

EMPIRICAL RESEARCH OF LONG-TERM CYCLES*

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World-wide interest in market conditions' researches and in the theory of business cycles usually arises in crisis periods. Scientists and researchers deal mainly with two problems in this field:

1. What is the reason for the crisis, and is it necessarily the result of laws of nature?
2. At what point of time can prosperity be expected?

To find a solution to these problems is in the focus of public processional interest.

The theoretical problems of long-term (Kondratev) cycles

For the sake of better understanding of long-term cycles we have to extend the limit of our investigations. Time is closely correlated with the three dimensions of space, so we can call it the fourth dimension. But it has different characteristic features than space. Time is continuous as well but the parts of time-continuum does not have the same meaning. Time is not a coexistence of being but a succession of moments, so it involves past, present and future as well. According to Aristotle¹ time can be experienced as the sequence of changes. Time is a progressive, irreversible process. Economic processes take place in time and also in space. Nowadays, since the technical progress accelerates, future becomes present more and more rapidly. Philosophers, historians have already recognised that the investigation of social processes within long periods (100–400 years) is very important. “What is time as such?” – puts up the question *N. Hartmann* in his work published in 1938: “...Time and Substantiality”. He answers as follows. “Essentially the most evident moment is probably the fact that the world cannot be regarded as a whole, it is separated into the phases of the progress. And what has reference to the whole world that has reference to everything which can be found in the world: objects, creatures, mankind. Everything is subordinated to the law that has gone, it does not exist any more and what exists now it won't be tomorrow.”² “We separate the

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¹ According to Aristotle: *Tempus est numerus motus secundum prius et posterius.*

² *Hartmann, N.*: *Lételeméleti vizsgálódások. Válogatás kisebb írásaiból.* Gondolat Kiadó. Budapest. 1972. 346. p.

world – says Hartmann – if we separate the essence of time into processes which take place simultaneously. World’s cohesion depends on the unity of time.” ... “Sequence separates time from space, from mere dimension and from the order defined only by quantity.”³

Most of the economists cut time into shorter periods, within the dimension of the time. The reason for this is that they usually deal with actual problems. The length of the period seldom reaches 15–20 years. Strategic decision have been overshadowed and tactics took prominent part instead. With good reasons *Géza Kovács* says that “the impossibility of solving short and middle-term problems often lies in the lack of long-term planning.”⁴ To solve this problem we have to research long-term (100–400 year periods) economic processes, i. e. the spiral movements of economic processes have to be researched as well. Among time periods the short ones are the most dangerous and illusory ones.⁵

In the 1920’s sociology realised that the life of society, the whole mankind changes periodically according to forever renewing processes. This periodicity can be shown in the field of economy, demography, politics, crime, fashion, art and literary schools and in the ideology as well. *J. A. Schumpeter*, the famous and significant bourgeois economist, suggests in his work, which was published in 1939, that we should call these cycles after the name of their discoverers.

In technical literature, nowadays, after Schumpeter,⁶ the following grouping of the business cycles is acceptable.

1. *Kitchin cycle*.⁷ 3–4 years’ short-term concerning the movements of stocks.
2. *Juglar cycle*.⁸ 6–8 years’ middle-term cycle (2 Kitchin cycles) which according to C. Juglar’s work is called commercial cycle.
3. *Labrousse cycle*.⁹ 10–12 years’ middle-term cycles (Juglar and Labrousse) are to be explained with the changes in investments.
4. *Kuznets cycle*.¹⁰ middle-term, 20–23 years’ hyper cycle (doubled Labrousse cycle) Kuznets discovered the so-called secondary secular movements mainly on the basis of North-American data. He didn’t regard these movements as cycles but regarded them as “waves” like other contemporary economists.
5. *Kondratev cycle*.¹¹ 40–60 years’ long-term cycle (2 Kuznets cycles). Theories concerning with clearing up Kondratev cycles haven’t explained the reason for the appearance of these cycles yet. There are explanations based on the facts of monetary, agriculture and production (see innovative, demographic, and investment cycles) factors and further judgements.
6. *Changes in secular trends*. Historians draw distinctions between 100 (2 Kondratev cycles) and 200–400 years’ cycles, which we can call century-trend changes.

