BEYOND *RANDOM CAUSES*: HARMONIC ANALYSIS OF BUSINESS CYCLES AT THE
MOSCOW CONJUNCTURE INSTITUTE

BY

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Abstract

*This article proposes a historical assessment of harmonic analysis of business cycles and its ability to both decompose and build cycles, as received at the Moscow Conuncture Institute. It traces how the Fourier transform arrived at the Institute, mediated by Henry L. Moore, in the works and actions of Albert Vainshtein, Nikolai Chetverikov, and Nikolai Kondratiev, ultimately leading to Eugen Slutsky's well-known 1927 article *The Summation of Random Causes as the Source of Cyclic Processes*. Although the evidence does not warrant the assumption that there was an orchestrated effort at the Institute to push forward a research agenda on harmonic analysis of business cycles, it certainly unfolded as more than the summation of random events and individual incursions. Moreover, the Institute as a whole could have produced much more on this matter if it had escaped Stalinist oppression for at least a few more years.*

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BEYOND *RANDOM CAUSES*: HARMONIC ANALYSIS OF BUSINESS CYCLES AT THE
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I. INTRODUCTION

Research on business cycles and waves has benefited from contributions of a relatively large number of well-known economists, including pioneers such as Clément Juglar, William Stanley Jevons, Joseph Kitchin, Henry L. Moore, Evgenii “Eugen” Evgenevich Slutsky, and Nikolai Dmitrievich Kondratiev. The ideas of the latter on this topic and his eponymous long waves have been the focus of thorough historiographical work (Barnett, 1998; Freeman and Louçã, 2001; Schumpeter, 1939).²

Kondratiev ([1922] 2004) looked for broad dynamic forces shaping capitalism and triggering long cycles. While some would acknowledge that long cycles do exist, others would think that conjunctural movements do not answer “the question of the cyclic nature of the

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² Kondratiev ([1922] 2004, pp. 23-24) mentions several other names who inspired his own work on cycles or waves: “[t]he works of Juglar, Tugan-Baranovsky, Spiethoff, Pohle, Eilenburg, Lescure, Aftalion, Bunyatan, Mitchell, and others, using empirical data, approached closely to the problem of economic cycles and elucidated much here.”

transition between those periods”; a third group would reject that such movements “are cyclic, viewing them as the result of random factors and movements in economic life” (Kondratiev, [1926] 1998, p. 27). Based on a broad and careful literature review, he described six different lines of research on business cycles: (i) identification of cyclical price movements without attempts to explain them; (ii) cycles as consequences of random causes, like wars, revolutions, or fluctuations in gold production; (iii) gold production, monetary circulation, and credit; (iv) socio-economic conditions of capital accumulation; (v) relationship between supply and demand; and (vi) relationship between supply and demand and the volume of gold production (Kondratiev, [1928] 1992, pp. 423-424). One important question, which at the time remained without an answer, would be how to combine different causes.

Kondratiev led the Moscow Conjuncture Institute (henceforth the “Institute”) between 1920 and 1929, when it was closed under the yoke of Stalin, but not before it entered into the history of econometrics (Morgan, 1990, pp. 64-68) and, more broadly, into the history of time series analysis (Klein, 1997, p. 246). The Institute was created by the Council of the Professors of the Timiryazev Agricultural Academy within the People’s Commissariat for Agriculture (*Narkomzem*) aiming mainly at the statistical assessment of the state of the Soviet and world economies, receiving, verifying, and analyzing data from various organizations and publications (Kondratiev, 1925). After its transfer to the People’s Commissariat for Finance (*Narkomfin*) in 1923, it grew to be the largest institution in the country for the study of economic conjuncture (Komlev, 1991).

Kondratiev ([1926] 1998, pp. 29-30; [1926] 1935, p. 115) explains he “arrived at the hypothesis concerning the existence of long waves in the years 1919-1921.” His results were published in 1922 in book form (“The World Economy and its Conjunctures During and after the War”), although the research project itself had already existed while he worked at a division of

the Timiryazev Agricultural Academy.³ Upon its creation, the Institute was a small institution with “only five persons being engaged, three of whom were computers [i.e., those in charge of calculations]” (Kondratiev, 1925, p. 320). In 1922, “[t]he Treasury Department offered to the Institute the possibility of enlarging to a considerable extent its scientific researches, in exchange for which the Institute was called upon to supply the Treasury Department with reliable data on economic conditions. The number of collaborators of the Institute increased to forty persons” (p. 322). In 1928, it had “54 permanent and 14 temporary members, including 23 leading economists and statisticians, many of whom [were] professors” (Kondratiev [1928] 1998, p. 272). Kondratiev’s investigations on long waves benefited from the growth of the Institute and its focus on “the study of world economic fluctuations” and “scientific research and methods” (Kondratiev, [1928] 1998, p. 278), not to mention his expanding network of collaboration and support.⁴

In the end of 1925, Kondratiev invited Slutsky to work at the Institute. He officially joined in January 1926 (Barnett, 2011, pp. 81-82). In 1927, Slutsky would publish his groundbreaking

³ Kondratiev ([1922] 2004, p. 22) refers to his research on long waves as originally “part of research into variations of Russian and foreign markets conducted by the Conjuncture Institute at the Petrovsky [later Timiryazev] Agricultural Academy.”

⁴ Such a growing network can be observed in the evolution of Kondratiev’s publications.

Whereas he seems to have himself organized the empirical and statistical data in his 1922 book, in 1926 he had the support of O. E. Priyakhina and N. S. Chetverikov (Kondratiev, [1926] 1998, p. 30; [1926] 2014, p. 28); in 1928, Kondratiev also acknowledges the statistical assistance provided by his fellow researchers at the Institute, including Ya. P. Guertchouk, M. V. Ignatiev, A. L. Vainshtein, E. E. Slutsky, V. E. Sprink, T. I. Rainov and others (Kondratiev, [1928] 1992, p. 377).

article on random causes of cyclical patterns (Slutsky, 1927). His innovative approach to the random causes of cycle composition made use of the so-called harmonic analysis, which is based on the Fourier transform – a powerful mathematical tool to understand wave-like natural phenomena developed roughly one century earlier by the acclaimed mathematician and physicist Jean-Baptiste Fourier (1822).

