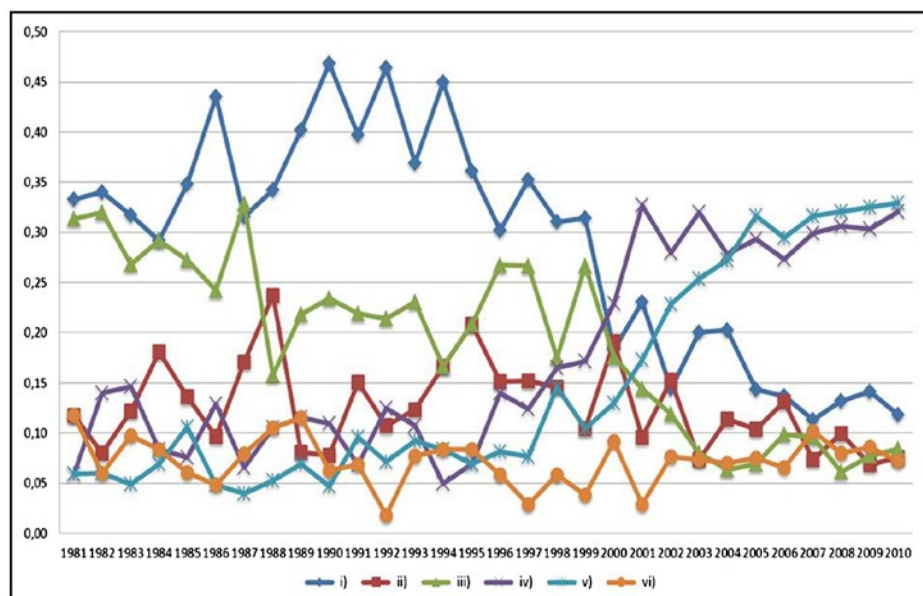


In the RBE, the fastest growth rate of article publications is of type-v articles, which involve “pure econometrics.” This could be due to the increased access to personal computers in the 1990s and programs such as Eviews and, later, Stata, prompting the sharp decline in type-iii publications based on descriptive statistics. This type of article represented between 10 and 30% of publications in the 1980s, between 20 and 30% in the 1990s finally growing to 30–60% of publications in the first decade of the century. However, this is the subject of future study, as we do not have data on the number of personal computers.

In Figure 4, we have data relative to the percentages of articles by type in ANPEC Meetings. First, we looked at type-i articles in the 1980s, which represented 30–40% of accepted submissions,

Figure 4. % Articles by type—ANPEC.

Source: ANPEC



reaching 40–45% of the total beginning in the mid-1990s, when they fall sharply to between 10 and 15% of publications by 2010.

With regards to type-iii articles, we saw that this type of article represented between 25 and 30% of articles accepted by ANPEC in the 1980s, declining to between 15 and 25% throughout the 1990s, falling to between 5 and 10% of all publications at the turn of the century. We saw that this decline follows the same trend as the REP, EE, and RBE.

Type-vi articles remained between 5 and 10% in the last three decades, without major variations in the percentages of publications of this type of article by ANPEC. There were also no major changes in the trend of acceptance of type-ii articles by ANPEC. We saw that this type of article remained between 10 and 15% of articles published in the last three decades at the meetings.

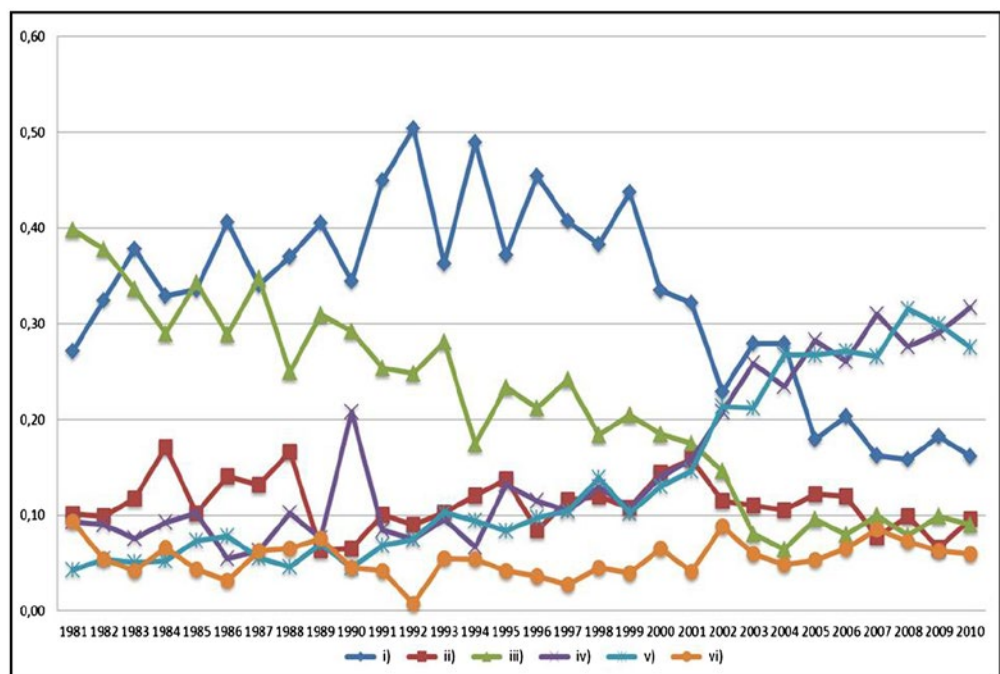
Looking at type iv and v articles, we saw that there was a significant upward trend in acceptance of these articles by ANPEC. Despite trending similarly to the EE, here the growth of acceptance of these types of articles is more radical. Type-iv articles (formalized economic theory with econometrics) spikes from between 5 and 15% in the 1980s through the mid-1990s to approximately 30% of publications in the last decade. Similarly, in Figure 4, we can see that type-v articles (pure econometrics) represent from 5 to 10% of articles in the 1980s through the mid-1990s, when they begin to grow and stand between 30 and 35% in the last decade.

