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Revisiting a Macroeconomic Controversy: The Case of the Multiplier–Accelerator Effect

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Abstract: This paper presents the bibliometrics of a Keynesian and neoclassical discussion about the multiplier–accelerator effect. Having its oldest roots in the 1930s, there was a special emphasis in the 1960s and 1970s on discussions regarding the dependence of current investment on economic growth (the accelerator effect). Through a bibliometric analysis, we also consider the Hicks–Samuelson contribution, also known as the multiplier–accelerator model. We identified, among other things, the most relevant authors on the topics, the economic areas that have been contributed to the most through keyword analysis, and the most notable contributions through citation analysis. We concluded that several areas in economics have taken advantage of the discussion around the multiplier–accelerator effect, especially the discussion on the business cycle, structural dynamics, and public finance.

Keywords: multiplier–accelerator; accelerator–multiplier; bibliometric analysis

JEL Classification: E12; C02; E21; E22

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1. Introduction

The relationship between investment and the production of an economy is one of the most analysed economic relationships in the last two hundred years. On the one hand, since investment is a component of aggregate expenditure, it is also a reflection of the production and income of a community. Richer and economically growing communities invest more. Richer and economically growing communities build more homes, more public buildings, and more infrastructure. However, investment is also, in and of itself, a cause of future production. Investments from today lead us to produce and earn more tomorrow.

Within the analyses carried out in the last century, a discussion arose around a combined effect of investment on production. In one way, an entire school of Keynesian analysis had detailed the capacity of the multiplier effect of investment. However, a whole generation of neoclassical and neo-Keynesian economists also analysed the so-called accelerator effect, that is, the capacity of the scale of the investment inducing more or less voluminous effects on the income of the community. This discussion became known as the discussion around the 'multiplier–accelerator effect'.

This article will revisit the discussion of the 'multiplier–accelerator effect'. It will do so through a bibliometric analysis. Bibliometric analyses are useful within scientific methodology, in general, and within economics in particular. On the one hand, they are useful in general, as they make it possible to identify the evolution of the scientific community's interest in analysing a given problem or phenomenon. As will be seen in this work, after moments of great stimulation (especially during the 1960s and 1970s), the study of the 'multiplier–accelerator effect' became less evident in terms of publications listed in the Scopus database (but the decrease in interest was also demonstrated in indicators different from Scopus publications, as we will point out). Within the field of economics,

bibliometric analyses make it possible to identify the economic areas that are the most involved in the phenomenon studied, either through the identification of keywords or through the universities/research centres to which the researchers are affiliated.

As we will see throughout this work, the study of the 'multiplier–accelerator effect' has already had involvements as varied as the analysis of economic cycles, economic development policies, or infrastructure development. In any case, despite the existence of peaks of interest over these more than seven decades of analysis, the 'multiplier–accelerator effect' has never been completely abandoned by the scientific community, demonstrating how it has the potential to contribute to various fields of analysis.

The remainder of this work begins with a section that presents the original discussion around the 'multiplier–accelerator effect' and the development of 'multiplier–accelerator' models. Then, the bibliometric section presents the basis of identified works around the 'multiplier–accelerator effect' and will discuss their distribution in terms of authors, citations, and keywords, among other dimensions. We will also analyse the evolution of the number of publications over the years. Finally, the last section will conclude this work.

2. The Development of Multiplier–Accelerator Models

The scientific understanding of the dynamics of economic growth made significant progress with the integration of two principles into the same framework of analysis that were previously considered conceptually discrete and distinct. The development of multiplier–accelerator models set the foundations for economic macrodynamics. Both the multiplier and accelerator are the link mechanisms of this change (Hieser 1967).

It is the purpose of this section to describe the accelerator and multiplier and their effect, the common denominator underlying them, and, most importantly, their interaction, which has been considered to be the essence of equilibrium growth models.

The origins of multiplier–accelerator (MA) models come from different works of scholars developed within Keynesian economics, where investment, government spending, and exports have a favourable multiplying effect on national income through their respective multipliers. Since the formulation of the analytic model proposed by Samuelson (1939a) and the conceptualization of a seminal model of growth by Harrod (1939), the consistency of the family of multiplier–accelerator models has grown over time.

We begin our discussion by looking at the multiplier principle. The multiplier has been considered a cornerstone in macroeconomic analysis and has enjoyed wide acceptance. The concept of the multiplier originated from Keynes (1936) and his joint work with colleagues (Kahn 1931; Keynes and Henderson 1929). The original model showed that a change in private investment increases income and stimulates the economy until people's savings balance the original investment. Therefore, the size of the investment multiplier depends on the marginal propensity to consume.

However, some researchers have argued that the multiplier is a nebulous concept that depends very much on the type, persistence, and financing source of government spending (Ramey 2011). This sheds light on previous research dealing with multiplier assessment that produced significantly different results. Cogan and Taylor (2012) estimated multipliers that are equal to or less than unity; Ramey (2011) found that the multiplier of government spending is approximately 1.4; and Galí et al. (2007) obtained multipliers as high as 2, while Romer and Romer (2010) found in their study that the tax multiplier in the US was about 3. In addition, multiplier estimations with different models lead to significantly different results within this branch of studies. The application of the Romer and Bernstein (2009) model generated a multiplier that ranged from 1.05 to 1.55, while the application of the Smets and Wouters (2007) model generated a multiplier that ranged from 0.4 to 1.03 (Cogan et al. 2010).

On the other hand, the early formulations regarding the accelerator principle were proposed by Carver (1903) and Aftalion (1909). According to their studies, an increase in the demand for goods will tend to cause a more than proportionate increase in the demand for productive assets. Clark (1917) incorporated the acceleration principle in his theory of the derived demand for capital equipment.

The family of multiplier–accelerator models is considered to originate from Samuelson's (1939a, 1939b) seminal work, which was later developed into nonlinear formats by Hicks (1950) and Goodwin (1949, 1950). The economic literature recognizes the merits of Harrod (1936, 1939) in joining the two distinct principles of the accelerator and multiplier together. In 1939, he laid the axiomatic basis of his theory by formulating propositions on the relations between income, income growth, the supply of saving, and the demand for saving, describing his theory as a 'marriage' of the 'acceleration principle' and the 'multiplier theory' (Harrod 1939, p. 14).

However, Samuelson (1939a, 1939b) integrated the two concepts into a rigorous and more complete model that was better capable of capturing the complexity of fluctuations in the national economy. The multiplier–accelerator model proposed by Samuelson has a Keynesian background. In that sense, Keynesian macroeconomics had regarded the interest rate as an equilibrating force for savings and investment. In addition, Samuelson's model focuses on the facts on the demand side, namely that investment follows the expected increase in demand.

The initial multiplier–accelerator model (Samuelson 1939b) shows a dual causality relationship between national income and investment. National income matches the total of government spending, consumption, and investment. The change in national income is determined by the values of the accelerator and multiplier. According to the multiplier analysis, an initial income increase generates subsequent additional spending, which multiplies the initial income increment by a factor determined by the fraction saved. The multiplier is a Kahn–Keynesian consumption multiplier that describes how an increase in investment generates a series of increases in consumption. On the other hand, the accelerator is a multiplier-type factor that describes how an increase in consumption generates a series of increases in investment. Thus, investment is seen as proportional by the coefficient of the 'accelerator' to the rate of change in past consumption.