There are two sides to the application of harmonic analysis to business cycles, namely wave composition and decomposition, which were to some extent jointly addressed at the Institute (Kondratiev, 1925; [1927] 1998; Barnett, 1998, pp. 8-13). Klein (1997, p. 16) alludes to the combination of Kondratiev's focus on decomposition of time series and Slutsky's pioneering work on the sources and composition of business cycles (see also Barnett, 2006; 2011; Kliukin, 2011). They were both aware of and interested in the works of Columbia University's professor Henry Moore and his "use of Fourier's theorem" (Moore, 1914, pp. 6-13). Other senior researchers of the Institute, such as Albert Lvovich Vainshtein (who prepared at least two detailed reviews of Moore's works) and Nikolai Sergeevich Chetverikov (the director of a formal project entitled *On the Application of Harmonic Analysis to Conjunctural Cycles*), also contributed to imprint a very comprehensive and promising interpretation of business cycles at the Institute, characterized by this integrated approach to cycle (de)composition and warranting a thorough historical account of how it unfolded.

As a first and broad attempt to situate the use of harmonic analysis in business cycle research centered on the Institute, Figure 1 presents a citation-based genealogy from Fourier to its members (Vainshtein, Kondratiev, Slutsky), including intermediaries (Arthur Schuster, Jevons, Moore, Wesley Mitchell) and succeeding contributors (Simon Kuznets, Ragnar Frisch, Joseph

Schumpeter).⁵ As it will become clear in the following sections, the Institute acted as a mainstay in these developments.

Figure 1 A citation-based tentative genealogy of the links between Fourier and the Moscow Conjuncture Institute, including intermediaries and succeeding contributors. Source: Authors

⁵ Important works on this subject such as Schumpeter (1939) and Mitchell (1927) would become more central in other contexts. Here, as the analysis is centered on the Institute, they appear in a supporting role.

While more general accounts on the application of harmonic analysis to business cycles at the Institute and elsewhere exist, as well as of the roles played by Kondratiev and Slutsky (e.g., Klein, 1997; Morgan, 1990; Schumpeter, 1939), the details of how Fourier's breakthrough appeared at that juncture remain unclear. Which members of the Institute or Western scholars contributed to this development? What was the Institute's role in the dissemination of harmonic analysis as a tool in business cycle research? Was there an orchestrated effort to deepen the understanding of business cycles by means of this tool, or did it mostly amount to individual interests and achievements? To answer these questions, this article proposes a historical assessment of harmonic analysis of business cycles according to its reception at the Institute.

The next section presents Fourier's main idea leading to harmonic analysis and its two-sided character in the investigation on cycles and waves, as well as Moore as a pioneer in the use of harmonic analysis in economics, whose work contributed to the dissemination of this tool among the researchers of the Institute. The following section assesses the role of Vainshtein in this same context. Section IV focuses on the figures of Slutsky and Kondratiev during the final years of the Institute, contrasting their stance toward harmonic analysis and establishing what could be referred to as a missed opportunity for further joint research work. Finally, Section V sheds light on Slutsky's legacy as the epitome of the importance of the Institute as a center for the dissemination of the application of harmonic analysis in economic conjuncture studies. Section VI brings concluding remarks.

II. THE FOURIER TRANSFORM AND MOORE'S PIONEERING WORKS ON CYCLES

In 1807, Fourier (1822) not only conceived a differential equation describing heat transfer phenomena, but also developed a non-trivial technique to solve it (Narasimhan, 1999). His achievement amounted to the most significant theoretical advancement on the issue of heat

transfer since Isaac Newton proposed the law of cooling, which states that the rate of heat transfer is proportional to the temperature difference between two bodies (Bergles, 1988). Fourier's partial differential equation mathematically describes the rate at which temperature is changing at any location in the interior of a solid body as a function of time. The equation mixes time and space, having a tough solution, which becomes straightforward if Fourier's technique is used, writing a generic function $f(t)$ as a sum of oscillatory functions (sines and cosines), known as the Fourier transform.⁶

Mathematically speaking, this transformation multiplies the original curve by the exponential function of an imaginary number, i.e., $e^{-i\omega t}$ (ω is the angular frequency), and integrates it over its domain. Thus, decomposing a function $F(t)$ into the different waves which constitute it is equal to calculating

$$F(\omega) = \int_{-\infty}^{\infty} F(t)e^{-i\omega t} dt$$

Using this technique, it is possible to decompose an arbitrary initial temperature distribution inside a solid body into each of its constituent frequencies and, in turn, to solve the heat transfer equation to each one of them, before finally adding up the temporal and spatial solutions from each frequency in order to get the general solution.

In an analogous manner, the Fourier transform can also be used to build an arbitrary function from periodic waves by means of the inverse transform. Due to the properties of the exponential of an imaginary number, the inverse Fourier transform is obtained by a simple sign change of the exponent in the previous equation:

⁶ For a detailed mathematical exposition of the Fourier transform, see Hamilton (1994, pp. 152-179) on “spectral analysis” and Bloomfield (2000) on “Fourier analysis of time series.”

$$F(t) = \int_{-\infty}^{\infty} F(\omega) e^{i\omega t} d\omega$$

As the exponential of an imaginary number can also be written as $e^{i\omega t} = \sin \omega t + i \cos \omega t$, the exponential term represents an oscillatory wave. Hence, in the inverse Fourier transform, we basically multiply an oscillatory wave (the exponential term) by its weight in the original function $F(\omega)$, and then add up all the waves with different frequencies (the integration over $d\omega$). Therefore, once the weight and the frequency of each wave are known, it is possible to build the original function by multiplying the weight along different wave frequencies and adding up all these frequencies.

Once developed, the Fourier transform would spread through different branches of science and engineering, with countless applications (Narasimhan, 1999, pp. 122-135). It has gradually entered into business cycle analysis in the late 19th century, when the influence of meteorological phenomena over agricultural output and economic crises became a key research question (e.g., Jevons, 1878; 1884; Schuster, 1872; 1898).

Klein (1997, pp. 250-251) mentions Moore as the first economist to deal with the Fourier transform in an explicit and well-developed way.⁷ His 1914 book brings a complete section on “The Use of Fourier’s Theorem” (pp. 6-13); in a second book, Moore (1923, pp. 42-46) includes a topic on “data and method” which again uses Fourier. As Figure 1 shows, Moore’s use of the Fourier transform was influenced by Schuster (1898), especially in relation to his application of

⁷ Bachelier (1900) is mentioned by Narasimhan (1999, p. 133) as a first use of Fourier in economics, namely for an investigation on stock prices. This reference would lead to a separate branch in our genealogy shown in Figure 1, as Mandelbrot (1963, 1987) mentions Bachelier and links Fourier to a modern conception of complexity.

periodograms, which Moore would transpose into economic analysis.⁸ His pioneering role in the utilization of harmonic analysis in economics is well known in the history of economics and econometrics (Le Gall, 1999; Morgan, 1990; Schumpeter, 1939; Turner and Wood, 2020).