It should be noted that most articles researched in this chapter are from ANPEC. Of a total of 5,733 articles, 3,210 or almost 56% are from this institution. Of course this is important and colors our next analysis, as we calculate the aggregate percent variation by type of article. This is because there could be discrepancies in the publication data, as ANPEC meeting articles are published in the same year and those of journals' are not. Therefore, in future individual analyses, we can try to identify possible problems such as the observation of a real point of inflection in the economic discourse of the Brazilian academy.

In Figure 5, we can see that in our analysis of all journals plus ANPEC meeting publications, type-i articles generally began to decline at the end of the 1990s. This type of article represented 30–40%

Figure 5. % Type i, ii, iii, iv, v, vi articles—ANPEC, REP, RBE, and EE.

Source: ANPEC, REP, RBE, EE



of publications in the 1980s, increasing to between 40 and 50% in the 1990s and stabilizing between 15 and 20% of the total in the last decade. Type-*iii* articles also declined, though more so since the beginning of the same decade, from between 30 and 40% in the 1980s, decreasing to between 20 and 30% in the 1990s, and stabilizing between 8 and 10% of articles that were published in the last decade.

On the other hand, we can see that, in general, there was an increase in publication of type *iv* and *v* articles. The former represented approximately 10% from the 1980s until the end of the 1990s, when they began to grow more significantly to 20 and 30% of articles published in the first decade of the new millennium. The latter represented between 0 and 10% in the 1980s until the end of the 1990s, when their publication began to grow, reaching between 20 and 30% in the last decade. Therefore, we can see a substantial increase in these articles together from 10 to 20%, to 40 to 60% of publications.

We can now see how mathematization has advanced, comparing the articles of types *i*, *iii*, and *vi*, being less mathematized according to our definitions, with articles of categories *ii*, *iv*, and *v*, being more mathematized, in each journal and ANPEC meeting publications.

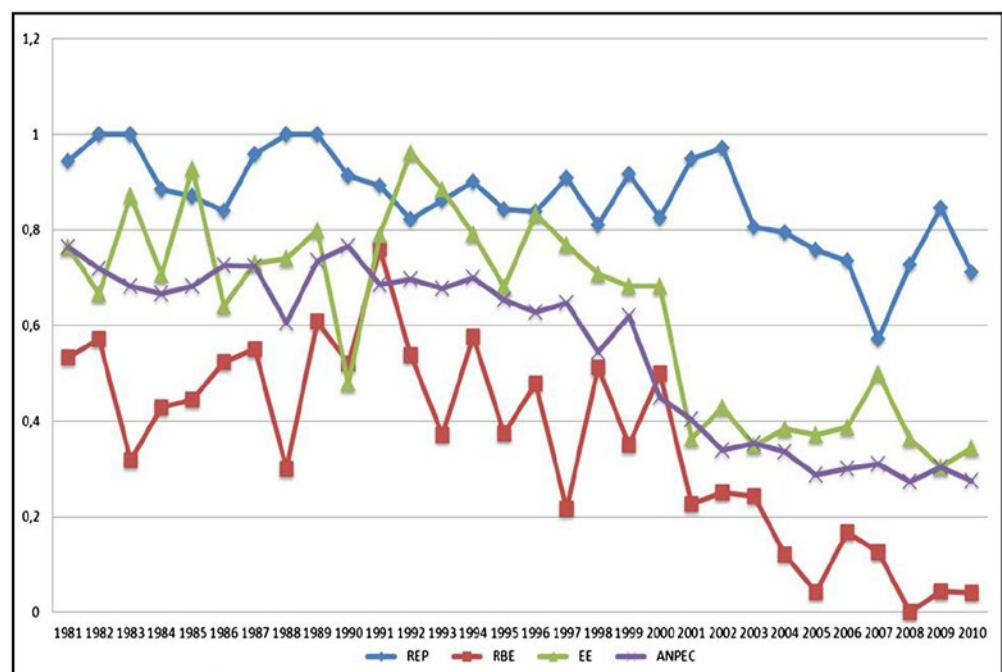
Analyzing Figure 6, we can see that in all journals and ANPEC meeting publications, there is a downward trend for publication of less-mathematized articles since the 1980s. In the EE and RBE, this decline is more apparent at the end of the 1990s. For ANPEC publications, this begins in the mid-1990s and in the REP, at the end of the last decade.

The extremes in terms of type of publication are represented by the RBE and the REP. From the 1980s until the end of the 1990s, the RBE published between 40 and 60% of less-mathematized articles, while today these often do not reach 5%. On the other hand, in the REP, between 80 and 100% of articles were published in the 1980s and 1990s that were less mathematized, while in the last decade this percentage has been between 40 and 60%.