³ See Note 2. 356. and 359. p.

⁴ *Kovács, Géza*: Nagy távlatú fejlődéstendenciák. (Magyarország 2020-ig.) MSZMP KB Társadalomtudományi Intézete. Bu-dapest. 1985. 11. p.

⁵ *Braudel, F.*: A tér és idő felosztása Európában. In.: *Fernand Braudel*: Anyagi civilizáció, gazdaság és kapitalizmus a XV-XVII. században. 3. A világ ideje. Világtörténet. 1980. No. 4. 49–50. p.

⁶ *Schumpeter, J. A.*: Business cycles: A theoretical historical and statistical analysis of the capitalist process. Vol. 2. New York. McGraw-Hill. 1939. 1132. p.

⁷ *Kitchin, J.*: Cycles and trends in economic factors. *Review of Economic Statistics*. 1923. No. 1. 10–16. p.

⁸ *Juglar, Cl.*: Des crises commerciales et leur retour périodique en France, en Angleterre et aux États Unis. Paris. 1862. 560 p.

⁹ *Labrousse, E.*: Esquisse du mouvement des prix et des revenus en France au XVIII^e siècle 2. Vol. Paris. Dalloz. 1933.

¹⁰ *Kuznets, S.*: Secular movements in production and prices. Boston – New York. 1930. 264 p.

¹¹ The works of *Kondratev, N. D.* (Kondratyev, Kondratiev) concerning the subject are as following: Mirovoje hozjajsztvo i jego, konjunkturi vo vremja i poszle vojnü. Vologda. 1922.; Bolsije cikli konjunkturi. *Voprosii Konjunkturi*. 1925. 28–79. p.; Die langen Wellen der Konjunktur. *Archiv für Sozialwissenschaft und Sozialpolitik*. 1926. 573–610. p.; The long waves in economic life. *Review of Economic Statistics*. 1935. 105–115. p.; The long waves in Economic life. *Review of Economic Statistics*. 1979. No. 4. 519–562. p.; A gazdasági fejlődés hosszú hullámai. *Történelmi Szemle*. 1980. No. 2. 241–269. p.

The length of the above distinguished business cycle-periods doubles. Nevertheless, the cycles with different periods occur simultaneously, are mixing together, and their movements increase or decrease the amplitude of the whole vibration. So, e. g. if the ascending or rising branch of a given Kondratev cycle meets the descending or declining branch of a shorter cycle, then crisis is reduced, otherwise it is increased. With an easy technical procedure we can divide the cycles into partial movements, we can take out some of them for the sake of deeper investigation of the desired motion.

On the basis of our national and international results of research we can draw the general conclusion that the reasons of the Kondratev cycles (and usually all the cycles) are not to be found in the ownership of production means. Even during the feudal system – though the corresponding data are not to our proposal – one could show the existence of long-term cycles. So, e. g. the changes in bread and corn prices in Cologne indicate Kondratev cycles from 1376 to 1797.¹²

It is known and proved that also in the capitalism are existing long-term cycles. In Hungary long-term cycles could be demonstrated in the field of industrial production and foreign trade.¹³ In this essay some results are given concerning different former-socialist (Soviet Union, Hungary, Poland, etc.) and capitalist (USA, Canada, Austria, Australia, etc.) countries.¹⁴ E. g. in Europe we can speak of 4 each other following main century-cycles. Within them there are the Kondratev and shorter cycles. In the following, we demonstrate the changes of the century-trends. The first and the last year-numbers show the start of rising and the end of declining. The data in brackets mark the culmination of the process i. e. the turning point of the century-trend and the long-term-cycles: the beginning of the crisis.¹⁵

To summarise the results see

the century-cycles

| | trough | | peak | | trough |
|------|--------|---|--------|---|--------|
| I. | 1250 | – | [1350] | – | 1510 |
| II. | 1510 | – | [1650] | – | 1743 |
| III. | 1743 | – | [1817] | – | 1896 |
| IV. | 1896 | – | [1973] | – | 2030? |

the long-term-cycles:

| | trough | | peak | | trough |
|------|--------|---|--------|---|--------|
| I. | 1780 | – | [1815] | – | 1848 |
| II. | 1848 | – | [1873] | – | 1896 |
| III. | 1896 | – | [1929] | – | 1945 |
| IV. | 1945 | – | [1973] | – | 1995? |

¹² See Note 5.