Moore's use of periodograms was instrumental for his analysis of the causal connections between an eight-year economic cycle and meteorological patterns. Moore (1923, p. 102) attributes his eight-year cycles to "the planet Venus in its eight-year periodic motion with respect to the Earth and the Sun." Despite the shortcomings of Moore's theory and the scorn from the majority of the academic community toward such "harvest theories" of economic cycles, there has more recently been a sort of "rehabilitation movement" to ascertain Moore's true legacy to economics (Le Gall, 1999), such as the acknowledgement of this role "in econometric business cycle research" (Morgan, 1990, p. 33); his "alternative program of mathematical economics, rival to neoclassicism" (Mirowski, 1990, pp. 598-599); and the assertion that he would be "considered by many to be the 'father of econometrics'" (Klein, 1997; p. 249). We would add one more argument in favor of Moore's rehabilitation, namely the fact that he served as an important reference to senior researchers of Kondratiev's Institute (Kondratiev, 1928, p. 424; Slutsky, 1927, p. 106; Vainshtein, 1925; [1926] 2010, *passim*) (see Figure 1), presenting the Fourier transform as an adequate tool to investigate business cycles.

⁸ Periodograms organize data being processed in a Fourier transform and provide a graphic presentation. They identify the existing cycles and show the duration of its constituent periods, thus facilitating the use of harmonic analysis to investigate periodicities. To Schumpeter (1939, fn. 2, pp. 165-166), periodograms were by then "gaining ground in economics", citing not only Moore but also Beveridge (1921; 1922), Crum (1923), and Wilson (1934) as pioneers in the application of periodograms to economic activity.

Notwithstanding the relevance of Moore's legacy, the problems and limitations of his approach can also help to understand the role of the Fourier transform in business cycle research. To Klein (1997, p. 118), Moore (along with Jevons and other advocates of the "harvest theories") was targeted for his "inclusion of meteorological phenomena as exogenous variables in economic functions."⁹ Klein adds that Moore's position was "based on the assumption that the variables under investigation were functions of time" and, therefore, "he was unable to contemplate a more organic, self-determining notion of dynamics (...) based (...) on a functional relationship with previous states of a process" (p. 257). To Le Gall (1999, p. 739), Moore's use of the Fourier transform displayed a "determinist framework (...) illustrated by his endless investigations of an eight-year cycle" and by an "exact periodicity of cycles." Analogously, Turner and Wood (2020) state that "Moore appears to be concerned with periods defined in integer numbers of years, rather than cycles defined in terms of particular frequencies."

As affirmed by Le Gall (1999) and Turner and Wood (2020), it seems Moore was fixated on the eight-year cycle, what might have prevented a wider investigation on other uses of the Fourier transform, such as the superposition of cycles. Moore's approach to cycle decomposition was constrained by a framework of strict and single periodic cycles, which is blatantly an influence of Schuster's works. This blind spot toward a more comprehensive use of the Fourier transform often meant a disregard for waves with different periodicities (and the implications in terms of superposition). An example would be his focus on eight-year cycles taken from "Sauerbeck's index numbers of general wholesale prices," although the obtained periodogram

⁹ Klein (1997, p. 118) warns that the "last laugh could be on these 'modern' critics," as meteorological variables become relevant if treated as endogenous, as the "climate is now influenced by economic development as well as vice versa."

showed twenty-four different periods (Moore, 1923, p. 66). Vainshtein (1925), to whom there was no reason why the eight-year cycle should be predominant, would fiercely criticize Moore's conclusions.

III. VAINSHTEIN ON MOORE: THE FOURIER TRANSFORM ARRIVES AT THE INSTITUTE

Vainshtein was a physicist and mathematician interested mainly in statistical economics, a subject in which he would be trained at the Moscow Commercial Institute, later renamed as Plekhanov Institute. He worked on a variety of issues, such as agricultural economics, systems of national accounts, linear programming, history of economic thought, and translations of academic works. He became well known for his contributions on national income and wealth (Vainshtein, 1969), although his legacy as an economist of the 1920s working for the development of the new socialist economy has not gone unnoticed (Campbell, 2012).

Vainshtein served as a senior consultant at the Institute, alongside Slutsky and Nikolay Nikolaevich Shaposhnikov, a figure better known for his role in the Russian synthesis between classical political economy and marginalism (Allisson, 2015). Vainshtein had previously worked at the Office for Agricultural Economics of *Narkomzem* and was associated with the Timiryazev Agricultural Academy, what might have been a steppingstone leading to Kondratiev's invitation to work at the Institute. Vainshtein remained there between 1923 and 1928, being "strongly involved in all the work of the Conjuncture Institute" (Campbell, 2012, p. 425), for which he would suffer long jail and exile sentences after it became a target of Stalinist repression.

Overshadowed by his prolific scientific production, Vainshtein's reviews of Moore's work are usually not mentioned amongst his main contributions. However, they sparked an interest in harmonic analysis within the ranks of the Institute, which is attested by its inclusion in formal

research projects on economic cycles led by Slutsky and others.¹⁰ The first of them was *Novaia Teoriia Ekonomicheskikh Tsiklov* (“New Theory on Economic Cycles”), an article published in the first issue of *Voprosy Koniunktury* (“Questions of Conjuncture”), an irregular series of the Institute dedicated to methodological and theoretical expositions (Vainshtein, 1925).¹¹ In the following year, Vainshtein would publish an extended appraisal of Moore’s work in a collection organized by the Research Institute for Agricultural Economics of the Timiryazev Agricultural Academy (Vainshtein, [1926] 2010).