On the other hand, when we look at all articles in the journals over the last three decades, we can see that there was a significant reduction in less-mathematized articles (types *i*, *iii*, and *vi*)

Figure 6. % Type *i*, *iii*, and *vi* articles.

Source: REP, RBE, EE, and ANPEC



throughout. In Figure 7, we can see that in the 1980s, these types of articles represented between 70 and 80% of total publications until the mid-1990s, when they begin to decline to 60 and 70% at the turn of the century, falling more sharply to their current position at between 30 and 40% of publications in the last decade.

Looking at Figure 8, we can see that in all journals and ANPEC meeting publications, there is a growing trend for publication of more-mathematized articles (types *ii*, *iv*, and *v*) since the 1980s.

Figure 7. % Type *i*, *iii*, and *vi* articles—ANPEC, REP, RBE, and EE/trend.

Source: ANPEC, REP, RBE, EE

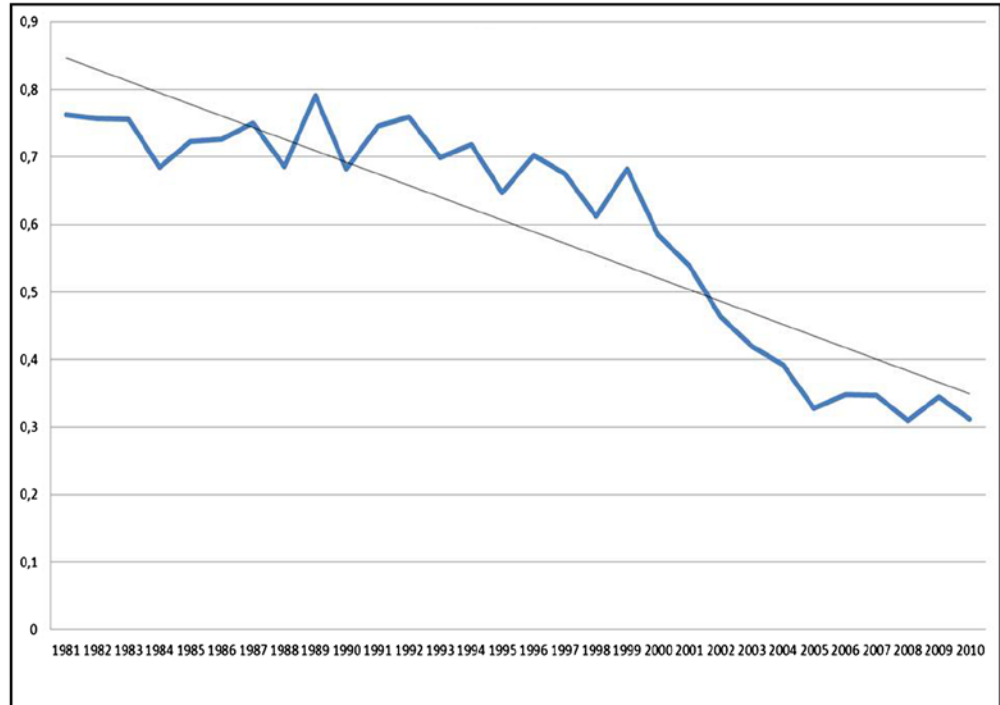
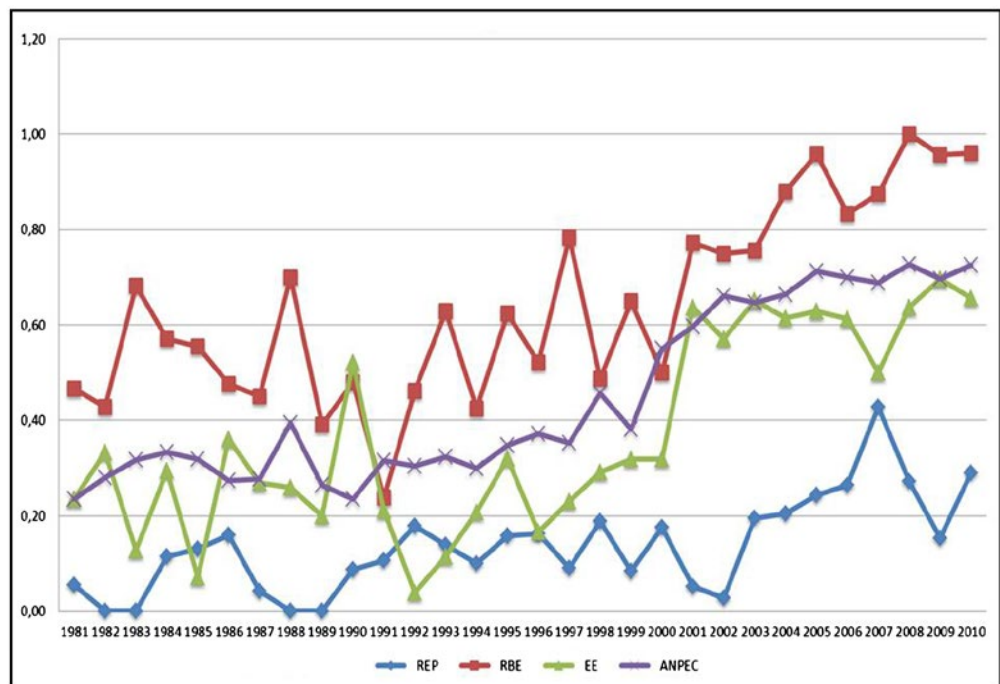


Figure 8. % Type *ii*, *iv*, and *v* articles.

