Romana, Ignacio Escañuela

Article

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Journal of
Economics and Political Economy
www.kspjournals.org
Volume 5 March 2018 Issue 1

Did Harvard barometers allow for the prediction of the 1929 Stock market crash?

By Ignacio Escañuela ROMANA [†]

Abstract. The Harvard barometers were an attempt to analyse and predict the business cycles, which took place in the 1920s. An initiative from the Harvard Economic Service (HES), it was one of the first and more important instrument used to try to understand the sequence in the economic fluctuations. This paper reconsiders the accepted position about the Harvard barometers, that using them it was impossible to predict the 1929 Depression. I arrive at a different conclusion. Based on the data from the *ABC* curves in August 1929, and with an available econometric methodology at that time, it would have been possible to forecast the fall in speculation, as defined in the curve *A*, whereas the fall in business (B), and in monetary and credit conditions (C) were unpredictable. The stock market crash could have been anticipated. The HES stated that curve A precedes B, and then C. This is not detected. This paper makes use of the harmonic analysis by breaking down series in sinusoidal curves. Taking into account this prediction, this work analyses if aggregation was the factor producing the perceived regularities. The conclusion is negative: aggregation did not produce those cycles, they were in the original data.
Keywords. Business cycles, 1929 crash, Forecasting, Periodogram, Economic history.
JEL. B23, C43, E32, N12.

1. Introduction: State of the art purpose

In the last years of the 1910s, a group of economists at Harvard University founded the Harvard Committee on Economic Research, known as Harvard Economic Service (HES). An institution designed to drive research in economic forecasting (Sambor, 2016). Warren M. Persons, a Professor of Economics at Harvard University, built the basic model of prediction for the business cycle. In 1922, The HES began to publish the Weekly Letters, where they gave a brief evaluation of economic progress, and they tried to predict the evolution in the next months. This was one of the two preeminent economic analysis services in the 1920s (Dominguez *et al.,* 1988). Fisher indexes were the other relevant service.

Persons thought that business cycles are neither regular, nor of fixed and repetitive duration. Their repetition and timing are irregular. Crum (1923), an economist in the HES, criticised the existence of periodicities in the economic events: "We believe that the economic period should not be assumed constant" (p.24). To analyse and predict the business cycle, Persons built three composite series. Each of this series was the result of an index aggregation. Previously, Persons imposed a process of filtration. This method was inductivist. Theory did not have a place in this approach, only empirical observation (e.g., Persons, 1916). The composition of the series and the relationship between them were the result of an empirical analysis of the American economy.

† Universidad de Loyola, Chicago, Illinois. USA.
☎. 954755807, 674155783
✉. ignacioesro@gmail.com

From Popper on, induction has been generally rejected because it would not have any foundation. Popper considers Hume's attack on induction correct, from a philosophical point of view (Popper, 1962).

The HES has been historically discredited because of the alleged failure in forecasting before and after the Great Crash in 1929. The HES maintained an optimistic outlook, which contrasted with the downturn and then the reality of Depression. In 1931, The HES abandoned the barometers. And this alleged failure led to the accepted conclusion that business cycles cannot be predicted. "Narrower studies of the period spanning the Service's lifetime preferred to express skepticism toward the achievements of economic forecasters in light of the sheer magnitude of their failures after 1929" (Sambor 2016). Rötheli (2006) makes a commonly accepted summary: "The extent of misjudgement of the course of general business activity (i.e., industrial production) by prominent forecasting services was undeniable but, as Dominguez *et al.,* (1988) document, the forecasting services cannot be faulted for remaining optimistic after the crash: even with the help of statistical methods of the 1980s and better data the great depression could not have been forecast" (p.4).

Dominguez *et al.,* (1988) mention Professor W.L. Crum's account, according to which, in the summer of 1929, a statistician from the HES "became alarmed when she noticed that the indexes indicated that a sharp downturn in economic activity was imminent" (p. 595). With this as a starting point, the authors wonder whether the Depression was predictable, especially based on Harvard barometers and Irving Fisher's commodity and stock market price indexes. Using auto-regressive vector models (VAR), they conclude it was not. 1929 was not predictable. "Our conclusion based on time-series methods that the Depression was not forecast table" (Domínguez *et al.,* 1988).

This work reconsiders all these conclusions from the scientific literature. I try to prove that the HES could have predicted the 1929 stock crash. And that it could have predicted this crash by means of a well-known statistical method, used in the 1920s. In addition, this work studies the possibility that applying the structure of lags stated by Persons, the Depression could have been forecasted.

2. Methodology

In this paper, the Harvard barometers, *ABC* curves, are used in order to analyse whether the Depression was, in effect, unpredictable. No Fisher indexes are used, due to the fact that their time length is shorter. Moreover, a different statistical methodology is applied. As a result, the paper focuses on Harvard curves and aims at verifying whether, by using these, the HES might have predicted the crisis: the dramatic downturn in economic production and asset prices.

The method used is the harmonic analysis. The fundamental theoretical assumption is that there exist regular movements that underlie and produce the observed changes. Therefore, it is assumed that the curves *A*, *B* and *C* can be broken down using a periodogram. That is to say, they pick up empirical (observable) cycles by subtracting the trend of the observed movements, and these cycles can be broken down in sinusoidal functions.

In 1822 Fourier established that a variable can be expressed as a sum of a number of sine and cosine terms. Such a sum is known as a Fourier series. The determination of the coefficients of these terms is called harmonic analysis. This method was well-known in the 1920s. Schuster developed this method in 1898. Mitchell studied the economic cycles and this was one of the procedure considered. Beveridge (1922) used it extensively, in order to analyse wheat prices. Yule (1927) used an autoregresive model, instead of the periodogram. Yule considered that a series of data could not be a sum of periodicities plus superposed random fluctuations, but a disturbed series. In conclusion, periodogram was a well-known econometric instrument in the 1920s.

In fact, the HES's explicit goal was to eliminate the trend or non-recurrent movement, so that it would be enough to subtract the series' mean to apply the periodogram. As from here, based on the data from January 1919 to August 1929 (128 months), the amplitude is calculated for each period and, consequently, so is each sinusoid's contribution to the variance of the variable to be explained (curve *A*, *B* or *C*).