Considering a simple empirical formalization (Puu 2004), this model considers that national income (Y) is equal to the sum of consumption (C) plus investment (I). Thus, for a given period t, we have $Y_t = C_t + I_t$. The investment at a moment t is made up of the substitution investment (a fixed value, usually neglected in the dynamic solution) and the induced investment, defined as a fraction of the most recent growth rate of income ($\Delta Y = Y_{t-1} - Y_{t-2}$), this is $I_t = a^*\Delta Y$. Consumption is defined as a proportion of the income of the previous period: $C_t = c^*Y_{t-1}$. Therefore,

$$Y_t = (a + c)^*Y_{t-1} - a^*Y_{t-2} \quad (1)$$

Depending on the magnitudes of the accelerator effect (a) and of the multiplier effect ($1/(1 - c)$), the model can have various paths for the projected income at leads $t + 1$, $t + 2$, etc. Hansen, Samuelson, and Hicks have also studied the so-called 'Super-Multiplier' given by $1/(1 - c - a)$. They showed there are four different profiles for fluctuations depending on the magnitudes of 'c' and 'a'. For instance, high 'c' and low 'a' converge to a steady-state of production; reversely, low 'c' and high 'a' can explain explosive/bipolar fluctuations. Super-multiplier models were discussed by several researchers (Cesaratto et al. 2003; Freitas and Serrano 2015; Dejuán 2017; Allain 2019; Fazzari et al. 2020).

While some authors see MA models as a stand-alone development from Harrod's (1939) work, others consider them as being essentially similar but under different parameter assumptions. More precisely, Coleman (1991) argues that the multiplier–accelerator models introduced by Samuelson (1939b), under plausible parameter assumptions, exhibit essentially the same properties of the model of economic growth developed by Harrod (1939). Further on, he argues that only if particular lags or unlikely coefficient estimates are

present can MA models exhibit cyclical fluctuations. On the other hand, Samuelson (1959) recognized the contribution of his mentor, Hansen, to the formulation of the multiplier–accelerator model. Two decades earlier, Hansen (1938) had proposed a model that joined multiplier analysis and the acceleration principle, referred to as the 'relation'. Hansen's cycle theory was formulated as a second-order difference equation by Samuelson.

Noting the extreme growth rates and the absence of periodicity of oscillations obtained using Samuelson's (1939a) model, Hicks (1950) added non-linearities to the model by imposing restrictions on the purely linear accelerator. Postulating an explosive accelerator coefficient, Hicks restricted its action by imposing a real ceiling on the expansion of the aggregate real output during the uptrend and a technical limitation on the effect of the accelerator during the downtrend. Additionally, Hicks introduced distributed lag systems for the multiplier and accelerator. The mathematical model of Hicksian floor and ceiling was formally formulated by Rau (1974). A similar model with the stationary case where autonomous expenditures, floor, and ceiling were all constant was proposed by Hommes (1995).

An interpretation of the discrete-time model was formulated by Kaldor (1940). According to this interpretation, the propensity to invest is compared to the propensity to save in the short run, where the capital stock is a given. In the long run, shifts in the saving and investment functions are studied due to endogenous changes in the capital stock generated by investment expenditures. Based on the Kaldorian model, several versions of the model were proposed in the macroeconomic literature (e.g., Matthews 1966; Dana and Malgrange 1984; Herrmann 1985; Lorenz 1992, 1993; Grasman and Wentzel 1994; Dohtani et al. 1996; Bischi et al. 2001).

Underlining the crucial role played by investments in a capitalist system, Kalecki's work represents another significant contribution to the development of multiplier–accelerator models. In a study of Kalecki (1935) proposed a non-linear cycle model consisting of functional equations including the bidirectional relationship between investment and growth (expressed by profit instead of output): investment creates profit and profit creates investment. Later on, through various studies, Kalecki (1943, 1954) consolidated business cycle modelling research, with various attempts to ensure the persistence of fluctuations with a number of assumptions in order to keep the system in motion.

Often, researchers in economic macrodynamics refer to the Samuelson (1939a, 1939b)–Hicks (1950) model. The interpretation of the multiplier–accelerator model in continuous time comes from Goodwin (1951). Additionally, Goodwin replaced the straight investment line with cut-offs by a smooth nonlinear investment function with vertical bounds. Additionally, continuous-time MA models were described by Rose (1959) and Nelson (1961), while Phillips (1957) applied stabilization rules to the model. Minsky (1957) was among the first to discuss multiplier–accelerator models in the context of a monetary system, paying attention to monetary prerequisites and monetary effects. He underlined that various monetary systems, by changing the level of liquidity, can act as a break on disinvestment or can stimulate recovery. The works of Sushko et al. (2004) and Puu et al. (2005) analyse the multiplier–accelerator model by considering the floor to be tied to the stock of capital. As a result, they noted that income shows an endogenously generated growth trend due to the increase in the capital stock and that the average growth rates calculated over the cycles are reduced compared to those of the original model.

The recent development of new mathematical techniques has allowed for the development of the model. For instance, Böhm and Jungeilges (2004) introduced a random perturbations case in which the multiplier–accelerator model belongs to the class of generalized two-dimensional vector autoregressive systems of order 1 (VAR1), including so-called Markov switching models. Cánovas Peña and Marín (2006) studied the multiplier–accelerator system under different assumptions by using the notions of non-autonomous discrete systems.

Researchers pointed out that the Hicks–Samuelson model demonstrates its current validity (Gandolfo 1985; Hommes 1995; Puu et al. 2005). The multiplier–accelerator model has been a valuable instrument for evaluating the impact of exogeneous shocks of various types on the macroeconomy (Marglin and Spiegler 2013). Policymakers around the world have implemented a diverse set of austerity or stimulation packages as responses to crises. Practitioners and researchers alike have revived multiplier–accelerator models to evaluate the impact of fiscal policies in such circumstances (e.g., Romer and Romer 2010). However, several shortcomings were highlighted. Among them, we find that the model is not able to produce lasting business cycles, the fact that empirically observed values of its parameters imply that the trajectory of national income is unstable, and that the model neglects expectations (Westerhoff 2006).

Nevertheless, the multiplier–accelerator model formulated by Samuelson (1939a, 1939b) has prominence in the economic literature. It has been developed over time by a large number of researchers into a family of multiplier–accelerator models that fit the current needs of macroeconomic analysis.

3. Methodology

This research uses a bibliometric methodology in order (i) to investigate the performance of different types of scientific actors (e.g., researchers, universities/other types of institutions, and countries) and the impact of their activity on the basis of bibliographic data and (ii) to perform a science mapping analysis based on bibliographic networks so as to extract knowledge from the intellectual, social, or conceptual structures. It has been underlined that measuring the quality and quantity of scientific production is extremely important to the advancement of knowledge and contributes to the progress of science, especially in the fields of economics, computer science, mathematics, physics, medicine, psychology, sociology, etc. (Martínez et al. 2015; Gutiérrez-Salcedo et al. 2018).

A bibliometric analysis is considered an essential step in discussing the status of a certain topic in a given scientific field (Mourao and Martinho 2020). Several works have highlighted the importance of bibliometric analyses for topics considered relevant in recent periods (Mourao and Martinho 2020; Zeng et al. 2021), but other works have also highlighted the several advantages of this analysis in realizing the evolution of a topic over the years (Zeng et al. 2021). In this dimension, some features have been highlighted, namely the distribution of citations related to the various works focused on the topic and the developed subtopics assessed by the range of identified keywords.