Source: REP, RBE, EE, ANPEC



In the EE and the RBE, this growth is more evident at the end of the 1990s. At ANPEC meetings, the increase of this type of publication happens in the mid-1990s and in the REP at the end of the last decade.

We can see that since the beginning of the 1980s, the RBE is the most-mathematized journal and REP the least mathematized. The former has presented higher growth of publication of mathematized articles than the latter, increasing the distance between the two in terms of what is considered the most adequate type of publication. From the 1980s until the end of the 1990s, the RBE published between 40 and 60% of more-mathematized articles, while in the last decade this percentage reached between 90 and 100% of publications. On the other hand, the REP published between 0 and 20% of more-mathematized articles in the 1980s and 1990s, while in the last decade this percentage has been between 20 and 40%.

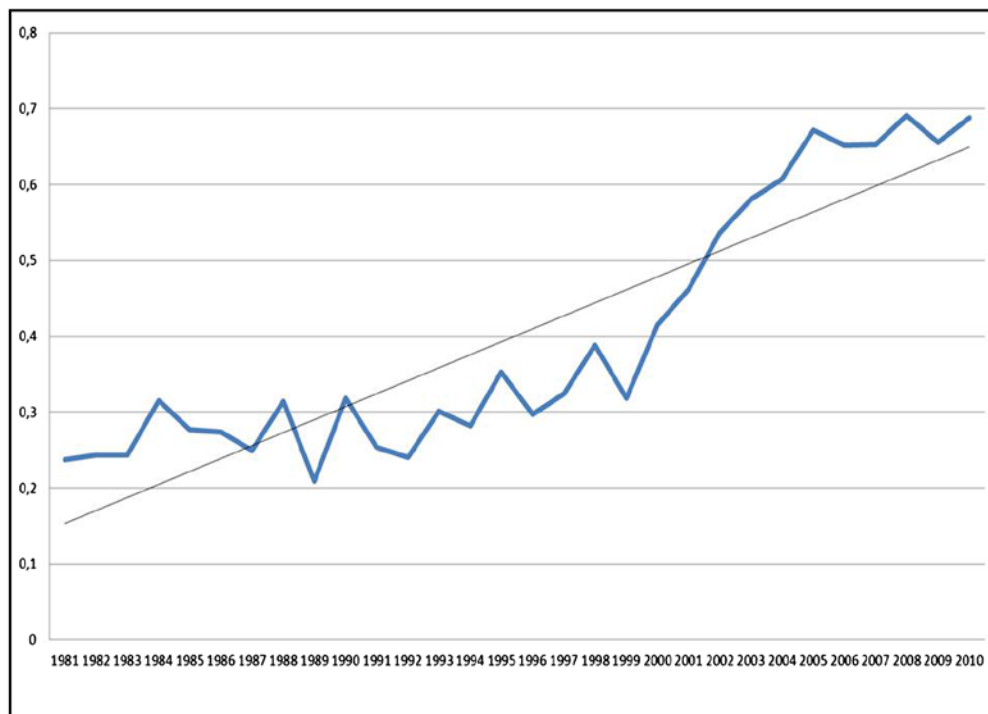
We can see that the publication of more-mathematized articles is average in the EE and ANPEC meetings. This means that the growth rate of publication of more-mathematized articles is considered average when compared to the RBE and REP, as in the former this rate is high and in the latter, less so, as we can see in Figure 8.

Generally, when we see all the articles of Brazil's three main economic journals and ANPEC meetings over the last three decades, it is clear that there was an advance in mathematization of economics in the Brazilian academy. To prove this, we turn to Figure 9, where the graphic analysis through qualitative categorization of the more-mathematized articles shows an increase of 20–30% at the beginning of the 1980s to between 60 and 70% of all publications in Brazil's three main economic journals and ANPEC meetings in the last decade.

Analyzing Figure 8, at first glance the inflection point in Brazilian economic discourse seems to be in the mid-1990s in ANPEC, although, in other journals, it seems to be at the end of the 1990s. Perhaps due to temporal discrepancies in the publications, the data on this inflection point are divergent.

Figure 9. % Type *ii*, *iv*, and *v* articles—ANPEC, REP, RBE, and EE/trend.

Source: ANPEC, REP, RBE, EE



This change in Brazilian economic discourse seems to be connected to economic opening, internationalization of the Brazilian economic academy, and technological progress. However, we do not have data regarding these events. This will be the subject of future study.

4. Quantitative Analysis

Some authors, like Mirowski (1991), consider the analysis of mathematization expressed by an increase in the average number of equations per page to be insufficient criteria as it does not show the true content of the economic discourse, that is, if it is more mathematical or not. According to Mirowski, discourse in natural language may be more propitious to formalization than is manifest in the number of equations. Although this may happen, we believe that these cases are atypical, and therefore we proceeded to use the number of equations as a proxy for mathematization.

For this reason, to prove the effectiveness of our analysis, considered superior in terms of content to the application of a quantitative variable of equations per page, we can see graphically the mathematization of economics when using the quantitative variable.

In Figure 10, we can see that the average number of equations per article in the RBE rises from a range of 8–10 in the 1980s to between 10 and 12 in the last decade, an increase of approximately 20% in the number of equations in the last 30 years.