Afterwards, in every instance when there are relevant theoretical cycles, and when the amplitude has a pertinent distribution, the analysis verifies whether the sum of the two most important calculated theoretical cycles predicts the curves' subsequent movement from September 1929 to their end in November 1931.

Formally, if $f(t)$ is a periodic function, its values are repeated at regular intervals of the explanatory variable t $[f(t) = f(t+k\cdot T)]$. Therefore, the function can be broken down in harmonics and be approximated with a reduced number of these.

$$f(t) = A_0 + A_1\cos(wt) + A_2\cos(2wt) + \dots + B_1\sin(wt) + B_2\sin(2wt) + \dots$$

The simplest periodic function is the harmonic with amplitude *R*, frequency *w* and phase *F*:

$$f(t) = R\cos(wt + F)$$

Where the size of the series is $T = 2\pi/w$.

The addition of several harmonics yields a compound oscillation that might be a satisfactory approximation of the perceived economic phenomena.

De Moivre's (Euler's) theorem (Masset, 2008):

$$e^{i2\pi f} = \cos(2\pi f) + i\sin(2\pi f)$$

Therefore:

$$X(f) = \sum_{t=-\infty}^{\infty} x(t)e^{-i2\pi ft}$$

Where f denotes the frequency at which X(f) is evaluated. This is the discrete version of the Fourier transform. The population spectrum of a covariance-stationary process y(t) can be defined as:

$$S_y(w) = \frac{1}{2\pi}\sum_{j=-\infty}^{\infty} g_j e^{-i2\pi fj}$$

Where gj is the j th autocovariance of y(t). Frequency f = 1/T , at which the spectrum is evaluated and T is the period length of one cycle at frequency f (Masset, 2008).

The estimation of the sample periodogram is related to the squared magnitude of the discrete-time Fourier transform │Y (f)│ of the time-series y(t),

$$\hat{S}_y(\omega) = \frac{1}{2\pi}\frac{1}{T}\left|X(f)\right|^2$$

Therefore, the aim of the periodogram is to reveal, based on the observed values for the time series, the (not directly observable) harmonic components that contribute to the explanation of that series. Consequently, if there is a series $f(t)$ that is free of its trend and whose size is *T*, it is possible to estimate *T* coefficients and *T*/2 harmonics. The problem is circumscribed to the estimation by multiple regressions of coefficients a_0, a_p, b_p, with explanatory variables cos(p• w_0•t) and sin(p• w_0•t).

The square of the amplitude for a period:

$$R^2 = a_p^2 + b_p^2$$

It can be defined as ordinate of the periodogram:

$$S = R^2 N$$

Where N is the number of observations.

To determine relevance, Greenstein (1935) used two tests: Schuster (1906) and Fisher (1929). Schuster required a minimum value of S to consider that a period is significant. S must be greater than or equal to the resulting value if the following expression:

$$P_s = e^{-S/\bar{S}} = 0.05$$

Where $\bar{S}$ is the average of S, for the complete sequence of Fourier.

Fisher proposed a test of significance more demanding than Schuster's proposal. Defining m and g:

$$m = \frac{N-2}{2}$$

$$g = \frac{R^2}{\sum R_i^2}$$

Then P_g must not be greater than 0.05.

$$P_g = m(1-g)^{m-1}$$

Therefore, it is possible to calculate the value of S critical to conclude there is a significant frequency.

3. Harvard Curves

Since 1919, based on studies carried out for the period that preceded World War I (1903-1914), the HES elaborated and published three monthly curves or indexes (or 'barometers') that should describe the state of the economy and allow to predict its future evolution. These curves did not rely on economic theory, but were based on an empiric and inductive rationale.

Each index was the result of a process of data filtering. The selected series were those thought to contain information on the evolution of speculation, economic activity or money and credit. It was interpreted that every series comprised a trend, a seasonal variation, a cyclical movement and a residual factor. The secular trend was "the regular increase or decrease (...) over the whole period under consideration" (Persons, 1922). By subtracting from the original series the trend and seasonal variation, the cycle would show up, with the successive expansive and recessive periods. The trend was calculated as a linear function adjusted by least squares, taking as intercept the series value considered normal. The seasonal variation was subtracted based on a monthly value considered normal. Once subtracted, the cycles were expressed in typified values. However, HES applied different filtering procedure for each series.

Afterwards, the various cycle series were compared with each other, to study the level of correlation between fluctuations and the most significant lag. The HES concluded that there were three different groups of series: curves *A*, *B* and *C*, a result of the aggregation of different data series. Some of these contained information on quantities; others contained information on prices. The HES changed the composition of the curves on several occasions (ILO, 1924, p. 51). As from 1919, the composition was the following:

- Curve *A*, which represented investment and speculation. It contained the series of:
  - Trading volume at the New York Stock Exchange. It was committed in 1923.
  - Average of New York bank clearings. New York bank debits from 1923 on.
  - Dow-Jones index of stock prices of 20 industrial companies.
- Curve *B*, related to business, where cyclical series were:
  - The average of bank debits carried out outside New York. Outside bank debits for 140 cities from 1923 on. Debits as a measure "of money volume of business" (Crum, 1927). Debits outside N.Y. to avoid speculative movements (p. 30).
  - Bradstreet's price index. A price index of ten goods, considered strategic, from 1923 on.
- Curve *C*, related to money or financial conditions, which contained:
  - The interest rates applied to commercial bills due in 4 to 6 months
  - The interest rates applied to bills due in 60 to 90 days (commercial paper rates).

The data used for the three curves can be looked up in Dominguez *et al.,* (1988).

The Economic Service studied the relationship among these three curves, as well as the distance between the highest and the lowest values. Based on this, it reached a conclusion on the state of the economy and its future evolution. It was observed that the curve *A* was the first to move, later (from two to eight months), followed by curve *B*, in the same direction; then they were followed (4-6 months) by curve *C*, also in the same direction (Persons, 1922c). Finally, it was observed that, following an upward movement in the curve *C*, there would follow an inverse change in curve *A*. A drop in stock prices would produce less investment, a recession in business, and then lower interest rates (Moore, 1969, p. 1). Until initial recession was overcome. Prediction and evaluation would rest on this statistical basis, and there would also be an assessment of the fundamentals of the economy. Nevertheless, Persons later pointed out that the relationship observed among the curves in the early 20s had gradually changed, mainly due to the Federal Reserve interventions, which had resulted in a loss of confidence by the HES in the barometers' predictive power.