¹³ Sipos, Béla: Vállalati árelőrejelzések. Közgazdasági és Jogi Könyvkiadó, Budapest. 1985. 247–263. p.

¹⁴ Sipos, Béla: Empirical research and forecasting based on Hungarian and world economic data series. 1985. 119–126. p. In.: The long-wave debate. Springer-Verlag. 430 p.; Empiricseszköje isszledoványije i prognóziroványije ciklov Kondrateva. In.: Trétyij mézsdunarodnűj szimpozium sztrancslenov SZEVI po problemam prognóziroványija naucsno-technicseszkovo progressza. Moszkva. 1986. 7–8. p.; A Kondratyev-ciklus empirikus vizsgálata és prognosztizálása. *Statisztikai Szemle*. No. 12. 1986. 1209–1237. p.; Sipos, Béla – Szentmiklósi, Miklós: A hosszú hullámok alakulása a mezőgazdaságban. *Statisztikai Szemle*. 1991. No. 10. 798–812. p.

¹⁵ See Note 5. 51. p.

It is obvious from the illustration that the length of the period of the century trend shortens. The first century-cycle lasted for about 260 years,¹⁶ the second one lasted only for about 233 years,¹⁷ the third one lasted only for about 153 years.¹⁸ The periods of the long-term-cycles are getting shorter: the first long-term-cycles lasted for about 68 years,¹⁹ the second one lasted 48 years,²⁰ the third one lasted 49 years.²¹ Within the cycles changes the ratio of the rising and declining branches, probably because of the changes of the Kondratev and the shorter cycles. Now, since the first oil-crisis (1973) we are at the end of the declining branch of the fourth cycle.

It is obvious after 1945 that the rising branch of the century-trend met the rising branch of the Kondratev cycle. So the two processes strengthened each other. The prosperity was strengthened also by the almost similar procedures of the restoration periods.²²

At the beginning of the 1920s the situation changed. The declining branch of the century-trend met the declining branch of the Kondratev cycle, so the crisis became more serious.

Methods

Considering the economic long waves we have more difficulties to cope with. According to the nature of the given research area, there is a need for the observation of long-time series. If we wish to process reliable and comparable data – which is an essential demand – then in most cases we have to go back to the 60s of the 19th century. Data from the period between the end of the 18th century and the middle of the 19th century are often insufficient and unreliable.

Kondratev elaborated his procedure for demonstrating and separating the long waves at the beginning of the 1920s.²³ The computer techniques have developed to a very high level during the last five decades but the methodological basis has remained the same. Naturally, the mathematical and statistical methodology have also developed but other methods (e. g. dynamic factor analysis, cluster analysis, production function, etc.) have been elaborated as well. This does not alter the fact that Kondratev's method gives a very good approach of long waves and his process is correct logically.

On elaborating his procedure Kondratev assumed that he could distinguish the following components in time series (in series of per capita production output):

1. short-term cycles of 3–4 years (Kitchin cycle)
2. middle-term cycles of 8–9 years (average of period length of Juglar and Labrousse cycles)
3. long-term cycles 40–60 years (long-term cycles named after Kondratev)
4. change of secular trends
5. random changes

¹⁶ 1510 - 1250 = 260

¹⁷ 1743 - 1510 = 233

¹⁸ 1896 - 1743 = 153

¹⁹ 1848 - 1780 = 68

²⁰ 1896 - 1848 = 48

²¹ 1945 - 1896 = 49

²² Jánossy, Ferenc: A gazdasági fejlődés trendvonaláról. 2. Ed. Magvető Könyvkiadó, Budapest. 1975. 388 p.

²³ See Note 11.

The so-called Kuznets cycles (20–30 years) were founded later (in 1930). Kondratev wanted to demonstrate the effect of the third component above.

Therefore he used the procedure below.