Looking at Figure 11, the increase in the number of equations per article in *Estudos Econômicos* is also evident. The number of equations increases from two to four in the 1980s to four to six in the 1990s, reaching six to eight in the last decade.

When we analyze ANPEC data in Figure 12, we can see an upward trend in the number of equations per article, from three to five in the 1980s to five to seven in the 1990s, reaching seven to eight in the last decade.

Figure 10. Average number of equations per article—RBE/ trend.

Source: RBE

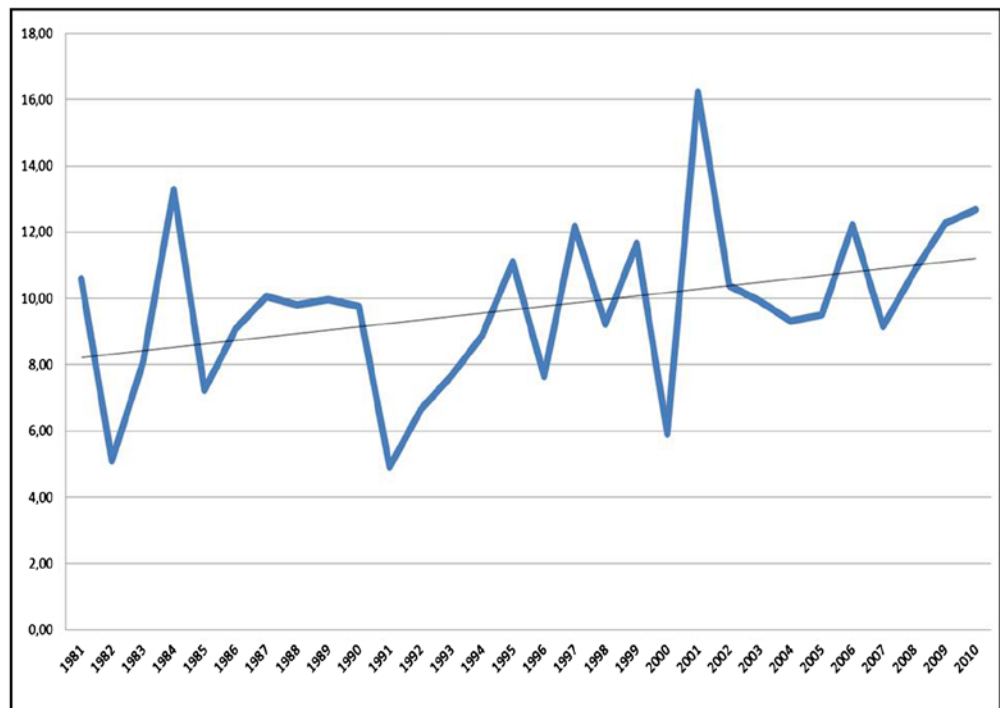


Figure 11. Average number of equations per article—EE/ trend.

Source: EE

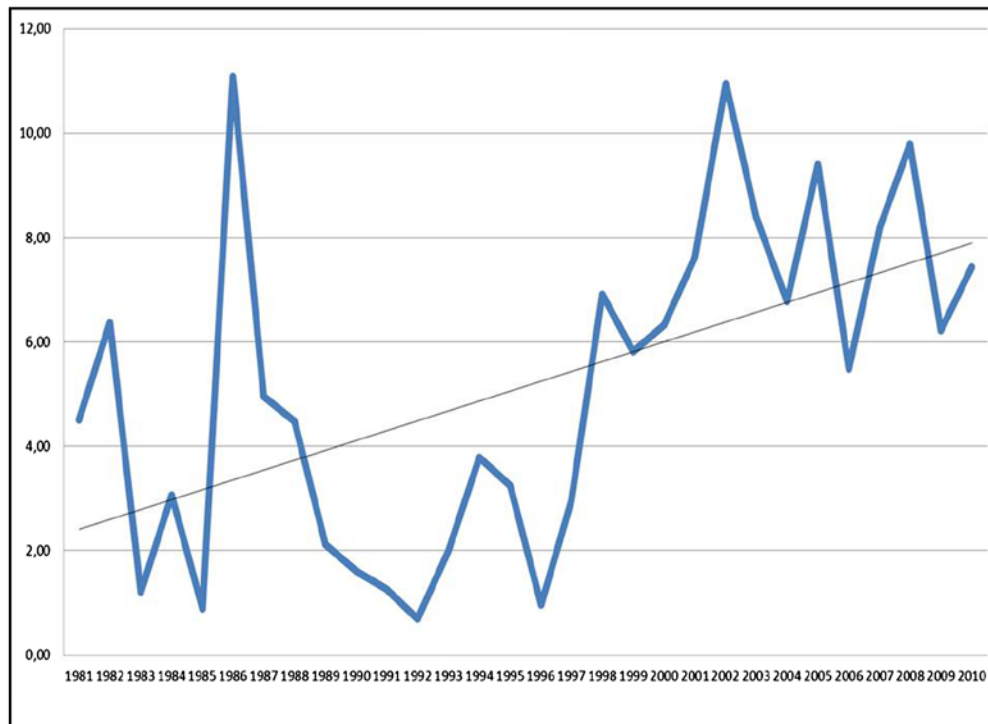
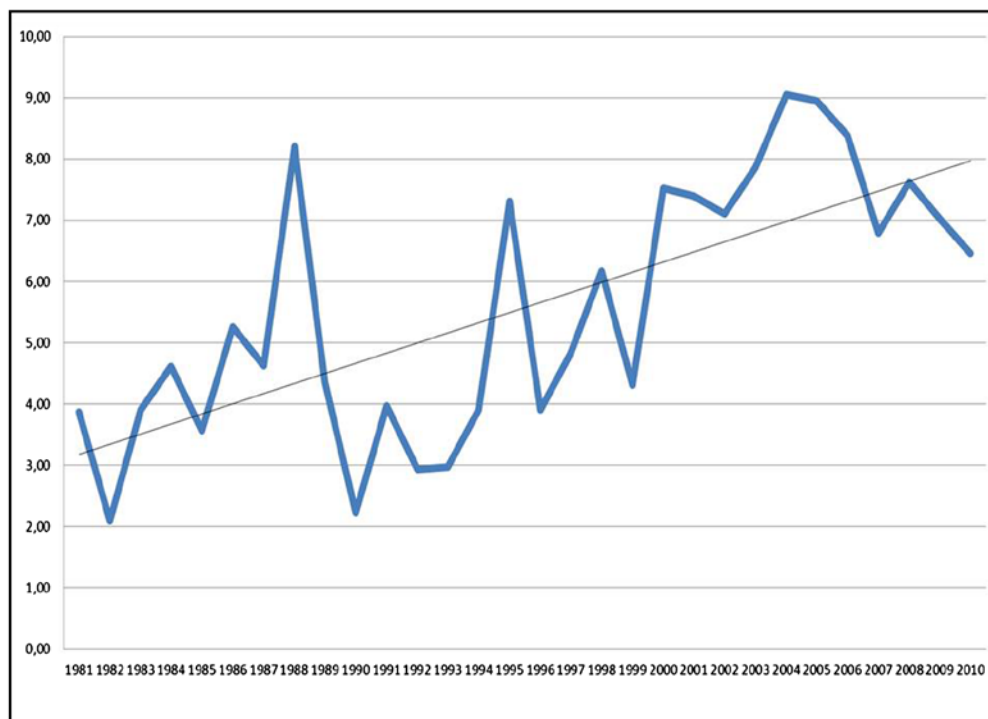