Romer (1990) suggests a mechanism of causation: The fall in stocks would produce uncertainty about future income, and then this would have caused a strong fall in consumption of durable goods. That could explain how curve A (speculation) could produce a later movement in the curve B (business). There is, also, a possible effect on producers, who would decide not to make investments of new plants and equipment (Romer, 1990). An explanation based on the importance of the stock market. Something suggested also by the HES.

4. Results

Data in Appendix 1.

A summary of the periodograms of the Harvard Cuves. Tables 1, 2, 3 and 4.

Table 1. *Periodogram. Harvard Curves.*

	Months	Years	Contribution to variance		
frequency	periods	periods	AC	BC	CC
1	128	10.66666667	60.4485679	37.0873842	65.4845431
2	64	5.333333333	14.1854206	3.218355634	4.593901889
3	42.66666667	3.555555556	3.005804504	3.768371278	0.964033957
4	32	2.666666667	1.388019882	27.6891847	20.6334814
5	25.6	2.133333333	2.55070546	7.465978902	1.849320658
6	21.33333333	1.777777778	2.090468347	1.896430572	2.801472516
7	18.28571429	1.523809524	1.984915617	3.087856333	0.032151289
8	16	1.333333333	1.767068871	0.38641408	0.403776512
9	14.22222222	1.185185185	1.757292337	0.171650984	0.028487824
10	12.8	1.066666667	1.516636256	1.254283611	0.164785338
Sum of two main			74.63398854	64.77656886	86.1180245

Table 2. *Periodograms Amplitudes Harvard Curves*

Curve A					Amplitudes			
Cosines	Coefficient	Sines	Coefficient	R^2	S	Rp	Variance contrib.	%
x11	2.07	x21	-2.22	9.22	1180.34*	3.04	0.60	60.45
x12	0.71	x22	-1.29	2.16	276.99*	1.47	0.14	14.19
x13	0.31	x23	-0.60	0.46	58.69	0.68	0.03	3.01
x14	-0.20	x24	-0.42	0.21	27.10	0.46	0.01	1.39
x15	0.11	x25	-0.61	0.39	49.81	0.62	0.03	2.55
x16	0.16	x26	-0.54	0.32	40.82	0.56	0.02	2.09
x17	0.02	x27	-0.55	0.30	38.76	0.55	0.02	1.98
x18	0.01	x28	-0.52	0.27	34.50	0.52	0.02	1.77
x19	0.03	x29	-0.52	0.27	34.31	0.52	0.02	1.76
x110	-0.03	x210	-0.48	0.23	29.61	0.48	0.02	1.52
Curve B					Amplitudes			
Cosines	Coefficient	Sines	Coefficient	R^2	S	Rp	Variance contrib.	%
x11	0.36	x21	-0.70	0.62	79.35*	0.79	0.37	37.09
x12	0.23	x22	0.04	0.05	6.89	0.23	0.03	3.22
x13	-0.18	x23	0.18	0.06	8.06	0.25	0.04	3.77
x14	-0.56	x24	-0.39	0.46	59.25*	0.68	0.28	27.69
x15	-0.05	x25	-0.35	0.12	15.97	0.35	0.07	7.47
x16	0.07	x26	-0.16	0.03	4.06	0.18	0.02	1.90
x17	0.14	x27	-0.18	0.05	6.61	0.23	0.03	3.09
x18	0.08	x28	0.00	0.01	0.83	0.08	0.00	0.39
x19	-0.03	x29	-0.04	0.00	0.37	0.05	0.00	0.17
x110	-0.02	x210	-0.14	0.02	2.68	0.14	0.01	1.25
x111	-0.08	x211	-0.20	0.05	6.09	0.22	0.03	2.85
x112	0.13	x212	-0.16	0.04	5.28	0.20	0.02	2.47
x113	0.00	x213	-0.06	0.00	0.47	0.06	0.00	0.22
x114	0.01	x214	-0.09	0.01	1.00	0.09	0.00	0.47
x115	0.08	x215	-0.05	0.01	1.09	0.09	0.01	0.51
x116	0.04	x216	-0.02	0.00	0.24	0.04	0.00	0.11
x117	0.09	x217	-0.06	0.01	1.47	0.11	0.01	0.69
x118	0.11	x218	-0.07	0.02	2.22	0.13	0.01	1.04
Curve C					Amplitudes			
Cosines	Coefficient	Sines	Coefficient	R^2	S	Rp	Variance contrib.	%
x11	0.83	x21	0.70	1.19	152.19*	1.09	0.65	65.48
x12	0.03	x22	0.29	0.08	10.68	0.29	0.05	4.59
x13	-0.13	x23	0.00	0.02	2.24	0.13	0.01	0.96
x14	0.00	x24	-0.61	0.37	47.95*	0.61	0.21	20.63
x15	0.13	x25	-0.13	0.03	4.30	0.18	0.02	1.85
x16	0.01	x26	-0.23	0.05	6.51	0.23	0.03	2.80

Table 3. *Schuster test Significant values*

Schuster test	AC	BC	CC
S (mean)	30.50949812	3.342748706	3.631133014
S (significant, 0.005)	161.70034	17.71656814	19.24500497

Table 4. *Fisher test*

		AC	BC	CC
m	(N-2)/2	63	63	63
g	0.05=63*(1-g)^(63-1)	0.1087613	0.1087613	0.1087613
Sum R^2		15.2547491	1.67137435	1.81556651
S (relevant)	S=R^2*N=	212.368171	23.2679485	25.2753118

Consequently, it may be observed that (1919:1 – 1929:8):

- In the curve *A*, the 128-month period, frequency 1 theoretical movement explains 60% of curve *A* variance. The 64-month period, frequency 2 cycle explains 14%

of curve *A* variance. Combined, both series explain 75% of the variation in curve *A*, an obviously relevant value. Both are relevant (Schuster's and Fischer's tests).