Firstly, Vainshtein presents Moore’s main proposition of eight-year cycles in rainfall fluctuations and their strong relationship with fluctuations in harvest yields, as well as raw material cycles for the same period, which would constitute key economic cycles caused by non-economic factors and, hence, intensely affect general price cycles:

¹⁰ Another potential source on the Fourier transform for the researchers of the Institute was Swedish professor Axel F. Enström. In his review of Moore’s books, Vainstein (1925, p. 10) mentions how, in 1924, Enström “poses the same 8-year cycle problem in a methodologically interesting manner.” Boianovsky and Trautwein (2007, pp. 488-489) describe how Enström influenced Johan Åkerman’s views on harmonic analysis in the 1910s. According to the authors, Enström’s 1913 and 1914 contributions put him on an equal footing with Moore as pioneers in the application of harmonic analysis to economic time series.

¹¹ The other publication of the Institute was *Ekonomicheskii Biulleten Koniunkturnogo Instituta* (“Economic Bulletin of the Conjuncture Institute”), focused on the production of economic data and indicators in addition to the publication of selected original research articles.

Hence, we get the following coherent reasoning by Prof. Moore: cyclic and strictly periodic fluctuations of meteorological factors cause fluctuations primarily in the production of goods, depending on climatic and environmental conditions, and in general cause similar fluctuations in the production of raw materials going into industrial processing. These are the main (*generating*) economic cycles. Fluctuations in the production of raw materials are correspondingly reflected in the prices of these goods, transmitted according to the law of production costs, and also in the prices of final products. Cyclical price fluctuations are, therefore, already derived from the main economic cycles; they are strictly periodic and can be explained by a single cause (Vainshtein, 1925, pp. 165-166, translated by the authors).

Vainshtein then makes a thorough exposition of how empirical series can have their cyclicity investigated by means of what he calls the “Fourier method”, according to which “any periodic motion, however complex it may be, can be decomposed into a series of simple harmonic oscillations” (p. 167). Moreover, Schuster’s periodogram is presented as a criterion to probabilistically distinguish between “true” and “random” cycles.

Moore’s search for mathematically strict periodicities (as opposed to Jevons’s average values derived from different periods) is systematically questioned by Vainshtein. Although one cannot deny its possibility, he highlights the lack of evidence from different perspectives, such as the shortcomings in the empirical data provided by Moore, especially in the face of diverging results obtained in other studies, and the legitimacy of statistical conclusions based on the use of periodograms (e.g., the inobservance of other likely periods or Moore’s controversial removal of the secular trend prior to the application of the harmonic analysis). Similar criticism is given for Moore’s results on raw material production and price cycles.

Furthermore, Vainshtein dismisses Moore's hypothesis for the cause of the eight-year cycles, for whom periodic changes in the position of Venus in relation to Earth and the Sun – either due to its influence on solar radiation on its way to Earth or to its direct effect as a source of magnetic fields – would account for changes in meteorological and, consequently, economic conditions. There would be no available knowledge in theoretical physics to support such claims. In addition, while the period of Venus's movement is strictly eight years long, those of rainfall and crop yields are only approximate figures. Vainshtein also weighs that, even if we accept such a strict relationship, there are non-meteorological phenomena which influence the cyclical fluctuations of agricultural productivity: improvements in land cultivation, soil conditions, crop composition, etc. Moore's method would be of little help in the consideration of these elements.

Overall, Vainshtein acknowledges Moore's arguments in favor of the relationship between rainfall, harvest yields, and prices of agricultural products, although he remains skeptical on Moore's elucidation of the mechanism through which raw materials cycles influence prices and the production of final goods. His main reproach to Moore's works relates to the "absence of an economic explanation for the mechanism of influence in the interconnections he establishes, an explanation which could not be given using his research method" (1925, p. 179). The formal statistical analysis, to Vainshtein, must be aided by an economic appraisal of the issue, requiring a detailed analysis of the dynamics of the development of an economy. As an attempt to find the root cause of economic phenomena, Moore's approach is unsuccessful. However, his theory is deemed as "elegant in form, lean in content, and rich in statistical material" (p. 179). With these statements, Vainshtein recognizes the merits of harmonic analysis for the study of economic cycles, despite the overstretched, naïve, and sometimes illogical inferences Moore seems to make based on his own results. While Vainshtein seems to understand the potential and limitations of the "Fourier method" in terms of explanatory power, Moore's ill-conceived use of harmonic

analysis in order to develop theories such as those correlating planetary movements and economic cycles is easy prey for his sharp mathematical understanding of the method.

In his second and expanded review of Moore's books, Vainshtein ([1926] 2010, p. 265, translated by the authors) warns about an intrinsic limitation of the harmonic analysis:

But there is a very significant consideration of a mathematical nature which forces the economist to be very careful when using the method of harmonic analysis to study economic phenomena. (...) [T]he values of the components of a static series are *completely independent* from each other. In reality, the complete independence of individual members of the series from each other rarely takes place. One of the founders of this method, Prof. Schuster, on whose work Moore has relied, in his first article on harmonic analysis indicates that, even in the case of meteorological data, we are not dealing with independent values.

Economic phenomena (e.g., prices and production output) would entail even stronger "inertial" regularities over time. This observance implies that the elements of the Fourier series do not present the same probabilities, and the likely effect is usually a decrease in the amplitude of shorter periods. Unlike Beveridge and G. Udny Yule, Moore would have completely ignored how this condition affected his results.

Vainshtein's approach to harmonic analysis raises some questions in the context of the Institute. Why was he interested in this subject matter? In intellectual terms, it could be seen as a continuation of his earlier works on agricultural prices. Alternatively, the originality and peculiarity of harmonic analysis within economic science, as well as the then international outlook of the Institute, might point to Kondratiev and other senior colleagues as active

supporters of this initiative.¹² According to the latter, the Institute provided a fruitful atmosphere for the exchange of ideas: “the Institute carries on another kind of research work requiring a greater period of time. These are the researches of individual members, although the results and the conclusions are also discussed collectively” (Kondratiev, 1925, p. 323). To Barnett (1998, p. 11), “Kondratiev worked very closely with his consultants on specific issues.” In addition, Kondratiev, who had first conceived his long wave hypothesis a few years earlier (Kondratiev, [1926] 1935), and Vainshtein, the second-in-command at the Institute¹³, shared the view in which an economic explanation for the mechanisms of influence in the generation of cycles was absolutely necessary. Vainshtein ([1926] 2010, p. 279) also posed this question for the purpose of forecasting:

we must point out that, even if one assumes that one of the components of the general dynamic process is the true harmonic oscillation of certain elements or the influence of cosmic factors, this is far from enough for forecasting purposes. The perturbing forces in economic and social events are so significant that any attempt to make an economic forecast based on only periodicity or due to cosmic factors is doomed to failure in advance.