Figure 12. Average number of equations per article—ANPEC meetings/trend.

Source: ANPEC



Even when we look at the *Revista de Economia Política*, in Figure 13, we can see a rise in the number of equations per article in the last three decades from one to two equations in the 1980s to two to three in the first decade of this century.

Superimposing Figures 10-13, we can compare the quantitative variable equations per article in all journals. With this, we can see that, compared to the RBE, the EE, despite a lower volume of equations per article, saw a more accentuated increase in this type of variable over the last three decades, as seen in Figure 14.

Figure 13. Average number of equations per article—REP/ trend.

Source: REP

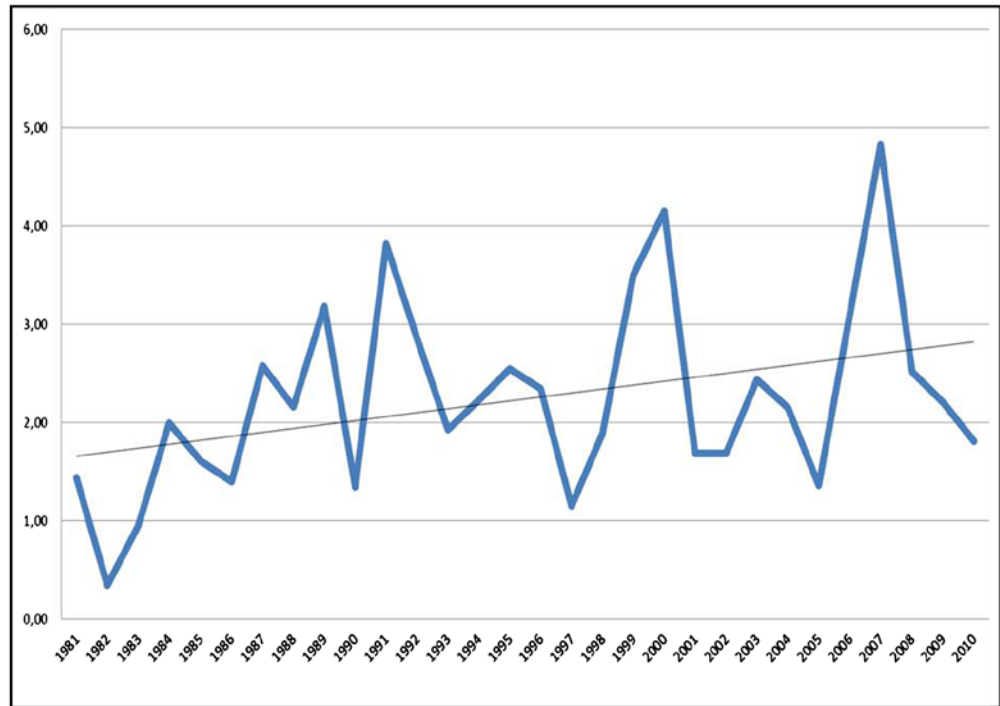


Figure 14. Average number of equations per article/trend.