- In the curve B, the 128-month period theoretical movement explains 37% of the variance, whereas the 32-month period explains 28%. Combined, both series explain 65% of curve *B* variance, another relevant value. Both are relevant (Schuster's and Fischer's tests).
- In the curve *C*, the 128-month period theoretical movement accounts for 65% of the curve *C* variance. The 32-month period cycle explains 21%. Combined, both series explain 86% of the curve *C* variance. Both are relevant (Schuster's and Fischer's tests).

Graphically, it is possible to observe both the fit between the series and the most relevant theoretical cycles, and the accuracy of the prediction as from September 1929. Series from 1919:1 – 1931:10, n = 154. Prediction is 1929:9 – 1931:10.

AC is the curve *A*, related to speculation, to which the mean has been subtracted. SUAC represents the sum of the main theoretical cycles (128 and 64 months), Figure 1.

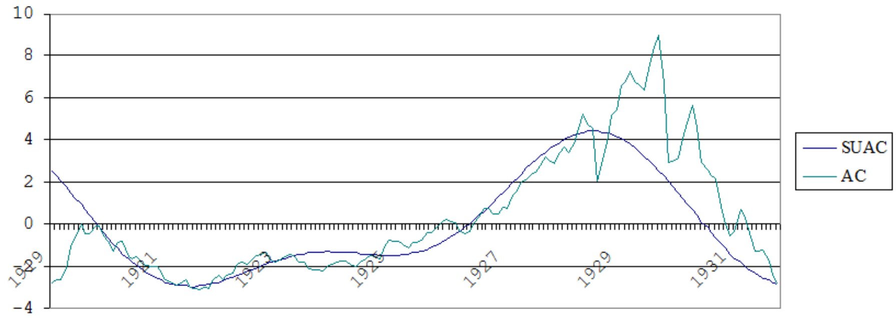

Figure 1. *SUAC is theoretical two main frequencies. AC curve A prediction. n=154.*

The theoretical cycles diverge from the data series in the years 1919 and 1929. Figure 2.

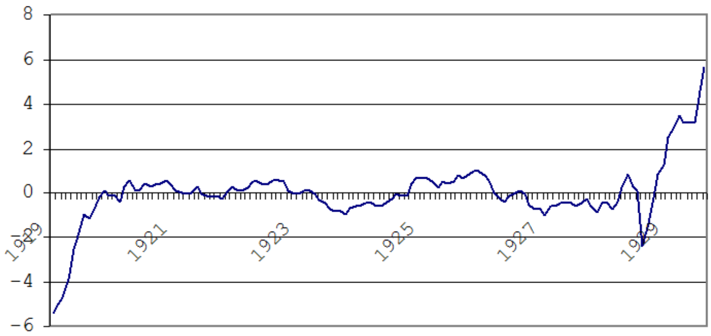

Figure 2. *AC-SUA*

In order to analyze the adjustment of significant theoretical cycles both with respect to the series of data of the curve A, it is interesting to consider the discrepancies (Figure 2). There is a strong discrepancy between SUA and AC in the beginning of the considered period. The reason is that the trend was calculated as a linear function adjusted by least squares, taking as intercept the value (of the series) considered normal. This method amplifies the explosive character of the extremes of the series. (Álvarez Vázquez, 2002).

Also, the prediction is acceptable, Consequently, based on the curve *A* data and using the periodogram, the sharp fall in speculation in September 1929 could have been foreseen. Unfortunately, the data are discontinued since August 1931. Table 5.

Table 5. *Prediction (curve A)*

			SUAC	AC	Resid.
1928	september	117	4.39024232	3.0475	-1.3427423
	october	118	4.34086063	3.8675	-0.4733606
	november	119	4.27043462	5.1475	0.87706538
	december	120	4.17927095	5.4675	1.28822905
1929	january	121	4.06782686	6.6075	2.53967314
	february	122	3.93670682	6.8075	2.87079318
	march	123	3.78665778	7.3075	3.52084222
	april	124	3.61856328	6.7675	3.14893672
	may	125	3.43343627	6.6275	3.19406373
	june	126	3.23241079	6.4075	3.17508921
	july	127	3.01673265	7.5975	4.58076735
	august	128	2.78774906	8.4075	5.61975094
	september	129	2.54689747	8.9575	6.41060253
	october	130	2.29569349	6.6575	4.36180651
	november	131	2.03571831	2.9275	0.89178169
	december	132	1.76860545	3.0075	1.23889455
1930	january	133	1.49602715	3.1275	1.63147285
	february	134	1.21968038	4.1075	2.88781962
	march	135	0.94127282	4.8075	3.86622718
	april	136	0.66250863	5.6175	4.95499137
	may	137	0.38507444	4.6375	4.25242556
	june	138	0.11062549	2.9375	2.82687451
	july	139	-0.1592279	2.5875	2.74672785
	august	140	-0.4229331	2.2875	2.71043311
	september	141	-0.6790081	2.1675	2.84650815
	october	142	-0.9260529	0.5875	1.51355287
	november	143	-1.1627601	0.0075	1.17026014
	december	144	-1.3879258	-0.5125	0.87542583
1931	january	145	-1.6004577	-0.3225	1.27795775
	february	146	-1.7993836	0.6775	2.47688364
	march	147	-1.9838579	0.4275	2.41135792
	april	148	-2.1531672	-0.2525	1.90066724
	may	149	-2.3067348	-1.2825	1.02423482
	june	150	-2.4441234	-1.2825	1.16162344
	july	151	-2.5650371	-1.2325	1.33253715
	august	152	-2.6693216	-1.7525	0.91682165
	september	153	-2.7569633	-2.3925	0.36446333
	october	154	-2.828087	-2.8325	-0.004413

It seems to be very relevant that 40 months later, the theoretical curve coincides with the actual value of the curve A (speculation).

The following chart illustrates the curve *B* (related to business) and the theoretical fit by theoretical cycles (128 and 32 months), Figure 3.