In this study, bibliometric analysis was performed using the open-source software tool for science mapping, VOS Viewer (version 1.6.11). VOS Viewer provides advanced features to create and visualize a variety of bibliometric networks. According to Van Eck and Waltman (2010), VOS Viewer is especially useful for displaying large bibliometric maps in an easy-to-interpret way by paying special attention to their graphical representation.

Bibliometric data for this study were retrieved from Elsevier's Scopus database on 15 August 2022. Scopus is the largest peer-reviewed indexing database available to academic, government, and corporate institutions, with over 24,000 active titles and over 83 million records (Scopus 2021). Additional information on the search interest of multiplier–accelerator models was obtained from Google Trends and Ngram. Data were retrieved from Scopus through the advanced search feature, querying documents that contained both the search terms 'accelerator' and 'multiplier' in title, abstract, or keywords. No time range was established for the retrieval of documents. We limited our results to the subject area 'Economics, Econometrics and Finance'. Then, we refined for the document types of 'article', 'book chapter', 'book', and 'conference proceedings'. The flow of the research process is illustrated in Figure 1.

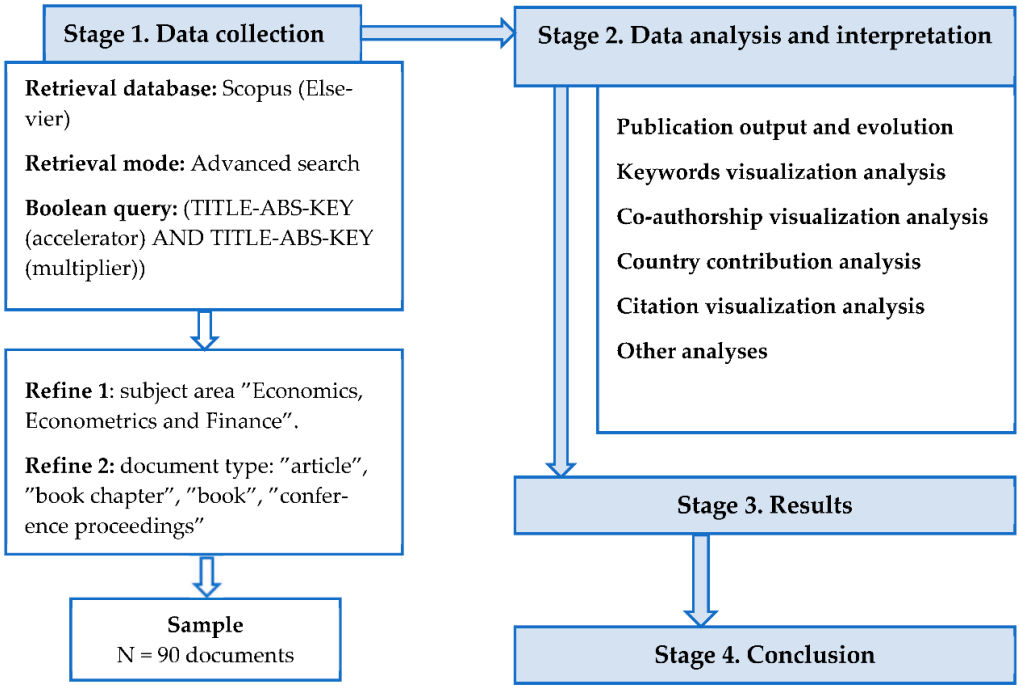

Figure 1. The flow of the research process (Source: own research).

4. Findings and Discussion

We discovered a total of 90 publications in Scopus, which were included in our final sample. The sample size denotes a somewhat reduced interest in this topic, given that no time-range restrictions were imposed on the sample. These publications were authored by a total of 132 researchers affiliated with a total of 109 institutions from 30 countries, as shown in Table 1. Multiple institutional affiliations were possible. On average, a researcher authored 1.2197 papers on the topic of the multiplier–accelerator effect, which denotes the occasional interest of the researchers in the application of the theory and in models using the multiplier–accelerator principle. We note that the largest number of papers per author was six papers and that the distribution of the papers/authors is highly skewed. However, there are five researchers in our sample who showed increased interest in the topic and who published three or more papers (Puu, T.—six papers; Gardini, L.—five papers; Sushko, I.—five papers o-authored with Puu, T. or Gardini, L.; Hommes, CH—three papers; and Sordi, S.—three papers).

Table 1. Summary statistics.

	Author	Institution	Country
Count	132	109	30
Mean	1.2197	1.3670	4.1
Standard Error	0.0639	0.0928	0.7556
Median	1	1	2.5
Mode	1	1	1
Standard Deviation	0.7343	0.9686	4.1385
Sample Variance	0.5392	0.9382	17.1276
Kurtosis	23.1966	14.6617	3.9364
Skewness	4.5629	3.6234	1.9723
Range	5	6	16
Minimum	1	1	1
Maximum	6	7	17

Source: own research.

Now, we move our attention to the growth in the number of publications. Scopus has indexed publications in the field of economics that date back to 1832. However, we found a low representation of the studies published before the second half of the twentieth century. Although the economic literature recognizes the merits of Harrod (1936, 1939) in joining the two distinct principles of the multiplier and accelerator together and that Samuelson (1939b) integrated the two concepts into a complete model, our sample includes studies published starting from the second half of the 20th century (e.g., Boulding 1955 and Hieser 1967) (see Figure 2).

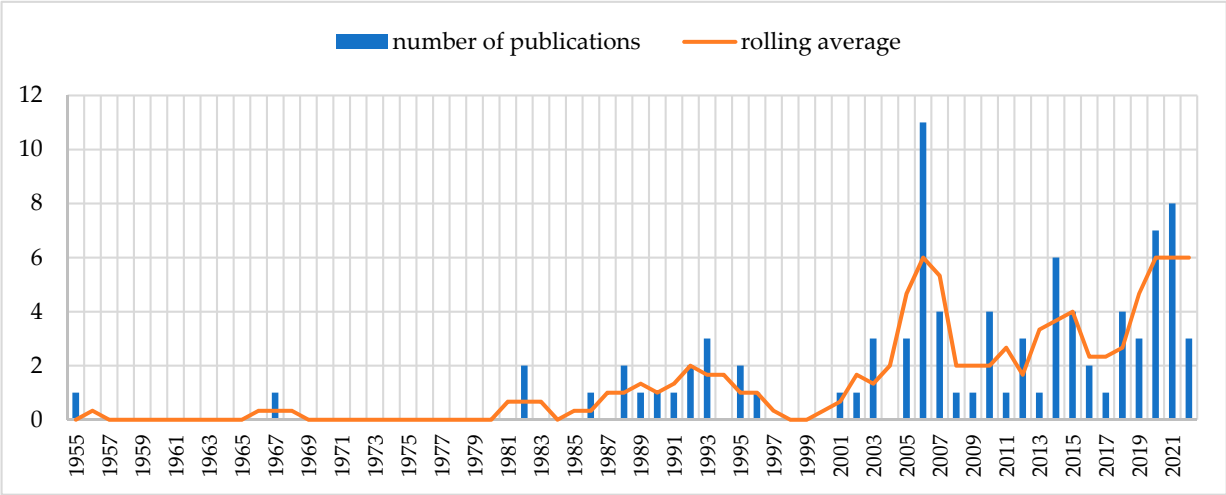

Figure 2. Evolution of the number of publications (Scopus data). (Note: Data for 2022 refer to the period of January–July 2022; source: own research.)