Source: REP, RBE, EE, ANPEC

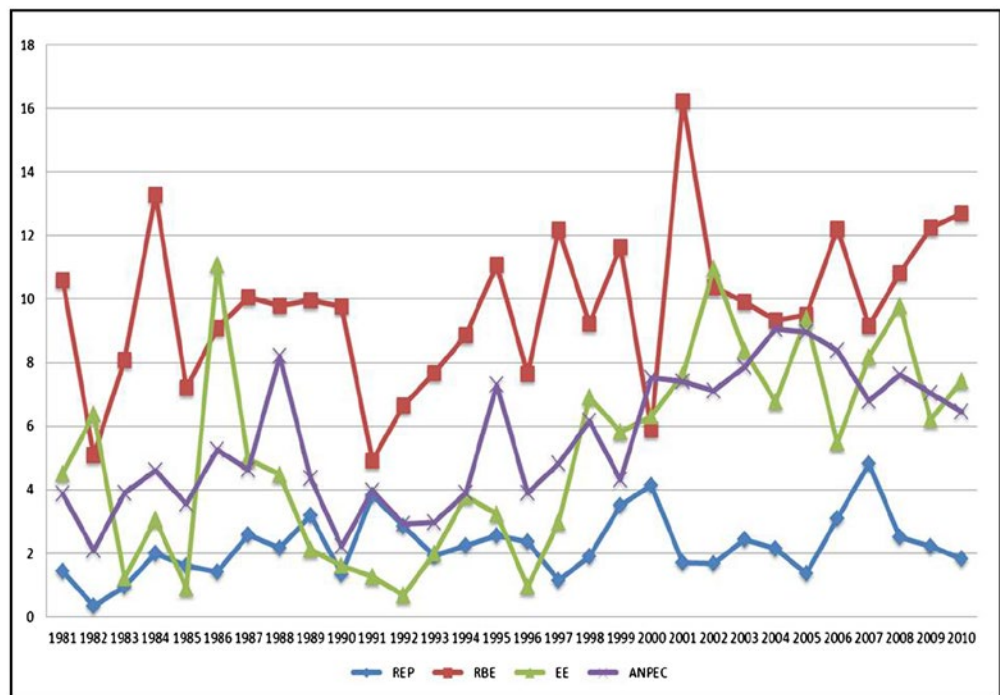
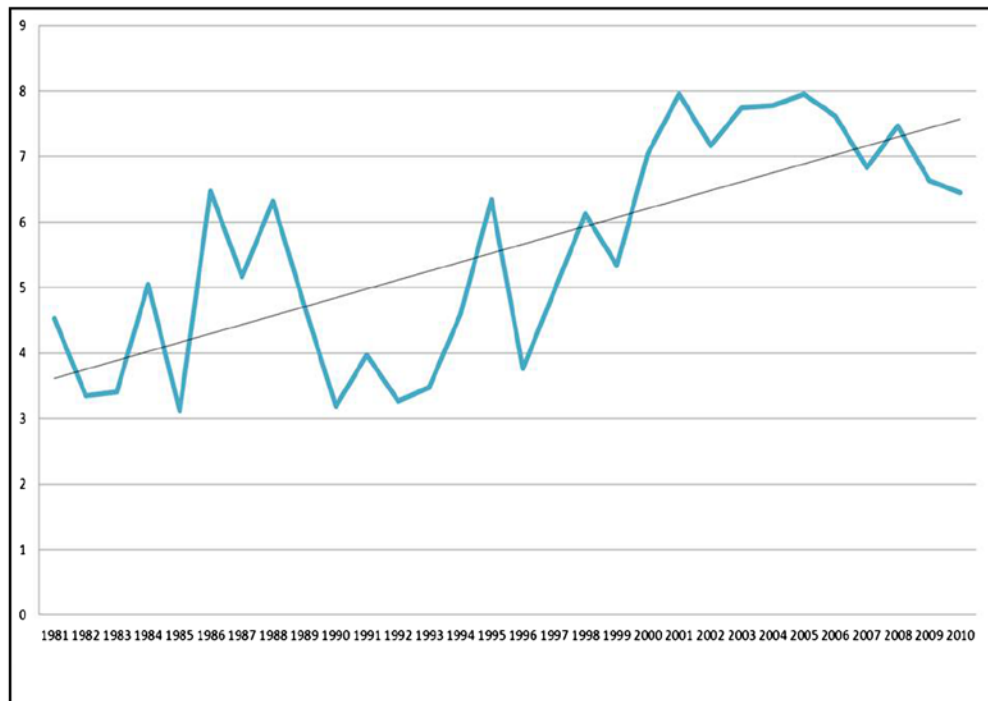


Figure 15. Average number of equations per article.

Source: ANPEC, REP, RBE, EE



We can also see trends similar to the EE in articles published at ANPEC meetings, that is, when compared to RBE publications, the highlighted variable grows faster. However, both the EE and ANPEC meeting publications, despite higher growth in the number of equations per article (between six and eight in the last decade), did not reach the level of the RBE (between 10 and 12 in the last decade).

When we see the variable in question in the REP, we can see that the advance in terms of number of equations was slower than in the EE and ANPEC. However, in relative terms, the number of equations in the REP has practically doubled in the last 30 years (between one and two in the 1980s to two to three in the first decade of the millennium). If compared to the RBE, increasing from 8 to 10 in the 1980s to 10–12 in the last decade, the REP was significantly influenced by the movement toward mathematizing economics, as the number of equations has grown faster than in the RBE, despite the RBE being a journal which, since the 1980s, has presented publications with more equations per article than the others.