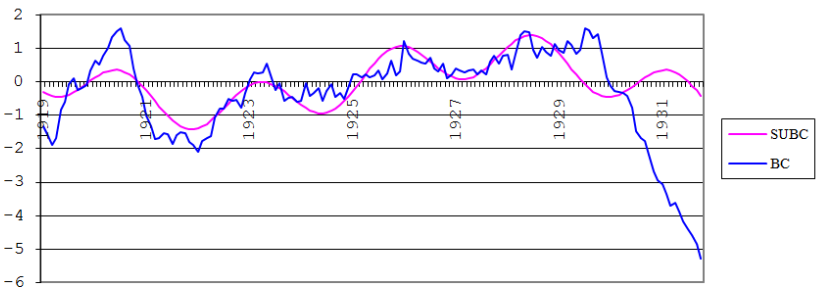

Figure 3. *SUBC is prediction BC actual data*

During the 20s, the curve is well adjusted to the data and follows the booms and busts in business, and it seems to herald the 1929 crisis. However, the prediction is evidently inaccurate. The fall in the theoretical curve is much slighter and shorter than the fall in the real series.

The third case is the curve *C* (related to monetary conditions), which makes use of the 128 and 32 month period theoretical cycles, Figure 4.

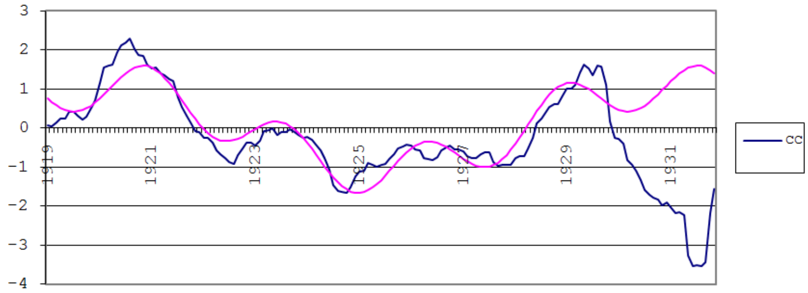

Figure 4. *SUC is prediction CC data*

As with the curve *B*, the initial fit is good and the theoretical movement heralds a fall before it occurs. In this case, since February 1929. However, the prediction falls short of the drop in monetary conditions that took place in the economy.

5. Aggregation

Finally, aggregation is not the source of regularity, in this case (Álvarez *et al.,* 2006). Harvard curves closely follow series of data. Their periodograms are very similar.

Curve BC, business, is related to series BCL, Bank Clearings Outside New York City for United States, Millions of Dollars, Monthly. Seasonally adjusted and without a linear trend against time (BCLB). However, the relationship is between cycles of frequencies 1 and 4.

Therefore, the HES selected two frequencies, but this selection implied that frequencies 2 and 3, which accounted for 59% of the variance, were eliminated. This was not unexpected, since Persons tried to choose the most empirically relevant movements, from the experience. The difference between the frequencies selected, and the two main harmonic components, is relevant. Table 6 and Figure 5.

Table 6. *Periodogram BC is Harvard business curve*

BCLB is banks clearings outside New York.

frequency	periods	BC	BCLB
1	128	37.0873842	21.4269319
2	64	3.21835563	40.6076936
3	42.67	3.76837128	18.3031092
4	32	27.6891847	17.5035147
5	25.6	7.4659789	1.1976405
6	21.33	1.89643057	0.51418232
7	18.29	3.08785633	0.15382438
8	16	0.38641408	0.02775914
9	14.22	0.17165098	0.02133787
10	12.8	1.25428361	0.01159312

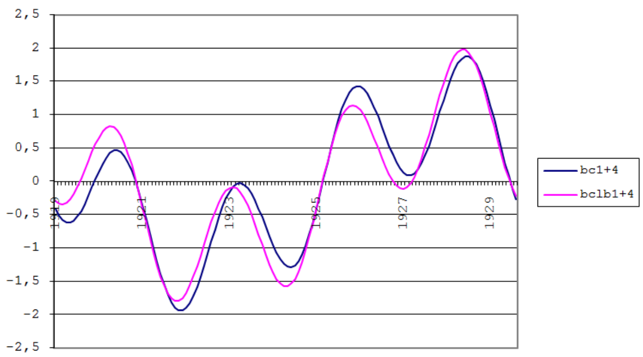

Figure 5. *BC versus BCLB, Frequencies 1 and 4*

Curve A and the prices of industrial firms stocks have equivalent theoretical cycles. ISPC is industrial stock price index, Dow-Jones, dollars per share. Series without a linear trend against time. Table 7 and figure 6.

Table 7. *Periodogram. AC is Harvard speculation curve*

ISPC is industrial stock price index.

Frequency	periods	AC	ISPC
1	128	60.44856795	54.25599754
2	64	14.18542059	13.10585921
3	42.67	3.005804504	7.848555265
4	32	1.388019882	3.8418128
5	25.6	2.55070546	3.456937618
6	21.33	2.090468347	2.990122307
7	18.29	1.984915617	2.215940716
8	16	1.767068871	1.694536488
9	14.22	1.757292337	1.278189336
10	12.8	1.516636256	0.68836015

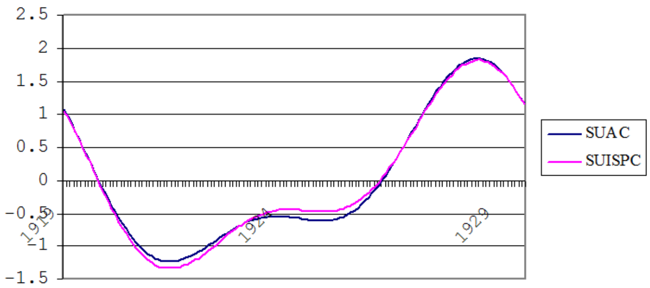

Figure 6. *Relationship between two main theoretical frequencies of AC and ISPC*

Curve C and interest rates RCP have both two theoretical cycles with the same frequency, which give reason of the 85% of observed variation. And SUCC, SURCP, are the aggregation of the two most important theoretical cycles, found by application of periodogram. Table 8 and figure 7.