Starting in the 1980s, researchers began to test the usefulness of multiplier–accelerator models and to further develop them. However, the number of publications remained relatively small. In the 1980s, a total of six papers were published. Researchers' interest in these models increased slightly in the 1990s, a period in which a total of 10 papers were published.

We can say that the interest of researchers in multiplier–accelerator models was awakened during the period of 2000–2009, a period in which 25 publications saw the light of the printing press, even if in an online format. Two monographies (edited by Nell 2005 and by Puu and Sushko 2006) with theoretical and empirical studies on multiplier–accelerator models account for the largest number of publications during this period (with the total number of publications being 25).

We note that interest in the multiplier–accelerator effect is currently on the rise. More than half of the documents included in our sample (52.22%) were published between 2010 and 2022 (until 31st July). During this period, researchers turned their attention to accelerator–multiplier theory and models to investigate various problems related to the financial crisis, business/trade/economic cycles, monetary and fiscal policies, environmental impacts, or technological developments. Through their work, researchers have found that the principle behind accelerator theory and multiplier models is still valid for investigating the challenges of modern times.

The documents in our sample were classified into different document types according to the Scopus database. Our sample included 77 journal articles, 9 book chapters, some of which were included in 3 books (Paul Samuelson & the Foundations of Modern Economics, by Puttaswamaiah 2019; Transformational Growth and the Business Cycle, edited by Nell (2005); and *Business cycle dynamics: Models and tools*, 2006, edited by Puu, T. and Sushko, I.). The book edited by Puu and Sushko (2006) comprises, among others, seven of the book chapters included in our sample.

One-third of the documents included in our sample were published in the following journals: *Business Cycle Dynamics Models and Tools*, *Metroeconomica*, *Journal of Economic Structures*, *Economic Modelling*, *History of Political Economy*, *Journal of Economic Dynamics and Control*, and *Structural Change and Economic Dynamics*. Regarding the possibility of access, 29 of the 90 documents are open access. In terms of language, 85 publications were written in English, 2 were written in Russian, 2 were written in Slovak, and 1 was written in Spanish.

Scientific collaboration between researchers leverages intellectual resources in research and academia, greatly benefits the scientific community, and enhances (international) knowledge transfer. The documents in our sample had received a total of 784 citations at the time that this research was being conducted. With few exceptions, the most cited works are more recently dated. The most influential papers that received over 30 citations per paper were Puu et al. (2005) (48 citations); Hommes (1995) (47 citations); Sterman (1989) (45 citations); Aguiar-Conraria and Wen (2007) (36 citations); Westerhoff (2006) (33 citations); and Freedman et al. (2010) (30 citations). Most of them are provided with open access by their publishers.

Figure 3 describes the network of citations with respect to the 90 publications identified. Figure 3 shows that the five authors with the most citations at the time of collection are Puu (147 citations), Sushko (152 citations), Gardini (71 citations), Wen (50 citations), and Westerhoff (43 citations). Figure 3 also shows that there is a high correlation between the number of published works and the number of citations for each author. Dividing the number of citations into the number of documents, we have an additional indicator of the (average) notoriousness of each author: Puu (29.4), Sushko (28.4), Gardini (14.2), Wen (25), and Westerhoff (21.5). Here, we must also recognize that close values for the indicator of Citations per Document can be related to coauthorship in several papers of the observed authors. One-quarter of the works has not received any citations thus far.

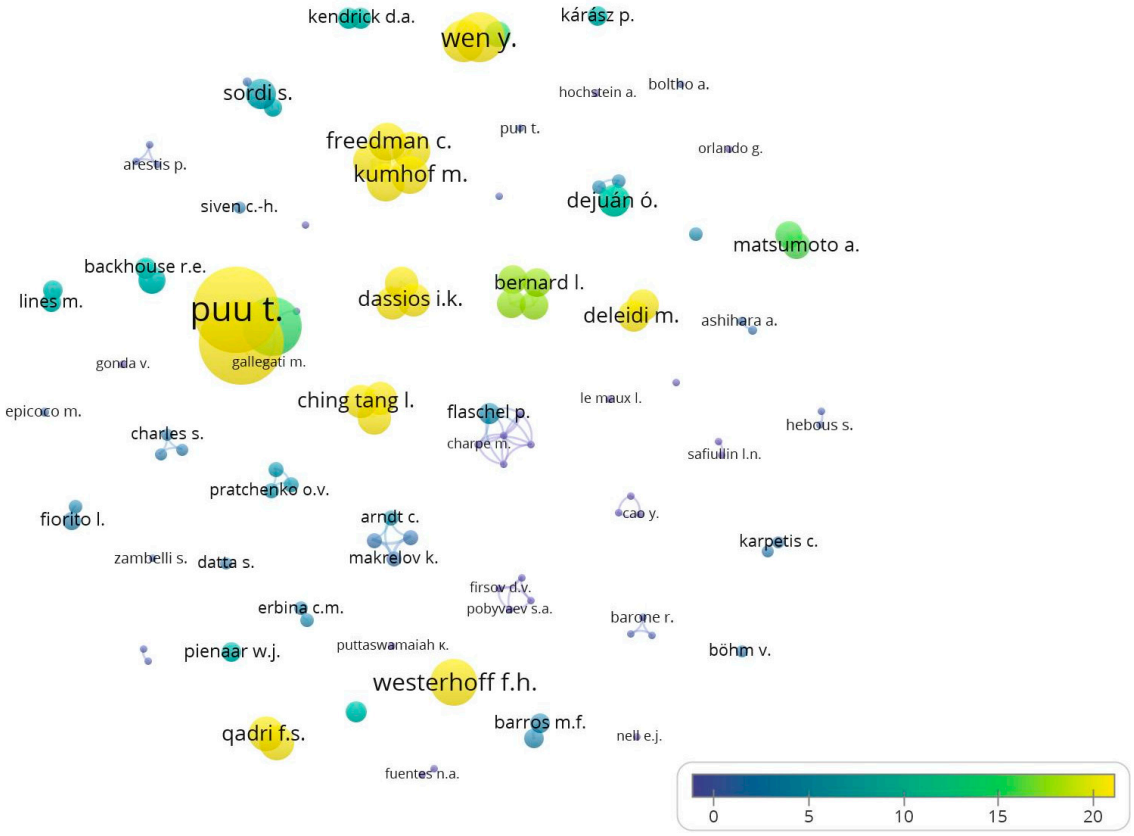

Figure 3. Citations of the authors publishing on accelerator–multiplier effect (Source: own research).

The affiliations of authors provide an overview of the institutions and countries in which there are strong preoccupations for the research theories and models that are grounded on use of the multiplier–accelerator effect in economic sciences. We report that two types of collaboration for scientific production are to be noted: (i) research groups comprising researchers from different universities and countries and (ii) research groups comprising researchers hosted by the same institution. The top of institutions hosting researchers that have published studies on the topic of multiplier–accelerator theory and models are Umeå Universitet, Sweden (seven papers authored by Puu, T.), the National of researchers in this topic given that a large number of papers were co-authored by a few groups of researchers, either from the same institution or from different institutions/countries.