I. He plotted the data of the time series (Y_t) ($t=1, 2, \dots, n$) and fitted them to an entire rational function of the n -th degree. The use of a function of more than third degree is unreasonable from the economic point of view, so he used linear functions and functions of the second and third degree. By increasing the degree of a function, the accuracy of estimation improves, but this function follows more and more the periodic and random fluctuations as well. When determining the degree of the function we consider economic aspects (direction of secular trend) instead of mathematical and statistical ones. The secular trend cannot follow the fluctuations of time series because these are manifestations of the random or periodic component.

II. Knowing the trend-values (\bar{Y}_t) we could estimate the residuums $Y_t - \bar{Y}_t$ on the basis of the data Y_t . So Kondratev eliminated the change of secular trends.

III. He distinguished the random fluctuations and cycles of 3 and 9 years by using the 9-element moving average for the residuums. The curves he got are showing long Kondratev cycles of 40–60 years. Now we set forth the procedures we applied. In the first procedure we followed Kondratev's method, in the second one, before eliminating the trend-effect, we used the moving average. For cutting out the shorter cycles we used 9-element-moving averages. So we eliminated the effect of the possible Kitchin's and Juglar's cycles (3 and 9 years) and random changes.²⁴

We investigated the empirical study of Kondratev cycles on the basis of 300 time series which meant the processing of about 25 thousand data. The final year of the cycles was 1980.

Data processing referred to 30 countries and the world economy. By choosing the countries we processed data of about 11–12 countries which definitely or at least considerably influenced the world economy. Generally, the time-series of the Soviet Union, the USA, Hungary and the countries of Western and Eastern Europe were examined by us in all cases.

The empirical study covered the following fields.

- Industry : production of brown coal, lignite, coal, crude iron, steel, lead, oil, electric power, gold, silver, iron, bauxite, aluminium, copper ore, copper, lead ore, cement, sugar, beer, car industry and shipbuilding.
- Agriculture: plant cultivation production of wheat, barley, corn, rice, potato, cotton, pure coffee, cocoa, animal husbandry, livestock of horses, cows, pigs, and sheep.
- Foreign trade: Export and import volume in dollars and international currency.
- Transport: length of railway-lines. Railway capacity of goods transportation, railway capacity of passenger transportation, stock of commercial ships.²⁵

Generally, the historical time-series reflect the quantity of production in natural units of measurement. However, this shows certain differences in case of some products. Comparability of time-series must be assured. Processing the data measured in natural

²⁴ The necessary computational program was made in 1981 by *Kiss, Tibor* assistant professor of Janus Pannonius University, Pécs, with the help of BMDP and TSP program-packets. He developed and run the program as well.

²⁵ See Note 14 and Time series of world economics 1860–1960. Közgazdasági és Jogi Könyvkiadó. Budapest. 1965. 157 p. Data for the period 1961–1996 are from: International Statistical Yearbooks, the yearbooks of Central Statistical Office, Budapest and the statistical yearbooks of United Nations Publications. New York.

units was supported by the fact that the currency had been changed during the studied period in a lot of countries. By “chaining” we assured comparability for these time-series. So e. g. in the case of Roumania, before 1950 they had another grouping of different coal sorts in the production area of brown and lignite coal than after that point of time. This correction (“chaining”) was made possible by the fact that production was known for both groups in 1948.

Supposing that this rate remains constant, we multiplied the data with (2720/960) where the numerator beginning in 1950, represents the value according to the old type of grouping in 1948, and the denominator represents the value according to the new type of grouping in 1948. This way the data became comparable.

The processed data are related to a calendar year. It was a great problem that data of time-series were in certain cases not complete for the studied period. So e. g. during the period of World War II. data were often insufficient and defective because the data collection was not formed out or the results were destroyed. We inserted estimations for those data.

In Hungary during the 30s and 40s some members of *Farkas Heller's* school²⁶ dealt with the work of Kondratev for the first time.²⁷ After a long pause historians published about Kondratev in the 80s, and after that the Kondratev's cycles aroused the economists' interest.

N. D. Kondratev (1892–1938), was an outstanding Soviet economist and he was the chairman of the first Prosperity Research Centre, and achieved considerable results within its short existence (1917–1930).