¹² The international outlook of the Institute resembled that of Kondratiev himself, who sought to establish an exchange with leading research centers in different countries. An example of such interactions is Kondratiev’s visit to the newly founded National Bureau of Economic Research in the end of 1924. On the other hand, in the following year Vainshtein would, for unknown reasons, not be given permission to go on a similar business trip to Germany, France, and Italy (Barnett, 1998, p. 95).

¹³ According to Barnett (1998, p.214, fn.35), “Vainshtein occupied a position above the other two consultants, as he earned an extra 75 rubles per month in the form of a bonus.”

To obtain a true picture of the world around us for the near future, it is necessary to combine various types and methods of forecasting, using, along with the formal mathematical and statistical method, an economic analysis of causal relationships and dependencies.

Another question relates to Vainshtein's influence over Slutsky's well-known 1927 article. Despite the different approaches which would be adopted, on the one hand, by Vainshtein and Kondratiev, and, on the other hand, by Slutsky, the fact that the application of harmonic analysis to business cycles was a given at the Institute might have caught the latter's attention upon his arrival in 1926. Barnett (2005, p. 112) asserts that the development of Slutsky's 1927 paper was actually "conditioned by his move from Kiev to Nikolai Kondratiev's Conuncture Institute." However, Barnett (2006, p.425) also deems that "Vainshtein's attitude [toward Moore's works] suggested he might have been similarly critical of Slutsky's effort." In contrast, we believe that, based on a careful assessment of Vainshtein's reviews of Moore's works, he might have been less disapproving of Slutsky's article than suspected. His criticism focused on particular aspects of Moore's analysis, which cannot be imputed to Slutsky. Overall, Vainshtein had a positive stance toward harmonic analysis and his works reveal some level of engagement in the institutional environment leading to Slutsky's 1927 article, not least because a detailed appraisal of harmonic analysis applied to business cycles could thitherto be found in none of the other published documents of the Institute.

IV. SLUTSKY, KONDRATIEV, AND THE END OF THE INSTITUTE

Slutsky arrived at the Institute after 13 years working at the Kiev Institute of Commerce. By that time, he was already reluctant to engage in economic research, although his intellectual

interest in such issues would never completely disappear.¹⁴ In his autobiography, Slutsky affirms that the new planned socialist economy of the Soviet Union offered problems for which he would neither care nor be equipped to tackle (Sheynin et al., 2010). In this sense, it seems strange that he would choose (not without some hesitation) to relocate to the Institute, even though he rightly believed that his mathematical and statistical skills would be deservedly acknowledged in his new position. In a letter to Ladislaus Bortkiewicz dated May 16th, 1926, he explained that his move to Moscow had been due to problems with the Ukrainian language (a compulsory decree came into effect stating that the Ukrainian language was to be used in all lectures held at academic institutions of that Republic, and Slutsky was not a fluent speaker) (Sheynin et al., 2010, letter n. 7). Other reasons for Slutsky's move to the Institute, according to Kliukin (2011), would have been its computational capacity and the autonomy enjoyed by researchers, in addition to the presence of Chetverikov, Slutsky's close friend and follower of Alexander Alexandrovich Chuprov (a leading figure of the so-called Saint Petersburg Statistical School).¹⁵ Thus, the

¹⁴ Slutsky's efforts to add new materials for the 1937 translation of his 1927 article is an example of his lasting academic interest in economics (Barnett, 2011, p. 89).

¹⁵ Chuprov's Saint Petersburg Statistical School (other distinguished members were Chetverikov and Oskar Anderson) stressed the role of statistics in social phenomena and its potential to establish and explain facts, being an "idiographic" science (as opposed to a "nomothetic" view of statistics as an axiomatic, mathematical science based on probability theory). Both Kondratiev and Slutsky have been influenced by Chuprov, whose methodological stance contrasts with the deductivist approach to the theory of economic cycles of Mikhail Tugan-Baranovsky, who could never merge the economist-theoretician and the statistician-empiricist (Kliukin, 2011, pp. 116-

Institute would rather be a solution at the personal level than an opportunity to make the transition toward non-economic applications of mathematics and statistics. Yet, while his first three articles as a member of the Institute (all published in 1927) deal with economic subjects, his subsequent contributions, a total of eight pieces dated from 1927 to 1930, focus on pure mathematics and statistics.¹⁶

Furthermore, as shown above, Slutsky was far from being the only economist at the Institute who was familiar with harmonic analysis and its use in the study of business cycles. According to Chetverikov ([1959] 2010, p. 254), “soon upon his arrival there, he was attracted by some scientific investigations (the study of cycles in the economy of capitalist countries). (...) E.E. [Slutsky] became an active participant of this research, and, as usual, surrendered himself to it with all his passion.” A letter to his wife written in March 1926 reads as follows:

I am head over heels in the new work, am carried away by it. I am almost definitively sure about being lucky to arrive at a rather considerable finding, to discover the secret of how are wavy oscillations originating by a source that, as it seems, had not been until now even suspected. Waves, known in physics, are engendered by forces of elasticity and rotary movements, but this does not yet explain those wavy movements that are observed in social phenomena. I obtained waves by issuing from random oscillations independent one from

118, translated by the authors). Klein (1997) also acknowledges the influence of Chuprov over Slutsky and Kondratiev.

¹⁶ The complete list of Slutsky’s articles while serving as a consultant at the MCI can be found in Barnett (2011, p. 82).

another and having no periodicities when combining them in some definite way (Slutsky *apud* Chetverikov, [1959] 2010, p. 255, italics in the original).

Hence, Barnett (2006, p. 425) correctly raised the possibility that “Slutsky had first realized that such statistical techniques might have been relevant to economic matters through exposure to such discussion in the Conjecture Institute” (e.g., Kondratiev’s long waves, Timofei Ivanovich Rainov’s association between economic cycles and scientific breakthroughs, Vainshtein’s review of Moore’s books, Chetverikov’s connection between prices and harvests etc.). Conversely, Slutsky’s background and brilliancy would stand out at the Institute. His 1927 article draws from a wide variety of sources, which go way beyond the usual references in Soviet economics (e.g., Tugan-Baranovsky). To an extent, “the impetus for the new approach of the 1927 article had originated from Slutsky himself” (Barnett, 2006, p. 417) and his ideas on random processes had already been formed back in Kiev (Kliukin, 2011).¹⁷ In any case, it remained little known until its English translation and publication in *Econometrica* in 1937. A few years later, it would already be deemed as a “classical contribution” (Allen, 1950).