Table 8. *Periodogram CC is Harvard money curve*

RCP is Commercial Paper Rates.

frequency	periods	CC	RCP
1	128	65,4845431	64,4897279
2	64	4,59390189	7,0731819
3	42,67	0,96403396	3,84232768
4	32	20,6334814	19,9075752
5	25,6	1,84932066	1,68909988
6	21,33	2,80147252	0,61056186
7	18,29	0,03215129	0,36046903
8	16	0,40377651	0,09586093
9	14,22	0,02848782	0,07154367
10	12,8	0,16478534	0,12828984

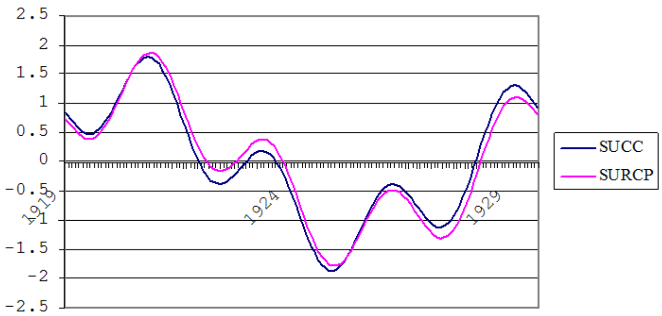

Figure 7. *Curves CC and RCP, Frequencies 1 and 4*

As a conclusion, aggregation is not relevant with respect to individual series (Álvarez *et al.,* 2006, p.5). Cycles are nor the result of previous aggregation.

6. Capacity of prediction

The series ISPC allows us to contrast prediction versus a longer series of data. If we extend until December of 1933, the theoretical cycles detected by periodogram also foretell the slight recovery that began to occur in the prices of the stock market. Figure 8 and Table 9.

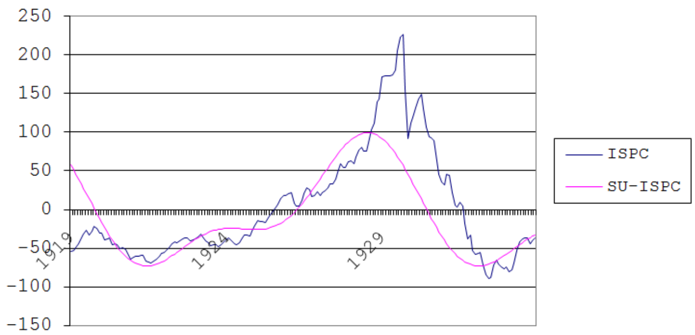

Figure 8. *ISPC prediction*

Table 9. *Prediction*

		t	SU-ISPC	ISPC	Resid
1929	september	1	57.58303339	226.102344	168.5193106
	october	2	51.84980698	155.252344	103.402537
	november	3	45.89394083	91.952344	46.05840317
	december	4	39.75219917	110.952344	71.20014483
1930	january	5	33.46251933	119.402344	85.93982467
	february	6	27.06369745	131.152344	104.0886466
	march	7	20.59506736	142.002344	121.4072766
	april	8	14.09617545	149.252344	135.1561685
	may	9	7.606454647	130.452344	122.8458894
	june	10	1.164900386	106.902344	105.7374436
	july	11	-5.190248262	93.552344	98.74259226
	august	12	-11.42181955	92.552344	103.9741635
	september	13	-17.49400913	88.752344	106.2463531
	october	14	-23.37266657	62.502344	85.87501057
	november	15	-29.02556562	44.702344	73.72790962
	december	16	-34.42265579	35.902344	70.32499979
1931	january	17	-39.53629305	31.002344	70.53863705
	february	18	-44.34144738	45.302344	89.64379138
	march	19	-48.81588553	43.802344	92.61822953
	april	20	-52.94032717	21.752344	74.69267117
	may	21	-56.69857324	5.202344	61.90091724
	june	22	-60.0776053	3.052344	63.1299493
	july	23	-63.06765502	9.102344	72.16999902
	august	24	-65.66224346	3.552344	69.21458746
	september	25	-67.85818964	-17.897656	49.96053364
	october	26	-69.65558869	-38.147656	31.50793269
	november	27	-71.05775972	-32.847656	38.21010372
	december	28	-72.07116418	-53.447656	18.62350818
1932	january	29	-72.70529553	-57.697656	15.00763953
	february	30	-72.97254142	-57.347656	15.62488542
	march	31	-72.88801985	-55.197656	17.69036385
	april	32	-72.46939096	-72.197656	0.271734961
	may	33	-71.73664634	-84.397656	-12.66100966
	june	34	-70.71187807	-89.397656	-18.68577793
	july	35	-69.41902976	-88.497656	-19.07862624
	august	36	-67.88363199	-71.847656	-3.96402401
	september	37	-66.13252501	-65.247656	0.884869007
	october	38	-64.19357114	-70.947656	-6.754084857
	november	39	-62.09536001	-74.047656	-11.95229599
	december	40	-59.86690928	-77.397656	-17.53074672
1933	january	41	-57.53736399	-74.397656	-16.86029201
	february	42	-55.13569736	-81.097656	-25.96195864
	march	43	-52.69041601	-78.497656	-25.80723999
	april	44	-50.22927247	-69.547656	-19.31838353
	may	45	-47.77898779	-52.947656	-5.16866821
	june	46	-45.36498691	-42.447656	2.91733091
	july	47	-43.01114942	-37.697656	5.313493421
	august	48	-40.73957806	-37.397656	3.341922062
	september	49	-38.57038722	-36.797656	1.772731221
	october	50	-36.52151347	-44.597656	-8.076142529
	november	51	-34.60854995	-40.797656	-6.189106055
	december	52	-32.84460614	-37.197656	-4.353049862

It is a long prediction of 52 months. From august 1929 until 1933 December. The HES affirmed that Harvard curves moved in the order from A to B, and from B to C, as I indicated. If this was the case, then the Depression could have been predicted. If the harmonic analysis is used to predict the movement of the curve A, then there will be temporal order if the theoretical series observe it. Nevertheless, the maximums and minimums of the indicated theoretical curves do not maintain stable temporary relationships. For example, the curve SUAC has minimum in December of 1921 and maximum one in 1928 July. The curve SUBC has minimum in December of 1921 and maximum one in December of 1925. While, curve SUCC has minimum in June of 1922, maximum one in June of 1923 and minimum one in January of 1925. There is no stable perceivable relation in the time between the three. The HES would have been able to predict the Stock market crash, but not the economic Depression.