In literature of economics and economic history they call the long-term fluctuations Kondratev cycles. Scientists were interested in the waves in the economic life since ever economic studies had been pursued. The period, when the theory of the self-acting system of economy was invented was not free from economical disorders. In England for instance there were severe crises in 1815, 1825, 1836–1837, 1857, in 1866 then in 1873. The crisis of 1873 shattered the economy of Europe. It is worth to note that even 100 years later, with the beginning of the 70s, the same crisis repeated again. The calculations made so far based on fundamental economic coefficients proved in many fields the existence of Kondratev cycles. Whenever the length of our time-series was greater than 100 elements, we were successful in showing the Kondratev cycles, too. It is also clear that the reason of the cycles cannot be found in the ownership, because the occurrence of the cycles could be shown in the field of mining and heavy industry in post-socialist, capitalist and in developing countries as well.

My intention was not to give economic-historical explanations of the long waves. The reasons of the Kondratev cycles can at least be regarded as some hypothesis of mine, so I am not able to explain ambiguously the causes of long waves. In the international literature there is no unique point of view about this. By all means it is remarkable that the period-length of the cycles doubles which provides reason for the assumption that the occurrence of resonance in economic life can prove effect too. The cyclic course of different economic or elementary phenomena can effect each other in a boosting or a

²⁶ Tanulmányok a konjunktúrakutatásról. Ed.: *Heller, Farkas*. Közgazdasági Könyvtár. Tom VI. Magyar Közgazdasági Társaság. Budapest. 1928. 168 p.

²⁷ *Heller, Farkas*: A közgazdasági elmélet története. Gergely R. 1943. 602 p.

weakening manner, and so the length of the periods and their amplitudes can be doubled. The length of doubling periods became shorter because of the quick technical progress. Nowadays, the population of the world for instance doubles within 30–40 years, though at the beginning of the 19th century the doubling time was 100 years yet. Similarly, the doubling time of productivity fell to about 30–40 years in the developed countries. In our days quantity of scientific results doubles in 10 years already.

Our conclusions for the future are the following: probable a decreasing branch of the Kondratev cycle started in the decade of the 60s, 70s and it met a decreasing branch of the secular trend.

Empirical results and research with Excel and Regal²⁸

I completed previous data from 1989 to 1996 in the field of steel, corn and sugar production. The dimension is kilogram/person. I used 9-element moving average and after this process I separated linear trend.²⁹

Table 1 and Figure 1 illustrates the long-term cycle (Kondratev cycle) in the field of steel production.

Table 1

Steel production long-term cycle
(kilogram/person)

| Country | Years of observations period (duration) | 1. cycles trough – peak – trough | 2. cycles trough – peak – trough | Duration of full cycle |
|----------------|---|-------------------------------------|-------------------------------------|---------------------------|
| Austria | 1891–1989 (99) | ? – 1894 – 1949 | 1949 – 1982 – ? | 89 |
| Belgium | 1880–1992 (113) | | 1904 – 1922 – 1984 | 81 |
| Czech Republic | 1919–1992 (74) | | 1948 – 1976 – 1992? | 45 |
| Hungary | 1920–1995 (76) | ? – 1920 – 1956 | 1956 – 1976 – 1995? | 40? |
| Italy | 1891–1993 (103) | ? – 1891 – 1948 | 1948 – 1978 – ? | 88 |
| Japan | 1920–1993 (74) | ? – 1920 – 1955 | 1955 – 1974 – 1993? | 39? |
| Russia | 1883–1995 (113) | ? – 1883? – 1947 | 1947 – 1977 – ? | 95 |
| United Kingdom | 1891–1994 (104) | ? – 1915 – 1929 | 1929 – 1963 – 1991 | 63 |
| United States | 1867–1994 (128) | | 1945 – 1990 – ? | ? |
| World total | 1890–1994 (100) | | 1947 – 1973 – ? | ? |

Long term cycles of steel production in most countries got in the declining branch in the 70's both in Czech Republic, Hungary, Italy, Japan, Russia, and in the world. In Austria and the USA the cycle turned down later (in 1982 and 1990, respectively), while in England the declining branch already started in 1963. In Belgium we experienced an opposite tendency: increasing branch: 1904–1922, declining branch: 1922–1984. Steel production approaches best the world tendency (1945–1973: increasing branch). This is also an evidence for the fact, that not the national features are characteristic in the Kondratev cycles. Kondratev cycles are global; they are the cycles of the whole world

²⁸ REGAL. Expert System for Multiple Linear Regression.