Slutsky’s 1927 article successfully applies harmonic analysis to support his claim on the random causes of cyclical patterns. He showed that an oscillatory series resembling actual business cycles could be generated from a random series by taking a moving sum or difference, regardless of the presence of weights or repetition in the process. Thus, instead of only looking for ways to decompose such cycles, Slutsky sets forth the possibility to build similar cycles using random series, and by doing so he brings into economics this other side of Fourier’s contribution (the inverse transform for the purposes of wave composition). Unlike Moore, he avoided

¹⁷ The use of harmonic analysis is also present in Slutsky (1929; 1934).

focusing on determined single-period cycles, describing cyclical processes rather as phenomena in which “on the waves of one order there appear superimposed waves of another order” (p. 116).

The implications of Slutsky’s results are at least two-fold: on the one hand, actual business cycles might be explained as “statistical artefacts” and, hence, can do without explanations in terms of economic mechanisms (the “spurious” or “statistical” interpretation); on the other hand, the inability to distinguish between randomly generated cycles and those with underlying periodic causes, given the fact that both might exist as manifestations of economic life, needs to be taken into account when studying cyclical economic phenomena (the “real” or genuine” interpretation) (Barnett, 2006, pp. 412-413).¹⁸ Slutsky summarizes his 1927 article as follows:

The summation of random causes generates a cyclical series which tends to imitate for a number of cycles a harmonic series of a relatively small number of sine curves. After a more or less considerable number of periods every regime becomes disarranged, the transition to another regime occurring sometimes rather gradually, sometimes more or less abruptly, around certain critical points ([1927], 1937, p. 123, italics in the original).

Although Slutsky acknowledges Schuster’s periodograms as a means to discover hidden periodicities, he deems that the lack of independence between the components of empirical series

¹⁸ If one could gather data for a sufficient amount of time, then, according to Slutsky, it would be possible to distinguish between randomly generated cycles and those with periodic causes, as the former go through “regime changes” – structural breaks leading to new regularities with different parameters – while that was not the case for the latter. However, Slutsky does not say how long must the series be for that to be the case.

(as noted by Vainshtein in his review of Moore's book) renders the use of Schuster's method unreliable, as "casual" waves could be interpreted as bearing strict regularity (also given the fact that empirical series are not long enough to provide proof of such strict regularities).¹⁹ From these premises, Slutsky – inspired by Yule (1926) in relation to what would be dubbed as the Slutsky-Yule effect – formulates the question: "is it possible that a definite structure of a connection between random fluctuations could form them into a system of more or less regular waves?" (Slutsky, [1927] 1937, p. 106). Instead of searching for the source of regularity in "the superposition of regular waves complicated only by purely random components" (p. 107), why not seek an explanation in random causes? This would have been the main course of action in promising fields within physics and biology, in which order (regularity) arises from chance or randomness precisely due to its arbitrary nature.

After 1927, Slutsky would not carry on with economic applications of his sophisticated analytical toolkit, preferring to work on mathematical and statistical theory or its implications to the natural sciences. Neither would his colleagues take up the challenge. It seems the technical staff of the Institute was becoming increasingly aware of the dangers of being associated either with economic issues of political relevance or, more precisely, with the figure of Kondratiev. According to Barnett (1995, p. 417), "members of the Conjecture Institute must have realised that their personal positions within the Soviet economic bureaucracy were inextricably connected to the fate of the actual markets which they studied and analysed in such an enthusiastic and original manner." That was certainly so for Slutsky, according to his letters to his wife discussing the personal risks associated with his work (Chetverikov, [1959] 2010).

¹⁹ On a footnote, Slutsky mentions how further developments in Schuster's method can overcome this difficulty.

Another reason for the interruption of this line of research at the Institute could be the overly advanced mathematical content of Slutsky's work. Barnett (2011, pp. 91-92) raises the question whether most of its researchers would possess the necessary mathematical skills to contribute to Slutsky's study on random causes of periodic waves. After all, Slutsky was not a clear political target; in fact, he was not arrested after the end of the Institute, to the contrary of other highly ranked scholars. Whatever the case, a look into Kondratiev's writings in the context of his role as head of the Institute is quite insightful regarding the level of interest in harmonic analysis of business cycles among its members.

Kondratiev (1989, pp. 416-450) wrote a report about the activities of the Institute ("Report on Works of the Conjunction Institute in 1926-1927 and Prospects for 1927-1928"), including a topic on "Work on the Methodology of the Study of Conjunction Conditions and Dynamics" (p. 430). Kondratiev explained that "[w]ork of this kind was carried out partly in connection with the formulation of problems on the study of patterns in the development of conjunction conditions and dynamics, partly in connection with the development of issues related to the analysis of the current conjunction."²⁰ He mentions the leaders of the group working on these issues:

²⁰ The first topic on this subject – "Work on the methodology of the study of conjunction conditions and dynamics" – referred to "research on levelling techniques to find out the main trends within their dynamics. It includes work on the application of the least squares method and the method of mechanical levelling. They have been ongoing for several years under the leadership of N.S. Chetverikov" (Kondratiev, 1989, p. 430). Kondratiev also mentions Chetverikov's assistance after explaining the need to use "more complex tools to process statistical series" (Kondratiev, [1926] 1998, p. 29). These comments show how Chetverikov's

“[W]orks on techniques for studying cyclic waves: in this area, the mathematical part of Slutsky’s study “Summation of random causes as the source of cyclic processes” (printed in *Voprosy Koniunktury*, v. 3) has started the work on the economic application of the methods he found for explaining cyclic waves. This also includes the study of the question “On the application of harmonic analysis to conjunctural cycles” – a work coming under the direction of N.S. Chetverikov and E.E. Slutsky (p. 430).

At this stage, the “Fourier method” discussed and applied at the Institute seems to have fulfilled two different but related roles. Firstly, following Moore’s use of periodograms, harmonic analysis led to the development of tools for investigating the duration and amplitude of existing cycles. Secondly, with Slutsky (1927), harmonic analysis would be a tool for theoretically building a cycle. Taken as a group, the members of the Institute pioneered this two-sided use of Fourier’s elaboration on cycles. This is additional evidence that harmonic analysis had found there a friendly host environment, and that a very fruitful interaction between those two uses might have been in motion at that specific time and place.