7. Conclusions

Periodogram, and harmonic analysis, was a well-known method in the 1920s. The application of the periodogram to Harvard curves *A, B* and *C*, in August 1929, would have signalled the collapse of speculation. That is, the sharp drop, from September 1929 on, in stock market prices and traded volumes, in the New York Stock Exchange. As well as the fall in the global volume of financial transactions, also based in New York. Nevertheless, this method, applied to Harvard curves, would not have been able to allow for the prediction of the Depression that was approaching.

Indeed, in the case of the curve *A*, related to speculation, the analysis signalled a strong fall. It also approximately predicted its magnitude. Taking into account the fact that Industrial stock price index had approximately the same theoretical cycles as the curve A, and considering the data until December 1933, the periodogram seems to allow for the prediction of the beginning of the slight recovery, from June 1932 on.

On the other hand, the theoretical cycles for curves B and C signalled a small, temporary decrease, in contrast with the sharp, much deeper and longer drop that actually occurred. The HES thought there was an important lag: first A, then B, finally C. Therefore, the collapse of speculation could have been considered as the cause of a probable Depression, months later. However, periodograms do not show this temporary preference between the curves. This method does not have, therefore, the capacity to predict the Great Depression.

Finally, ABC curves were the product of an aggregation that did not supposed any relevant change. Individual series did contain the regularities.

Therefore, all this work implies that the HES would have been able to predict the Stock market crash. And this result could be significative in order to reconsider the prediction of cycles in the stock market.

Appendix

Table 10. Data

		Dominguez et al. (1988).			NBER	NBER	Federal Reserve Bank of St. Louis
		Harvard			Commercial Paper Rates	Industrial stock price index, Dow-Jones.	Bank clearings outside NY for US
		Speculation	Business	Money	Rates	Dollars per share	Millions of Dollars
	DATA	A	B	C	RCP	ISP	BCL
1919	1	-1.13	-0.88	0.39	5.25	81.65	469.9
	2	-1	-1.14	0.36	5.18	82.45	414.8
	3	-0.96	-1.46	0.45	5.38	86.55	438.9
	4	-0.44	-1.23	0.55	5.38	91.15	442.6
	5	0.62	-0.4	0.56	5.38	99.4	461.7
	6	1	-0.16	0.73	5.53	103.6	483.4
	7	1.69	0.35	0.74	5.43	109.7	504.5
	8	1.22	0.54	0.64	5.38	103.25	489.7
	9	1.24	0.18	0.52	5.38	108.2	533.2
	10	1.63	0.26	0.61	5.38	113.9	584.4
	11	1.62	0.34	0.83	5.5	111.6	558.8
	12	1.16	0.76	1.02	5.88	105.8	593.7
1920	1	0.88	1.07	1.46	6	105.9	595.8
	2	0.38	0.95	1.87	6.4	96.5	522.7
	3	0.82	1.2	1.91	6.67	97.95	612.7
	4	0.88	1.44	1.93	6.82	99.45	595.6
	5	0.15	1.76	2.27	7.16	91.1	551.4
	6	0.05	1.94	2.44	7.72	91.7	597.8
	7	0.14	2.02	2.5	7.84	90.7	575.3
	8	-0.19	1.68	2.61	8	85.25	534
	9	-0.28	1.5	2.33	7.97	86.5	582.7
	10	-0.36	0.84	2.2	8	84.85	586.9
	11	-0.34	0.35	2.17	7.93	79.3	555.2
	12	-0.64	-0.01	1.95	7.88	72.2	547.9
1921	1	-0.97	-0.58	1.85	7.82	74.75	456.4
	2	-1.1	-0.88	1.87	7.75	75.7	409.9
	3	-1.24	-1.27	1.73	7.62	75.05	436
	4	-1.2	-1.25	1.68	7.56	77	423.2
	5	-0.95	-1.09	1.57	6.93	76.7	390.2
	6	-1.3	-1.14	1.53	6.71	69.2	417.9
	7	-1.36	-1.42	1.1	6.28	68.6	392.9
	8	-1.46	-1.16	0.85	5.95	66.95	392.7
	9	-1.31	-1.08	0.63	5.88	69.35	417.1
	10	-1.41	-1.09	0.46	5.62	71.7	433.6
	11	-1.04	-1.35	0.24	5.17	75.7	426.9
	12	-0.74	-1.44	0.2	5.12	79.8	436.9
1922	1	-0.94	-1.66	0.07	4.91	80.6	407.6
	2	-0.74	-1.34	0.07	4.88	83.75	399.3
	3	-0.6	-1.25	-0.06	4.79	87.2	432
	4	-0.24	-1.2	-0.26	4.56	91.3	425.4
	5	-0.14	-0.64	-0.35	4.28	93.95	438
	6	-0.2	-0.38	-0.46	4.03	93.55	466.9
	7	-0.02	-0.38	-0.55	3.94	95	434.5
	8	0.2	-0.08	-0.61	3.88	98.5	432.8
	9	0.28	-0.14	-0.39	4.19	99.2	465.3
	10	0.3	-0.1	-0.22	4.39	99.75	516.3
	11	-0.02	-0.34	-0.06	4.61	95.75	494.6
	12	-0.12	0.1	-0.06	4.62	97	503.8
1923	1	-0.04	0.52	-0.14	4.62	98.2	565.4
	2	0.14	0.71	-0.01	4.68	100.8	517
	3	0.24	0.69	0.24	5.03	103.9	558.9
	4	0.12	0.72	0.27	5.12	100.55	553.7
	5	-0.12	0.98	0.31	5.12	95.5	557.8
	6	-0.17	0.62	0.14	4.91	92.55	568.5
	7	-0.43	0.2	0.22	4.95	89.3	525.7
	8	-0.48	0.38	0.22	5.03	90.45	498.6
	9	-0.49	-0.13	0.29	5.12	90.75	512.3
	10	-0.56	-0.06	0.2	5.12	88.15	577.9
	11	-0.34	-0.03	0.14	5.09	90.65	557.9
	12	-0.24	-0.16	0.07	4.88	94.1	561.3
1924	1	-0.16	-0.14	0.09	4.88	97.8	573.65
	2	-0.09	0.39	0	4.78	98.8	537.31
	3	-0.1	0.01	-0.12	4.62	95.6	549.21
	4	-0.26	0.1	-0.25	4.62	91.95	563.61
	5	-0.33	0.24	-0.45	4.19	90.4	540.72
	6	-0.18	-0.12	-0.76	3.97	93.3	537.12
	7	0.03	0.16	-1.14	3.52	99.25	552.19
	8	0.21	0.36	-1.29	3.25	103.55	517.98
	9	0.09	-0.01	-1.32	3.12	102.9	557.52
	10	0.08	0.1	-1.35	3.12	101.65	614.45
	11	0.62	-0.08	-1.2	3.22	107.65	581.87
	12	0.93	0.24	-0.92	3.55	115.45	622.96
1925	1	0.84	0.66	-0.81	3.62	121.55	627.57
	2	0.9	0.66	-0.79	3.62	120.45	587.42
	3	0.74	0.58	-0.59	3.91	120.35	602.4
	4	0.5	0.66	-0.63	3.93	119.7	618.66
	5	0.79	0.56	-0.67	3.88	125.55	581.7
	6	0.82	0.64	-0.63	3.88	128.9	640.93
	7	0.94	0.78	-0.6	3.9	133.9	632.49
	8	1.26	0.5	-0.49	3.97	138.85	575.22