²⁹ 9-element moving average- linear trend ($y = b_0 + b_1 x$).

economy. The bigger countries (USA, Russia) follow the cycles better than the smaller countries (e. g. Belgium, Austria).

Figures depict 9-element moving averages and the approaching linear trends. The difference between the two series is the Kondratev cycle.

Figure 1. Steel production/population

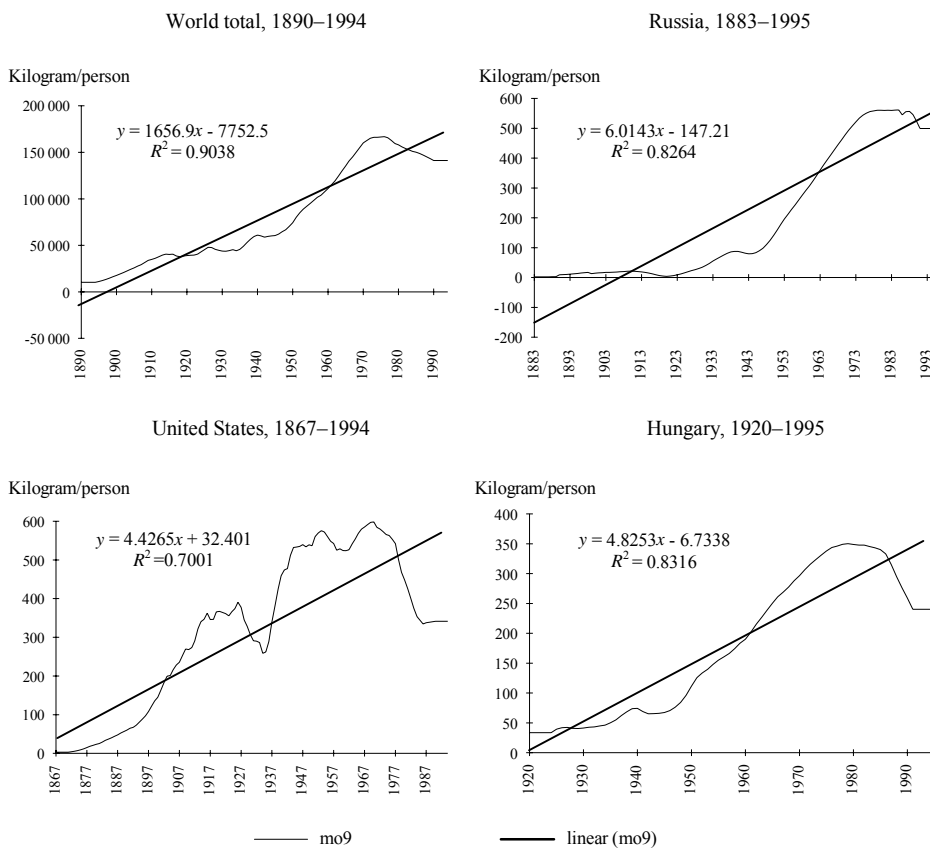


Table 2 shows the long term cycles of corn. Bulgarian long cycles follow the world tendency. The increasing branch started later, after the II. World War in Egypt (1953), Brazil (1961), and India (1960). The increasing branch already started earlier, in 1937 in the USA. The tendency of world production (1949–1983) also shows delay comparing to the average tendency (1945–1973).

Table 2 and Figure 2 illustrate the long-term cycle (Kondratev cycle) in the field of corn production.

In corn production (kilogram/person) 9-element moving average is used, and after this process linear trend is separated.

Table 3 shows the long term cycle of sugar (cane) production. The average tendency is also approached best by the world production series (1947–1975). The cycle turned

back later in the other investigated countries (Argentina 1985, Austria 1980 and Belgium 1985).