Recalling the data shown in Table 1, the Academy of Sciences, Ukraine (five papers by Sushko, I.), Universität Bielefeld, Germany (five papers co-authored by 10 researchers), Universita degli Studi di Urbino Carlo Bo, Italy (five papers co-authored by 3 researchers), and The New School, New York, USA (four papers co-authored by several researchers). We can observe the intensive specialization documents in our sample were published by researchers from a total of 30 countries. Figure 4 shows the geographical distribution of documents by country. We can confirm that Italy contributed the largest number of documents (17) to our sample, followed by the United States (16 documents), Germany (10 documents), Sweden (8 documents), United Kingdom (7 documents), and the Netherlands (6 documents). Five or fewer documents come from the rest of the countries highlighted in the Figure 4.

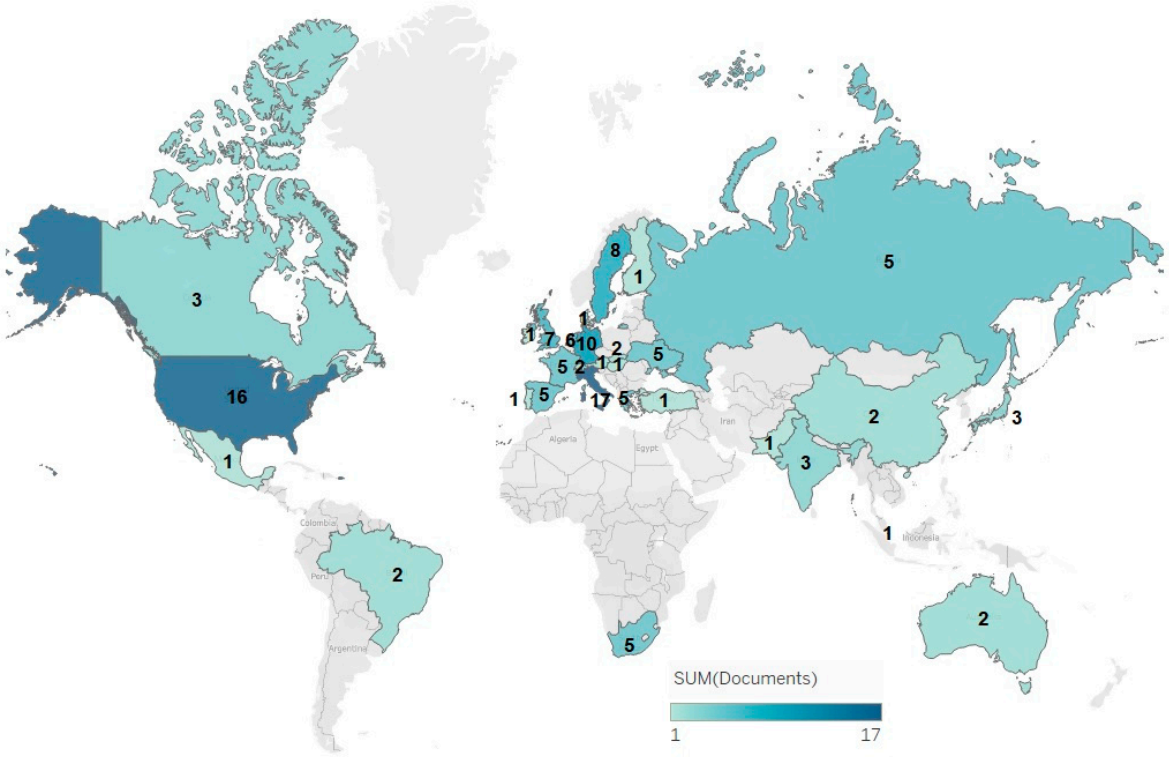

Figure 4. Geographical distribution of documents by country (Source: own research).

In addition, we note that more than a quarter of the publications (25 out of 90 documents) received funding from various institutions or funding agencies. Among them, we find the European Commission; Japan Society for the Promotion of Science; UK Research and Innovation; Russian Foundation for Basic Research; Deutsche Forschungsgemeinschaft; Conselho Nacional de Desenvolvimento Científico e Tecnológico; European Central Bank, etc.

The Interest In multiplier–accelerator models might alternatively be assessed by looking at Google trends data. These data are available from 1 January 2004 onward and show

the number of times a particular term was searched through the Google engine at the worldwide level. Figure 5 shows the evolution of the cumulative searches for the search terms 'accelerator multiplier' and 'multiplier accelerator'. The interest in the topic of multiplier–accelerator models was the highest in the period prior to the publication of the largest number of papers in 2006. Since 2007, interest in these search terms has waned to an average of 133 searches per year, which denotes a rather reduced interest in these models.

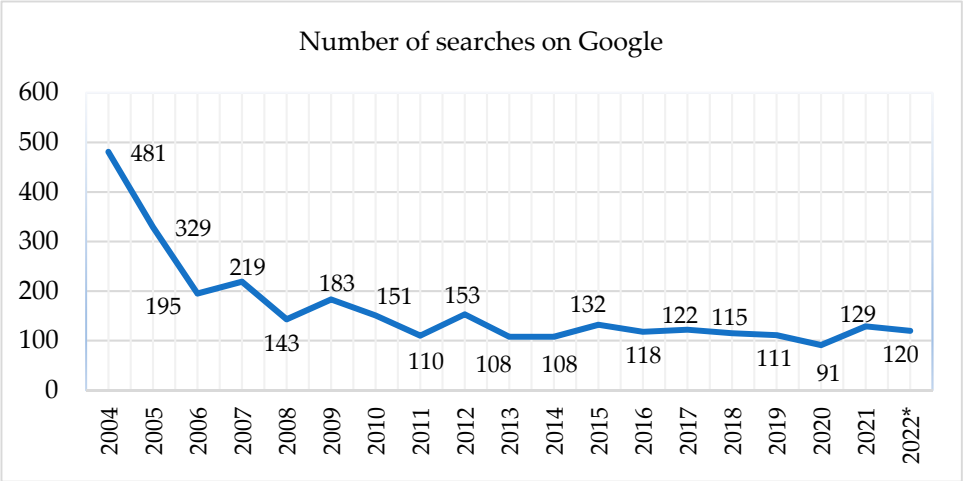

Figure 5. Evolution of the interest in the multiplier–accelerator issue (Google Trends data). Notes: data refer to the Science Category; * For 2022, data are for January–July. (Source: own research).

Table 2 shows that there are 281 keywords associated with the 90 works listed in Scopus. The most frequent are 'fiscal policy', 'business cycle', 'investment', 'difference equations', 'Keynesian theory', 'financial crisis', 'modeling', or 'multiplier accelerator'. Table 2 only shows the (twenty-one) keywords with a minimum occurrence of two in the 90 observed publications; the remaining keywords can be exhibited upon request.

Table 2. The most frequent keywords in publications about multiplier–accelerator effect.

