Effects of Non-Economic Factors on the Cyclcal Fluctuations of Price Level in Korea

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I

There are a number of studies on the peculiarities of inflation in underdeveloped economies.[1] These studies are, however, confined to the cases of Latin American countries, and the essence of methodologies applied in the studies is basically estimations of linear parameters of an extended quantity equation with lagged variables. As it is generally observed, inflation in most of underdeveloped economies are, to some extent, affected by non-economic factors such as political instability, social disorder, abrupt institutional changes, etc. Sometimes, these factors underlying the basic movement of price level change are reflected in such variables as quantity of money supply, income velocity, gross national product. But sometimes they are not shown in the behavior of economic variables at all.

This paper attempts to investigate marginal contributions of non-economic factors to price level change in Korea by employing a simple harmonic analysis. The data used in the study are time-series wholesale price indexes observed at the end of each quarter beginning from 1952 through 1972. Since no GNP implicit deflator is available for each of quarters, the selection of WPI seems to be inevi-

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1) See, for example, Arnold C. Harberger, "The Dynamics of Inflation in Chile," in Carl Christ *et. al.*, *Measurement in Economics: Studies in Mathematical Economics and Econometrics in Memory of Yehuda Grunfeld* (Stanford: Stanford University Press, 1963) pp. 219—250, Jere R. Behrman *Price Determaination in an Inflationary Economy: The Dynamics of Chilean Inflation Revisited*, University of Pennsylvania Discussion Paper No. 151, 1970, (mimeographed), and Robert C. Vogel, "The Dynamics of Inflation in Latin America, 1950—1969," *American Economic Review* Vol. LXIV, No. 1 (March 1974) pp. 102—114.

table. This paper is accordingly a mixture of statistical analysis and verbal descripti on.

Ⅱ

A typical time-series analysis assumes that the data contain a trend, cyclical behavior and stochastic elements as follows:

$$X=f[T(t),\ C(t),\ u], \tag{1}$$

where X=time-series variables,

T=trend,

C=cyclical pattern,

t=time, and

u=stochastic disturbance term.

When the above equation is linearized, we may express it in the following form.

$$X=T(t)+C(t)+u. \tag{2}$$

Suppose further that the trend is in some way eliminatied. Then, we have

$$Y=X-T(t)=C(t)+u, \tag{3}$$

where Y is defined as a trend-eliminated time-sereis variable. In eliminating trend from X we may apply a polynomial regression, which takes an equational form as Equation (3):

$$T=\sum_{i=0}^{k}\alpha_i t^i, \tag{4}$$

where α_i denotes estimated linear parameters. Then, by replacing $T(t)$ with Equation(4), we have

$$Y=X-\sum_{i=0}^{k}\alpha_i t^i+u. \tag{5}$$

Let us represent Y as a trigonometric function to show its cyclical behavior as Eqaution (6)

$$Y=\mu\cos(\lambda t-\theta)+u, \tag{6}$$

where μ, λ and θ denote given constants. When Equation (6) is further extended, we hav(

$$Y=\beta_1\sin\lambda t+\beta_2\cos\lambda t+u, \tag{7}$$

where

$$\beta_1=\mu\cos\theta$$
$$\beta_2=\mu\sin\theta,$$

both of which are also constants. When λ is represented as a fraction of 2π, we have Equation (8) as

$$\lambda=\frac{2\pi}{k}, \tag{8}$$

and Equation (7) is again represented as Equation (9) as

$$Y=\beta_1\sin\left(\frac{2\pi}{k}t\right)+\beta_2\cos\left(\frac{2\pi}{k}t\right)+u. \tag{9}$$

Since Equation (6) is periodic with the period of $2\pi/\lambda$,[2] Equation (8) tells immediately that the variable Y is periodoc with the period of k. Equation (9) may be practically revised as Equation (10):

$$Y=\beta_0+\beta_1\sin\left(\frac{2\pi}{k}t\right)+\beta_2\cos\left(\frac{2\pi}{k}t\right)+u. \tag{10}$$

When β_i are estimated by an usual method, we obtain both period and amplitude as

$$\text{period}=k, \tag{11}$$
$$\text{amplitude}=2\mu=2\sqrt{\beta_1^2+\beta_2^2}. \tag{12}$$