	9	1.26	0.69	-0.37	4.15	142.45	633.2
	10	1.5	1.06	-0.21	4.38	150.65	688.23
	11	1.78	0.64	-0.17	4.38	153.8	644.93
	12	1.87	0.75	-0.12	4.38	154.55	680.05
1926	1	1.82	1.65	-0.14	4.35	156.1	661.62
	2	1.74	1.28	-0.24	4.15	158.4	618.05
	3	1.35	1.11	-0.27	4.28	144.25	657.07
	4	1.24	1.06	-0.47	4.19	140.55	650.15
	5	1.34	1.01	-0.49	4.03	140.3	612.38
	6	1.75	0.98	-0.5	3.88	148.15	663.49
	7	2.04	1.14	-0.43	3.94	156.8	642.36
	8	2.4	0.84	-0.27	4.22	163.5	588.06
	9	2.46	0.74	-0.18	4.4	161.2	624.94
	10	2.18	0.99	-0.14	4.53	152.7	661.99
	11	2.19	0.55	-0.23	4.43	153.95	635.94
	12	2.47	0.65	-0.23	4.4	159.3	659.67
1927	1	2.4	0.82	-0.28	4.19	154.65	634.09
	2	3.06	0.76	-0.41	3.91	158.15	619.93
	3	3.27	0.72	-0.46	4	160.1	652.68
	4	3.63	0.76	-0.45	4.09	164.05	642.28
	5	3.82	0.8	-0.35	4.12	168.8	620.94
	6	4.08	0.66	-0.3	4.12	168.85	661.13
	7	4.14	0.78	-0.32	4.06	175.35	606.81
	8	4.46	0.66	-0.55	3.9	183.85	599.78
	9	4.88	1.05	-0.65	3.91	195.3	641.76
	10	4.66	1.2	-0.63	4	189.8	669.98
	11	4.56	0.98	-0.62	3.93	189.95	672.41
	12	5.11	1.22	-0.63	3.97	198	667.01
1928	1	5.32	1.23	-0.47	3.88	198.95	659.87
	2	5.07	0.79	-0.41	3.99	195.35	611.87
	3	5.52	1.26	-0.41	4.19	204.5	656.89
	4	6.26	1.82	-0.21	4.31	212.45	655.95
	5	6.94	1.93	0.07	4.55	216.3	683.49
	6	6.37	1.92	0.43	4.72	211.5	683.22
	7	6.23	1.38	0.56	5.09	210.85	617.87
	8	3.7	1.16	0.71	5.42	227.25	601.09
	9	4.72	1.46	0.86	5.59	239.3	642.14
	10	5.54	1.33	0.92	5.51	247.45	725.57
	11	6.82	1.2	0.92	5.38	274.9	696.66
	12	7.14	1.55	1.15	5.44	278.65	702.36
1929	1	8.28	1.4	1.33	5.5	307.25	710
	2	8.48	1.31	1.33	5.56	309	668.05
	3	8.98	1.64	1.43	5.69	308.85	668.75
	4	8.44	1.54	1.75	5.88	309.2	671.36
	5	8.3	1.26	1.95	6	310.25	647.63
	6	8.08	1.38	1.85	6	316.45	646.9
	7	9.27	2.03	1.68	6	341.45	690.34
	8	10.08	1.96	1.92	6.08	359.15	673.02
	9	10.63	1.74	1.9	6.12	362.35	672.8
	10	8.33	1.84	1.43	6.12	291.5	770.1
	11	4.6	1.3	0.49	5.41	228.2	735.39
	12	4.68	0.58	0.05	5	247.2	651.23
1930	1	4.8	0.31	0.04	4.9	255.65	595.85
	2	5.78	0.16	-0.08	4.62	267.4	555.96
	3	6.48	0.14	-0.51	4.1	278.25	558.45
	4	7.29	0.1	-0.63	3.88	285.5	572.42
	5	6.31	0.02	-0.78	3.68	266.7	551.96
	6	4.61	-0.33	-1.03	3.44	243.15	548.79
	7	4.26	-1.04	-1.27	3.15	229.8	553
	8	3.96	-1.23	-1.41	3	228.8	476.23
	9	3.84	-1.32	-1.47	3	225	496.89
	10	2.26	-1.74	-1.53	3	198.75	540.29
	11	1.68	-2.24	-1.66	2.97	180.95	465.68
	12	1.16	-2.5	-1.59	2.85	172.15	500.11
1931	1	1.35	-2.63	-1.73	2.82	167.25	462.7
	2	2.35	-2.9	-1.86	2.5	181.55	417.5
	3	2.1	-3.25	-1.85	2.53	180.05	422.73
	4	1.42	-3.17	-1.93	2.4	158	448.01
	5	0.39	-3.45	-2.96	2.12	141.45	416.34
	6	0.39	-3.72	-3.22	2.12	139.3	438.66
	7	0.44	-3.96	-3.2	1.95	145.35	413.35
	8	-0.08	-4.14	-3.23	1.88	139.8	361.52
	9	-0.72	-4.41	-3.12	1.88	118.35	380.83
	10	-1.16	-4.84	-1.87	3.35	98.1	384.24

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