However, at that junction, Kondratiev did not believe in the role of random processes and their ability to build cycles. In his 1926 report, he reaffirmed the purpose of decomposition methods as making “the existence of large cycles more visual and accurate,” and deemed randomness as a burden to be minimized by the accuracy of the method, as in any other scientific endeavor. Kondratiev (1989, p. 320) repeatedly states that “the applied method can, given a

work, as described in Kondratiev’s report (1989, p. 430), was integrated with investigations on long waves.

determined research problem, destroy cycles, and not create them” and that “it is clear that large cycles are not created by the method, but, on the contrary, the method is applied due to the presence of large cycles in empirical curves.” Therefore, Kliukin (2011) points to a certain methodological opposition between Slutsky and Chetverikov (who was the head of the methodological section of the Institute), on the one side, and Kondratiev, on the other, not only with respect to such diverging views on large cycles, but also as a result of Kondratiev’s focus on the construction of index numbers, in detriment of other research lines, as the main contribution of the Institute to the stabilization and development of the Soviet economy.²¹

Kliukin (2011) also detects what could be retrospectively seen as a missed opportunity: on June 11th, 1926, Slutsky showed to Kondratiev some of his results leading to the 1927 paper, having later written that “Kondratiev is very pleased and will not rush me to finish” (p. 120). Apparently, these results were of empirical nature and still lacked the innovative mathematical foundation, which Slutsky would only develop a few days later, between June 16th and 22nd. Thus, Kondratiev might have interpreted the cyclical processes obtained by Slutsky as a corroboration of his own theory on large cycles, failing at that moment to realize the theoretical significance of Slutsky’s work. A few years later, as a prisoner in Suzdal, Kondratiev would acknowledge the far-reaching meaning of Slutsky’s breakthrough. Between 1932 and 1933, he would request

²¹ Kliukin (2011) (to whom the intellectual comparison between Slutsky and Kondratiev has not been fully explored in Western scholarship) divides the level of correlation between Slutsky’s and Kondratiev’s ideas into three different phases: before Slutsky’s move to the Institute, with Chuprov’s methodological approach to statistics as a common element; their time together at the Institute, with some ambiguity and little overlap; and in the 1930s, when Kondratiev finally realized the actual implications of Slutsky’s work on random processes.

innumerable copies of Slutsky's papers, especially those related to the law of large numbers and the gradual development of his concept of random processes leading to the constitution of order (e.g., Kondratiev, [1930-1932] 1998). Unfortunately, his first reaction, back in 1927, to Slutsky's final draft is unknown, which is probably due to the dramatic change, from the second half of 1927 onwards, in the hitherto relatively peaceful political atmosphere within the Institute.²²

As freedom of thought quickly vanished in Stalin's Soviet Union, especially in fields and subjects associated with public policy, the Institute became one of the first victims of the new administrative command system. Kondratiev's defense of pro-market industrialization, his disagreements with Gosplan officials and their views on economic development, and his involvement in agrarian issues – based on which he was accused of being one of the leaders of the “Working Peasants Party” – would cost him dearly. Since July 1927, his signature would disappear from official documents of the Institute to higher authorities. He lost his position in the beginning of 1928 (cutting short his ongoing research project on large cycles, at least at that moment), his personal liberty in 1930, and his life in 1938.²³ In July 1928, the Institute would be

²² In an interview to Komlev (1991), Aleksandr Aleksandrovich Konius, a former researcher of the Institute, reports how, still in 1926, Chetverikov wrote to Chuprov asking for his return to Russia, given the fact that working conditions were acceptable, without “the slightest violence against a researcher's conscience.” This indicates that in 1927 the political atmosphere degraded very rapidly for the members of the Institute, a factor which must be taken into account when reconstructing the abrupt end to the intellectual exchanges between Kondratiev and Slutsky.

²³ Klein (1999) discusses how, within the debates on business cycles, Slutsky's formal mathematics of stationary stochastic processes might be seen as a bigger threat to orthodox Marxism and, in turn, to the Soviet establishment than Kondratiev's empirical assessment of the

transferred from the auspices of *Narkomfin* to the Central Statistical Administration, and many of its senior scholars would be sacked.²⁴ It operated for a little over one year, for some time under the leadership of the statistician Pavel Ilich Popov. The Institute was officially closed at the end of 1929, when the Central Statistical Administration itself went through organizational changes (Komlev, 1991).

In its short existence, the Institute managed to become one of the worldwide leading research centers in the study of market conjuncture (Barnett, 1995; 2011). To Komlev (1991), its disbandment and those of similar institutions meant not only a significant loss to Soviet economic science, but also the end of one of the last links to pre-revolutionary Russian economic thought, characterized by a highly scientific culture, a deep understanding of the nature of self-regulating economic processes, and the development of state-of-the-art methodologies for market research.

V. KUZNETS, FRISCH, AND SLUTSKY'S LEGACY

The implications of Slutsky's results mentioned above, the "real" or genuine", and the "spurious" or "statistical" interpretations, would be respectively formulated by two of Slutsky's

material base and political superstructure of the economy. However, it is more likely that Kondratiev's political involvement in pressing issues, as opposed to Slutsky's complex mathematical theories, would be deemed as an imminent threat to Stalin. The international outlook and exchanges which were so esteemed by members of the Institute might also have played a role in its downfall.

²⁴ Some spent time in prison, such as Vainshtein and Chetverikov, and resumed their scientific activities later on; in any case, most of them had to change their fields of study, including Slutsky (Komlev, 1991).

well-known contemporaries, respectively Simon Kuznets and Ragnar Frisch. Their interpretations would contribute to the development of different lines of research throughout the 20th century, enduring to this day.

Kuznets was a member of Mitchell's National Bureau of Economic Research (NBER). He could read Russian, so his views on Slutsky's article were already published in 1929. His corroboration of Slutsky's main thesis is accompanied by a discussion on a so-called "inverted inference", i.e., whether the fact that a summation of random causes yields a periodic wave also means that such waves are primarily a result of this type of causes and can be explained by their characteristics. Kuznets (1929, p. 274) is skeptic: "[s]uch inference, of course, cannot carry with it any certainty, since we are never certain of all the contingencies of other hypotheses to which the formations of cycles in economic data may be reduced." He acknowledges the significance of the influence of random factors, albeit it is not an exclusive one. Other conditions would need to be assessed (e.g., how economic mechanisms act upon probability distributions), a hint toward the desirability of an integrated approach hitherto rarely to be seen in the literature.