Keywords	Occurrences	Total Link Strength
fiscal policy	6	39
business cycle	6	34
investment	4	30
difference equations	4	18
Keynesian theory	3	34
financial crisis	3	30
modeling	3	20
multiplier–accelerator	3	15
financial accelerator	3	14
Samuelson model	3	14
econometrics	2	23
economic impact	2	22
numerical model	2	21
nonlinearity	2	20
economic theory	2	19
structural change	2	16
financial friction	2	15
economic dynamics	2	13
stability	2	12
fiscal multipliers	2	11
Samuelson	2	11

Note: 'Total link strength' refers to the total strength of the keywords links of a given expression with other keywords; a higher value indicates a higher popularity of the group containing a given keyword. (Source: own research.)

However, in addition to the singularity of each keyword, it is also important to check the simultaneity of the keywords in a publication. Figure 6 was constructed using VOS Viewer software on the Scopus database. Figure 6 also shows that there are certain keywords that occur more frequently in the older works. 'Business cycle', 'economic development', or 'financial stimulus' were especially frequent in works published around 2010. These terms were also connected, showing a defined branch of work at the time studying the 'multiplier–accelerator effect' by considering business cycles and economic development or financial stimulus. More recently, we find works with keywords such as 'computable general equilibrium', 'structural change', 'kaldor model', or 'multiplier', which also proves a move in the sub-topics analysed in the main topic of the 'multiplier–accelerator' issue. Independently of the time of publication, Figure 6 shows that the works focusing on the multiplier–accelerator topic use some central keywords. These words are specifically related to the business cycles, investment decisions, or structural/infrastructural dimensions.

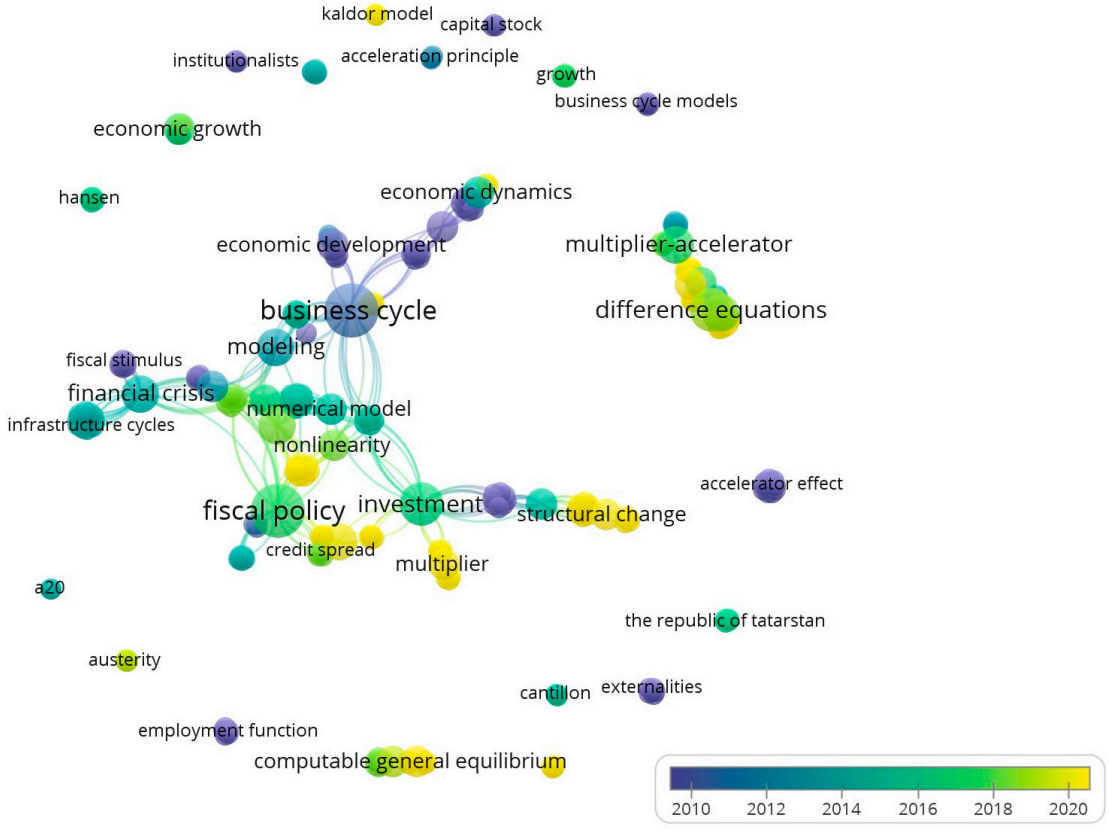

Figure 6. Keywords in the papers on the multiplier–accelerator effect (Source: own research).

The general trend of the times when the terms 'accelerator' and 'multiplier' appeared in publications written in English throughout the world can be visualized using an Ngram chart (Figure 7). The Google Books online Ngram corpus represents a collection of digitized books with over 500 billion words in seven different languages distributed in the n-gram format. An *n*-gram is a sequence of *n* words divided by a space character. The Google Ngram viewer presents for each specified n-gram the year in which it occurred and how many times. As discussed, the 'multiplier–accelerator effect' is an economic topic that received special attention in the 1960s and 1970s, which is clearly illustrated in Figure 7. However, the occurrences of the two n-grams for 'multiplier–accelerator' and 'accelerator–multiplier' in publications registered a decreasing trend, although two other periods of significant interest were recorded around 1990 and 2014. We associate these periods with the economic crises that affected the US economy.

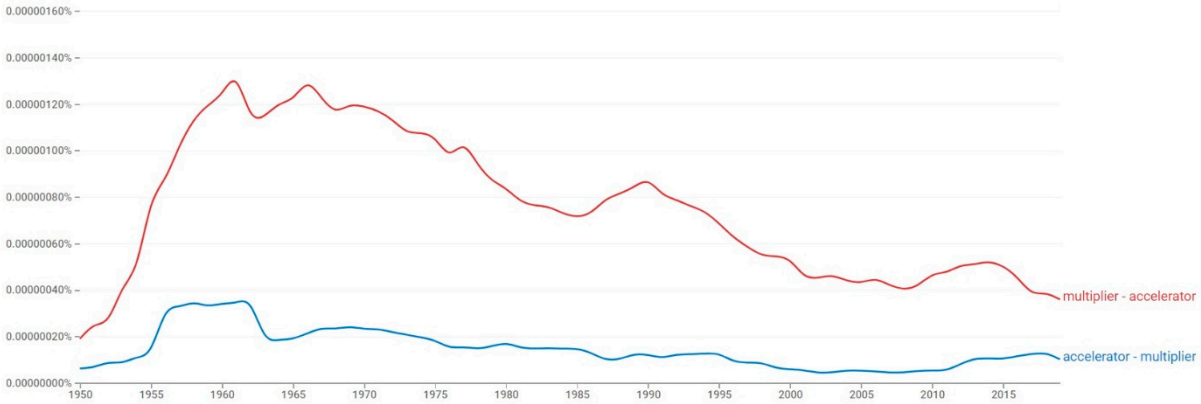

Figure 7. Evolution of the key terms incidence on Google Books Ngram (Source: own research).

Through the bibliometric analysis of Scopus data, we identified the growth in the number of documents presenting research in which authors employed the 'multiplier–accelerator' effect. However, the interest in how this principle works and can be applied in modern economics seems to fall at the worldwide level in the long run if we were to consider the data retrieved from Google Tends (data related to the number of searches) and Google Ngram (data related to the number of occurrences in digital books). In addition to these evolutions, we identified the most notable contributions to the scientific corpus of the 'multiplier accelerator' and the main research topics that were investigated using the 'multiplier accelerator effect' through keyword analysis.