However, we know that k and β_i cannot be simultaneously estimated by an usual least square method. Trial and error iterative method may be employed in estimating k and β_i. With help of a periodogram,[3] a number of k's are selected,

2) For proof, see T. W. Anderson, *The Statistical Analysis of Time Series*, (New York: John Wiley and Sons, Inc., 1972), p. 93.
3) For detailed method, see William I. Greenwald, *Statistics for Economics* (Columbia, Ohio: Charles E. Merrill Books, Inc., 1963) pp. 297—303.

and with each of predetermined k's, β_i may be estimated by ordinary least square method. The most preferred equation in terms of estimated statistics is, then, chosen to be used in analysis.

Ⅲ

Application of polymomial regression to estimations of the secular trend in the time-series data of WPI results in the following three equations;

$$\hat{X}_t = -6.7826 + 1.4026t \quad (13)$$
$$\qquad (39.78)$$

$$R=0.975 \qquad SEE=7.84 \qquad F(1, 82)=1582.1$$

$$\hat{X}_t = 13.9313 + 0.01624t^2 \quad (14)$$
$$\qquad (66.06)$$

$$R=0.991 \qquad SEE=4.79 \qquad F(1, 82)=4364.3$$

$$\hat{X}_t = 8.2399 + 0.3545t + 0.0123t^2 \quad (15)$$
$$\qquad (4.52) \quad (13.78)$$

$$R=0.993 \qquad SEE=4.31 \qquad F(2, 81)=2708.5$$

where X denotes WPI with 1970=100, and t denotes discrete time variable with 1 for the first quarter of 1952, 2 for the second quarter of 1952, so on until 84 for the last quarter of 1972.[4] R, SEE and F are the correlation coefficient, standard error of estimates and F statistic, respectively. Analysis of variance and other statistics indicate that Equation (15) represents the best trend in terms of goodness of fit. Defining the obtained time trend as Equation (16)

$$T = \hat{X}_t, \quad (16)$$

the cyclical portion of the time series is calculated as Equation (17)

$$Y_t = X_t - \hat{X}_t. \quad (17)$$

In Equation (17), it is immediately clear that Y_t is estimated residual of Equation (15).

Since important economic variables which are considered to affect the change in price level have a very strong time trend, we may establish that

4) See Appendix I at the end of this paper.

$$\rho(X_t,\ Z_t) \neq 0 \tag{18}$$

the correlations between X_t and the economic variables Z_t are significantly different from zero as stated by Equation (18). On this preposition, it may be conjectured that the cyclical behavior of Y_t is primarily attributed to non-economic factors.

With the use of a periodogram, a number of candiate periods, k's, are obtained as follows:

$$k=30,\ 36,\ 40,\ 45,$$

which dictate that

$$2\pi/k=12,\ 10,\ 9,\ 8.$$

The best estimation of Equation (10) out of using each of candidate k's above are obtained as follows:

$$Y_t = 0.4138 - \underset{(-4.491)}{1.6597}\sin\left(\frac{2\pi}{36}t\right) - \underset{(-12.417)}{4.7184}\cos\left(\frac{2\pi}{36}t\right) + \hat{u}_t \tag{19}$$