Table 2

Corn production long-term cycle
(kilogram/person)

| Country | Years of observations period (duration) | 1. cycles trough – peak – trough (duration) | 2. cycles trough – peak – trough |
|---------------|---|---|----------------------------------|
| Brasilia | 1917–1995 (79) | ? – 1932 – 1961 | 1961 – 1991 – ? |
| Bulgaria | 1889–1995 (107) | ? – 1890 – 1945 | 1945 – 1975 – ? |
| Egypt | 1920–1994 (75) | ? – 1924 – 1953 | 1953 – 1990 – ? |
| India | 1911–1996 (86) | 1916 – 1926 – 1960 (45) | 1960 – 1972 – ? |
| United States | 1866–1995 (130) | 1870 – 1902 – 1937 (68) | 1937 – 1982 – ? |
| World total | 1901–1995 (95) | ? – 1909 – 1949 | 1949 – 1983 – ? |

Figure 2. Corn production/population

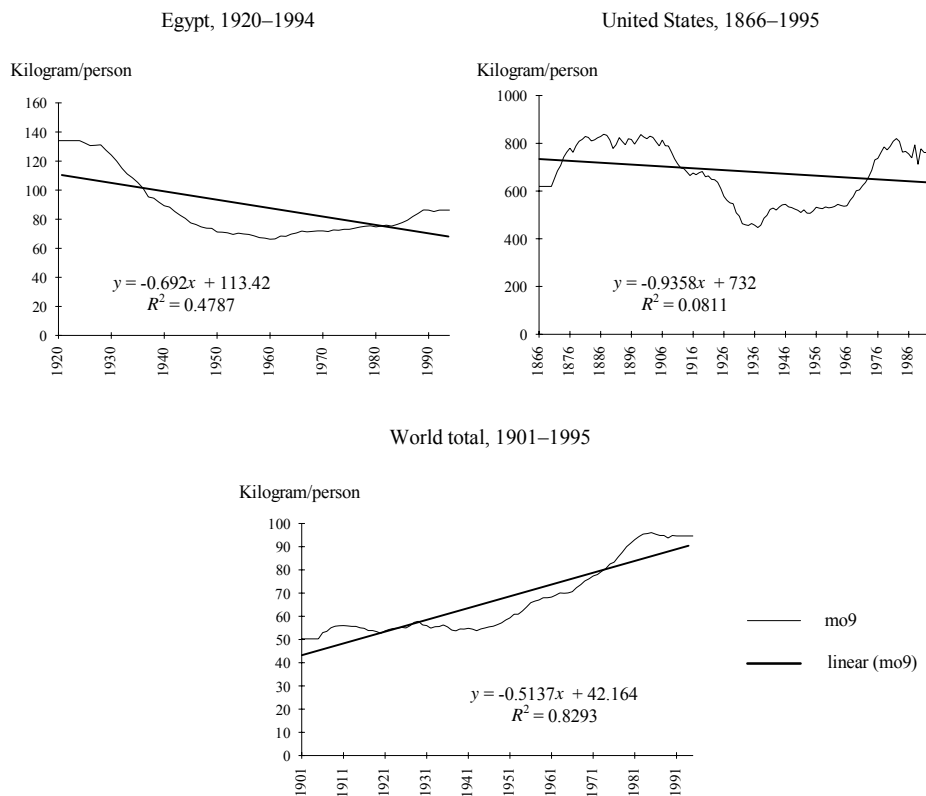


Table 3 illustrates the long-term cycle (Kondratev cycle) in the field of sugar production.

Table 3

Sugar production long-term cycle
(kilogram/person)

| Country | Years of observations period (duration) | 1. cycles trough – peak – trough (duration) | 2. cycles trough – peak – trough |
|-------------|---|---|-------------------------------------|
| Argentina | 1891–1989 (99) | 1926 – 1934 – 1953 (28) | 1953 – 1985 – ? |
| Austria | 1891–1993 (103) | ? – 1891 – 1951 | 1951 – 1980 – ? |
| Belgium | 1880–1991 (112) | ? – 1899 – 1945 | 1945 – 1985 – ? |
| World total | 1921–1995 (75) | ? – 1928 – 1947 | 1947 – 1975 – ? |

Computations concerning the basic economic factors proved the existence of long-term waves. The research is focused on empirical investigation and statistical induction. The researchers are expecting the next increase of Kondratev long-term cycle in the next years. The basic innovations (radically new technics and products) will determine in the future changes in long-term cycles.