5. Conclusions

One of the discussions that brought together the names of neoclassical economists such as Samuelson with economists of the Keynesian school, such as Hicks or Harrod, was the discussion about the so-called 'multiplier–accelerator effect'. Taking advantage of the formalization around aggregate demand models, this discussion sought to explain the cyclical oscillations of the economy, for example in aggregate income, depending on the intensity of investment and the weight that this exerted on aggregate income.

Despite a certain mechanism (or determinism) underlying the discussion focused on the initial models, the 'multiplier–accelerator effect' was having peaks of popularity in the academy—the decades of neo-Keynesian projection (1960s and 1970s) contributed to the popularity of these periods, but later a drop in the number of publications listed by Scopus was observed. Despite this recent trend, there has always been work on the subject, especially since the early 2000s, when the discussion gained new stimuli.

This work carried out, in an original way, a bibliometric analysis around this discussion. Using the Scopus database, we observed which authors have published work on this discussion, which research centres are more focused, which citation networks are associated, and which economics topics and keywords are used the most.

We found that the areas that followed this discussion the most were the areas around 'business cycle', 'fiscal policy', and 'investment.' The research centres reflecting the presence of the most productive authors on the subject are the Umeå Universitet, Sweden (seven papers authored by Puu, T.); National Academy of Sciences, Ukraine (give papers by Sushko, I.); and Universität Bielefeld, Germany (five papers co-authored by 10 researchers). Finally, among other detailed evidence in this work, there are groups of authors who have worked as coauthors that dominate the number of publications and the associated citations.

Next, we highlight several implications of this analysis. On the one hand, the discussion around the 'multiplier–accelerator effect' has never died. This proves that the community of economists has been able to transport this discussion to other fields than the original ones. Second, we verified that the popularity of the topic is convergent, regardless of the observed metrics (the number of publications listed in Scopus, searches in Google, etc.) or a greater interest on the part of the general population. Finally, we observed an

evolution in the use of keywords associated with the listed works. If, in the early 2010s, works with keywords such as 'business cycle' or 'economic development' predominated, in the 2020s, works centred on keywords such as 'structural change' or 'general equilibrium' appear, which shows an evolution of the areas covered by the multiplier–accelerator effect issue.

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References

Aftalion, Albert. 1909. La realité des surproductions generales. *Revue D'economie Politique* 18: 696–706.
Aguiar-Conraria, Luís, and Yi Wen. 2007. Understanding the large negative impact of oil shocks. *Journal of Money, Credit and Banking* 39: 925–44. [CrossRef]
Allain, Olivier. 2019. Demographic Growth, Harrodian (in)Stability and the Supermultiplier. *Cambridge Journal of Economics* 43: 85–106. [CrossRef]
Bischi, Gian Italo, Roberto Dieci, Giorgio Rodano, and Enrico Saltari. 2001. Multiple attractors and global bifurcations in a Kaldor-type business cycle model. *Journal of Evolutionary Economics* 11: 527–54. [CrossRef]
Böhm, Volker, and Jochen Jungeilges. 2004. *Estimating Affine Economic Models with Discrete Random Perturbations*. Discussion Paper 513. Bielefeld: Department of Economics, University of Bielefeld.
Boulding, Kenneth Ewart. 1955. In defense of statics. *The Quarterly Journal of Economics* 69: 485–502. [CrossRef]
Cánovas Peña, Jose S., and Manuel Ruiz Marín. 2006. Non-Autonomous Business Cycle Model. In *Business Cycle Dynamics: Models and Tools*. Edited by Tönu Puu and Iryna Sushko. Berlin: Springer, chp. 5. pp. 143–78.
Carver, Thomas Nixon. 1903. A Suggestion for a Theory of Industrial Depressions. *The Quarterly Journal of Economics* 17: 497–500. [CrossRef]
Cesaratto, Sergio, Franklin Serrano, and Antonella Stirati. 2003. Technical change, effective demand and employment. *Review of Political Economy* 15: 33–52. [CrossRef]
Clark, J. Maurice. 1917. Business acceleration and the law of demand. *Journal of Political Economy* 25: 217–35. [CrossRef]
Cogan, John F., and John B. Taylor. 2012. What the Government Purchases Multiplier Actually Multiplied in the 2009 Stimulus Package. In *Government Policies and the Delayed Economic Recovery*. Edited by Lee Ohanian, John B. Taylor and Ian Wright. Stanford: Hoover Institution, Stanford University, chp. 5.
Cogan, John F., Tobias Cwik, John B. Taylor, and Volker Wieland. 2010. New Keynesian versus old Keynesian government spending multipliers. *Journal of Economic Dynamics and Control* 34: 281–95. [CrossRef]
Coleman, William. 1991. Harrod's Growth Model and the Multiplier-Accelerator Model: Two Sides of the Same Coin? *Metroeconomica* 42: 199–211. [CrossRef]
Dana, Rose Anne, and Pierre Malgrange. 1984. The dynamics of a discrete version of a growth cycle model. In *Analyzing the Structure of Economic Models*. Edited by Jean Pierre Ancot. The Hague: Martinus Nijhofif, pp. 205–22.
Dejuán, Óscar. 2017. Hidden links in the warranted rate of growth: The supermultiplier way out. *The European Journal of the History of Economic Thought* 24: 369–94. [CrossRef]
Dohtani, Akitaka, Tetsuya Misawa, Toshio Inaba, Masanori Yokoo, and Tatsuji Owase. 1996. Chaos, complex transients and noise: Illustration with a Kaldor model. *Chaos Solitons & Fractals* 7: 2157–74.
Fazzari, Steven M., Piero Ferri, and Anna Maria Variato. 2020. Demand-led growth and accommodating supply. *Cambridge Journal of Economics* 44: 583–605. [CrossRef]
Freedman, Charles, Michael Kumhof, Douglas Laxton, Dirk Muir, and Susanna Mursula. 2010. Global effects of fiscal stimulus during the crisis. *Journal of Monetary Economics* 57: 506–26. [CrossRef]
Freitas, Fabio, and Franklin Serrano. 2015. Growth Rate and Level Effects, the Stability of the Adjustment of Capacity to Demand and the Sraffian Supermultiplier. *Review of Political Economy* 27: 258–81. [CrossRef]
Galí, Jordi, J. David López-Salido, and Javier Vallés. 2007. Understanding the Effects of Government Spending on Consumption. *Journal of the European Economic Association* 5: 227–70. [CrossRef]
Gandolfo, Giancarlo. 1985. *Economic Dynamics: Methods and Models*. Amsterdam: Elsevier.