For Kuznets, treating cycles as the mere summation of random events leads to the conclusion that they do not require hypotheses on underlying, recurrent economic reasons; all that is necessary is to explain how a determined cumulative process acts within the economy in order to produce a determined cyclical oscillation. In this respect, Kuznets alludes to how

institutional explanations of business cycles deal mainly with the economic forces that make for cumulation, with forces that explain why a given random event is not immediately cancelled by an opposite reaction but allowed to exert its influence for some time to come, an economic counterpart of the statistical mechanism of a moving average (1929, p. 275).

This is what Barnett (2006, p. 417) calls the “Kuznets elucidation” of Slutsky’s 1927 article, which would be in favor of a “real cyclical process occurring in an economy modelled as a moving average procedure itself.” It is to be contrasted with the “Frisch elucidation” (p. 419), focused on “spurious cycles generated by some types of statistical manipulation of data series.” Frisch (1931) pointed to the econometrically relevant aspects of Slutsky’s work, mainly how to use his results to eliminate spurious cycles, instead of considering the potential role of the summation of random causes in the formation of business cycles.²⁵

Klein (1999, p. 156) attributes Slutsky’s “subsequent reputation for discovering spurious qualities of random functions” to Yule (1926) and “Frisch’s (1931) spin on Slutsky’s work”, i.e., to the “Frisch elucidation.”²⁶ As a result, “Slutsky’s name is now more closely associated with the generation of spurious cycles than with his advocacy of the summation of random disturbances as an explanation for actual cyclical phenomena” (p. 157).

²⁵ Two years later, however, Frisch (1933) would also contribute to the real interpretation of Slutsky’s work, while attempting to explain how the summation of random causes can take place in an economic system (Barnett, 2006). Moreover, by means of his correspondence with Slutsky, he might have played a role in the revisions done by Slutsky for the 1937 translation article in *Econometrica*, given the adoption of elements of Frisch’s model, such as periodic vibrations and random disturbances (Barnett, 2011). For a more comprehensive account bearing on Frisch’s contribution, see Louçã (1997).

²⁶ To Klein (1999), the works of Slutsky, Yule, and Frisch would also have caught the attention of statisticians to the possibility that random components might be important elements of the data-generating process, and not only errors of observation.

While both elucidations can be somehow traced back to Slutsky ([1927] 1937), the “Frisch elucidation” seems to be a misinterpretation or at least an unintended consequence from his own point-of-view. His belief in the actual manifestation of economic cycles as a result of the effects of linear combinations of random elements is clear in the text. For example, one of his premises is “[s]uppose we are inclined to believe in the reality of the strict periodicity of a business cycle (...)” ([1927] 1937, p.106). Whereas his mention to Yule’s work on nonsense correlations might be seen as legitimization of the “Frisch elucidation” (Barnett, 2006), it is unlikely that Slutsky would agree that his findings only imply that there is a problem with the manipulation of time series. Klein (1997, pp. 278-279) agrees with this view, stating that “Slutsky saw true, not spurious cycles resulting from moving averages on random variables” and that “it was obvious that he was searching for true causes of cycles in his models.”

Slutsky’s employment of harmonic analysis to the study of business cycles would have a long-lasting impact. After the initial responses of his contemporaries, this part of his legacy would be revived in the second half of the 20th century by the so-called modern spectral analysis, which is based on wave decomposition using the Fourier transform (e.g., Hatanaka, 1963; Nerlove, 1964; Granger, 1966; Harvey, 1975).²⁷ Granger and Engle (1983) mention Moore

²⁷ Although the term “spectral analysis” has become the main terminology since the 1960s, “harmonic analysis” is here given preference to encompass wave composition and decomposition as the two sides of Fourier transforms. Cargill (1974) offers an overview of the early stages of development of spectral analysis in economics.

(1914) and Beveridge (1921; 1922) as the first applications of the method, and Davis (1941) as a forgotten link between Fourier series, periodograms, and modern approaches.²⁸

VI. CONCLUDING REMARKS

Fourier's development of harmonic analysis has been a part of the history of business cycle research at least since the late 19th century. The account of such a history revolves around its ability to decompose cycles as well as to build them. In this regard, the research program conducted at the Institute by Slutsky and Chetverikov, supported and shared by Kondratiev and Vainshtein, and having Moore as a key reference (alongside the indirect or less evident influences of Schuster, Mitchell, Jevons, Enström, and others) served as a uniquely fruitful juncture for the reception of the Fourier transform as a tool for the investigation of business cycles.

Harmonic analysis became an established research method at the Institute, although the pioneering and recurrent application of Fourier's mathematical conception into economic dynamics by these four senior researchers (aided by the data-related supporting role of many statisticians and computers) was only one of the methodological advances then made to address economic conjuncture issues (the construction of index numbers was favored by Kondratiev in terms of time and resource allocation). In any event, the Institute played an important role in the dissemination of this tool in economics, epitomized in Slutsky's 1927 article.

²⁸ A large research project on the economic applications of spectral analysis was initiated at Princeton in 1959 by Oskar Morgenstern, who for many years had shared with John von Neumann a positive view on the potential of this method for assessing time series. The supervisor was John W. Tukey, and staff included Michio Hatanaka, Clive Granger, and Michael Godfrey, among others (Granger and Engle, 1983; Cargill, 1974).

Although the evidence does not warrant the conclusion that there was an orchestrated effort at the Institute to push forward a research agenda on harmonic analysis of business cycles, it certainly unfolded as more than the summation of random events and individual incursions. Within its walls, the approach to cycles based on Fourier transforms amounted to a group effort which preceded the arrival of Slutsky. He ultimately benefited from the contributions made by Vainshtein's reviews, Chetverikov's co-direction of a formal research project, and Kondratiev's institutional support and interlocution, which together constituted fertile ground for his breakthrough. Moreover, based on the exchanges between Slutsky and Kondratiev in 1926 and 1927, as well as on Kondratiev's belated understanding of the implications of Slutsky's ideas in *The Summation of Random Causes*, the Institute as a whole could have produced much more if it had escaped Stalinist oppression for at least a few more years.

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