Considering all journals and ANPEC meeting publications, we can see in Figure 15 that there is a general trend toward mathematization of economics in the Brazilian academy through the growing number of equations per article, from three to five in the 1980s to five to six in the 1990s, reaching six to eight in the last decade.

5. Convergence between Qualitative and Quantitative Variables

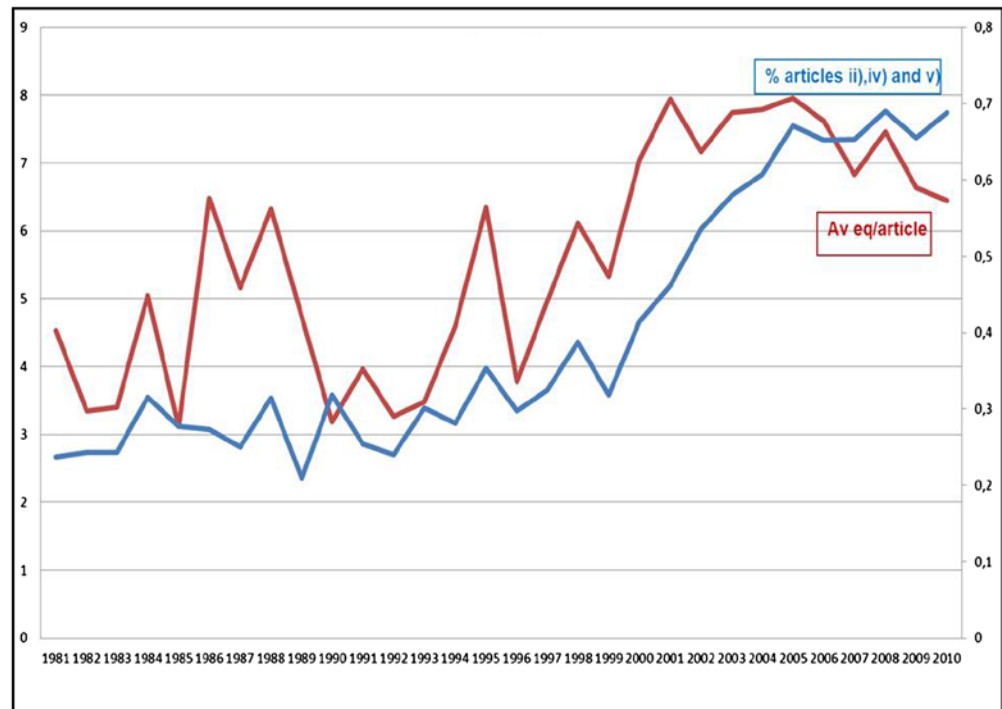
We ask ourselves if there is a convergence of the quantitative analysis with our previous qualitative analysis.

Superimposing both graphs: percentage of articles type *ii*, *iv*, and *v* and the sum of the number of equations per article of all journals, we seek to answer this question.

Looking at Figure 16, we can see that indeed there is a convergence of our qualitative and quantitative analyses.

Figure 16. Number of equations per article— ANPEC, REP, RBE, and EE/% Type *ii*, *iv*, and *v* articles— ANPEC, REP, RBE, and EE.

Source: ANPEC, REP, RBE, EE



6. Final Considerations

Throughout this paper, we have developed concepts to verify the advance of mathematization of economics within the Brazilian academy. Through qualitative analysis of 5,733 articles from three of Brazil's main economic journals and ANPEC meetings from 1981 till 2010, we can see that there was in fact an inflection point in Brazilian economic discourse in the mid-1990s.

At this point, articles based primarily on formalized economic theory with econometric models (type *iv*) and purely econometric articles (type *v*), practically without formalized economic theory, have grown to represent more than 50% of published articles.

To test the robustness of our definitions, we also analyzed a quantitative variable, equations per article, and we saw that there was a convergence with our qualitative trend. This means that our qualitative analysis was better than the quantitative, as in addition to convergent trends the former offered more information about each of the journals individually than the latter.⁴

Regarding the cause of the change in Brazilian economic discourse, although this article does specifically address this matter, we suggest some lines of investigation that will guide our future analysis. We believe that one of the causes of this process was the Brazilian economic opening in the 1990s. Brazil's increased role in global commerce caused an internationalization of Brazilian economic thought. Meanwhile, this internationalization brought an apparatus that was not innovative, that is, mathematized economic models developed by mainstream economics.

Inherent in this process, technological progress can also be highlighted as a factor supporting the advance of the mathematization of economics in the Brazilian academy. With the increasing use of personal computers and the assistance of econometric software like Eviews and, later, Stata, the cost of econometric research fell sharply, which certainly explains the enormous diffusion of these types of studies in our research.

However, we do not have sufficient data to corroborate these affirmations in this article, Therefore, we plan to study the cause of the change in Brazilian economic discourse beginning in the mid-1990s in more detail in future research.

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Notes

1. In this article, the terms formalization, mathematization, and axiomization are considered synonyms, although they have different meanings (see Weintraub, 1998). The increased use of mathematical language is also the advance of each of these approaches.
2. The Beed and Kane (1991) article presents the pros and cons of formalization of economics.
3. Mirowski developed this analysis in full detail in previous work (Mirowski, 1989).
4. Like all research conducted in Brazil. In this sense, we can say that researchers in our country dedicate little time to basic theoretical research, concentrating on theories and models copied from abroad.

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