Goodwin, Richard M. 1949. The business cycle as a self-sustaining oscillation. *Econometrica* 17: 184–85.
Goodwin, Richard M. 1951. The nonlinear accelerator and the persistence of business cycles. *Econometrica* 19: 1–17. [CrossRef]
Grasman, Johan, and Jolanda J. Wentzel. 1994. Coexistence of a limit cycle and an equilibrium in a Kaldor's business cycle model and its consequences. *Journal of Economic Behavior and Organization* 24: 369–77. [CrossRef]
Gutiérrez-Salcedo, María, María Ángeles Martinez, Jose A. Moral-Munoz, Enrique Herrera-Viedma, and Manuel J. Cobo. 2018. Some bibliometric procedures for analyzing and evaluating research fields. *Applied Intelligence* 48: 1275–87. [CrossRef]
Hansen, Alvin. 1938. *Full Recovery or Stagnation?* New York: Norton.
Harrod, Roy Forbes. 1936. *The Trade Cycle: An Essay*. Oxford: Clarendon Press.
Harrod, Roy Forbes. 1939. An essay in dynamic theory. *Economic Journal* 49: 14–33. [CrossRef]
Herrmann, R. 1985. *Stability and Chaos in a Kaldor-Type Model, DP22*. Göttingen: Department of Economics, University of Gottingen.
Hicks, John Richard. 1950. *A Contribution to the Theory of the Trade Cycle*. Oxford: Oxford University Press.
Hieser, Ron. 1967. Linear Economics: The Multiplier-Accelerator Nexus. *Australian Economic Papers* 6: 208–22. [CrossRef]
Hommes, Cars H. 1995. A reconsideration of Hicks' non-linear trade cycle model. *Structural Change and Economic Dynamics* 6: 435–59. [CrossRef]
Kahn, Richard Ferdinand. 1931. The relation of home investment to unemployment. *Economic Journal* 41: 173–98. [CrossRef]
Kaldor, Nicholas. 1940. A Model of the Trade Cycle. *Economic Journal* 50: 78–92. [CrossRef]
Kalecki, Michał. 1935. A Macrodynamic Theory of the Business Cycle. *Econometrica* 3: 327–44. [CrossRef]
Kalecki, Michał. 1943. *Studies in Economic Dynamics*. London: Allen & Unwin.
Kalecki, Michał. 1954. *Theory of Economic Dynamics*. London: Allen & Unwin.
Keynes, John Maynard. 1936. *The General Theory of Employment, Interest and Money*. London: Macmillan.
Keynes, John Maynard, and Hubert Douglas Henderson. 1929. *Can Lloyd George Do It? An Examination of the Liberal Pledge*. London: The Nation and Athenaeum.
Lorenz, Hans-Walter. 1992. Multiple attractors. Complex Basin Boundaries, and Transient Motion in Deterministic Economic Systems. In *Dynamic Economic Models and Optimal Control*. Edited by G. Feichtinger. Amsterdam: North Holland Publishing, pp. 411–30.
Lorenz, Hans-Walter. 1993. *Nonlinear Dynamical Economics and Chaotic Motion*, 2nd ed. New York: Springer.
Marglin, Stephen A., and Peter Spiegler. 2013. Unpacking the Multiplier: Making Sense of Recent Assessments of Fiscal Stimulus Policy. *Social Research: An International Quarterly* 80: 819–54. [CrossRef]
Martínez, Ma Angeles, Manuel Jesús Cobo, Manuel Herrera, and Enrique Herrera-Viedma. 2015. Analyzing the scientific evolution of social work using science mapping. *Research on Social Work Practice* 5: 257–77. [CrossRef]
Matthews, Robert Charles Oliver. 1966. *The Trade Cycle*. Bristol: Nisbet.
Minsky, Hyman Philip. 1957. Monetary Systems and Accelerator Models. *The American Economic Review* 47: 860–83.
Mourao, Paulo, and Vítor Domingues Martinho. 2020. Forest entrepreneurship: A bibliometric analysis and a discussion about the co-authorship networks of an emerging scientific field. *Journal of Cleaner Production* 256: 120413. [CrossRef]
Nell, Edward, ed. 2005. *Transformational Growth and the Business Cycle*. London: Routledge.
Nelson, Richard R. 1961. A Note on Stability and the Behaviour Assumptions of Harrod-Type Models. *The Economic Journal* 71: 335–49. [CrossRef]
Phillips, Alban William Housego. 1957. Stabilisation policy and the time form of lagged responses. *Economic Journal* 67: 265–77. [CrossRef]
Puttaswamaiah, K., ed. 2019. *Paul Samuelson and the Foundations of Modern Economics*. London: Routledge.
Puu, T. 2004. *Relative Dynamics and the Hicks Trade Cycle Model*. CERUM Working Paper 74. Hong Kong: CERUM.
Puu, Tönu, and Iryna Sushko, eds. 2006. *Business Cycle Dynamics: Models and Tools*. Berlin: Springer.
Puu, Tönu, Laura Gardini, and Iryna Sushko. 2005. A Hicksian multiplier-accelerator model with floor determined by capital stock. *Journal of Economic Behavior and Organization* 56: 331–48. [CrossRef]
Ramey, Valerie A. 2011. Can Government Purchases Stimulate the Economy? *Journal of Economic Literature* 49: 673–85. [CrossRef]
Rau, Nicholas. 1974. *Trade Cycle: Theory and Evidence*. London: Macmillan.
Romer, Christina, and Jared Bernstein. 2009. The Job Impact of the American Recovery and Reinvestment Plan. Available online: https://www.economy.com/mark-zandi/documents/The_Job_Impact_of_the_American_Recovery_and_Reinvestment_Plan.pdf (accessed on 15 August 2022).
Romer, Christina D., and David H. Romer. 2010. *The Macroeconomic Effects of Tax Changes: Estimates based on a New Measure of Fiscal Shocks*. NBER Working Paper 13264. Cambridge: National Bureau of Economic Research, Inc.
Rose, H. 1959. The Possibility of Warranted Growth. *The Economic Journal* 69: 313–32. [CrossRef]
Samuelson, Paul. 1939a. Interactions between the multiplier analysis and the principles of acceleration. *Review of Economic Statistics* 21: 75–78. [CrossRef]
Samuelson, Paul. 1939b. A synthesis of the principle of acceleration and the multiplier. *Journal of Political Economy* 47: 786–97. [CrossRef]
Samuelson, Paul. 1959. Alvin Hansen and the Interactions between the Multiplier Analysis and the Principle of Acceleration. *Review of Economics and Statistics* 91: 183–84. [CrossRef]
Scopus. 2021. What Content Is Indexed in Scopus? Available online: https://service.elsevier.com/app/answers/detail/a_id/11274/supporthub/scopus/ (accessed on 15 August 2022).

Smets, Frank, and Rafael Wouters. 2007. Shocks and Frictions in U.S. Business Cycles: A Bayesian DSGE Approach. *American Economic Review* 97: 506–606. [CrossRef]

Sterman, John D. 1989. Deterministic chaos in an experimental economic system. *Journal of Economic Behavior and Organization* 12: 1–28. [CrossRef]

Sushko, Iryna, Laura Gardini, and Tönu Puu. 2004. Tongues of periodicity in a family of two-dimensional maps of real Mobius type. *Chaos, Solitons & Fractals* 21: 403–12.

Van Eck, Nees J., and Ludo Waltman. 2010. Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics* 84: 523–38. [CrossRef] [PubMed]

Westerhoff, Frank H. 2006. Samuelson's multiplier–accelerator model revisited. *Applied Economics Letters* 13: 89–92. [CrossRef]

Zeng, Jingjing, Jiansheng Qu, Hanqing Ma, and Xiaohua Gou. 2021. Characteristics and Trends of household carbon emissions research from 1993 to 2019: A bibliometric analysis and its implications. *Journal of Cleaner Production* 295: 126468. [CrossRef]