$$R=0.8292 \qquad SEE=0.241 \qquad F(3, 80)=89.102$$

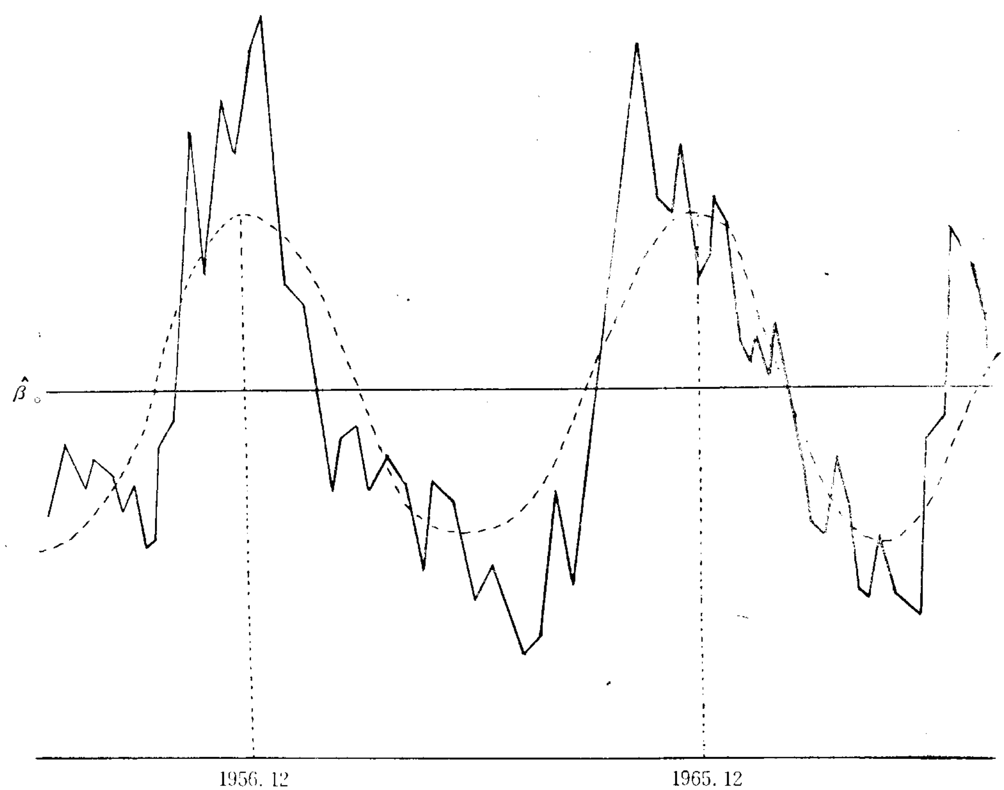
Accordingly, it is determined that the best k is 36, and estimated amplitude of a cycle, 2μ, is equal to 10.0038. All statistics estimated are acceptable. When Y_t and $\hat{Y}_t$ are scattered on a diagram, we obtain Figure 1.[5] $\hat{Y}_t$ is defined as Equation (20)

$$\hat{Y}_t = Y_t - \hat{u}_t \tag{20}$$

As it is represented by the optimal k, the period of a cycle is 36 quarters, i.e., nine years. This indicates that when secular trend is eliminated from WPI series, the price level reaches a peak generally with an interval of nine years.

5) See Appendix II for statistics used for drawing Figure 1.

Figure 1 Actual and Established Cycles



IV

As it is shown in Figure 1, the first peak is found around the second quarter of 1956~the second quarter of 1957, and the second peak around the second quarter of 1964~the second quarter of 1965. Even though the third one is not shown in the figure, it is easy to forecast that it would be around 1973~1974.

The first peak may be partly explained by the fact that the fall harvest of 1956 was a bad one, which must have been caused by undesirable climatic conditions such as short or excessive precipitation,[6] low temperature, etc. Since the agricultural production in the 1950's was very keenly sensitive to climatic condition as compared to other factors the magnitute of the impact must have been great. In an economically stagnant society where no significant inputs of capital and technology are made annually, the largest share of agricultural production is decided by climatic conditions, and it eventually gives an impact on price level.

The second peak may also have been partially affected by bad agricultural production. However, this time the magnitude must have been quite less. The year 1962 and 1963 were consecutive two years in which the grain harvest was worst. The bad harvest was also caused by undesirable climatic conditions. In addition, the second peak may be also partially explained by the political and social disorder in 1964 and 1965, when the military regime was transferred to civilian hands and the new government's attempt to renormalize the relation between Korea and Japan was harshly confronted by mass protest.

From the above reasoning, we may derive a conclusion that even though we cannot completely discard the possibiliity of mere coincidence, the climatic conditions seem to affect cyclical fluctuations of price level through the variation of grain productin. Furthermore, when climatic factors had less impact on grain production due to the development of agricultural technology and capital formation, other factors such as political instability seems to affect the price level by forming pessimistic expectation among people. However, the obtained period of a cycle is hardly associated to either one of these two factors alone seperately. In order to investigate the regularity of cycles, an extensive study is needed based on a large sample.

6) The causal relationship between agricultural production and precipitation is somewhat extensively treated in Suk Bum Yoon, "The Effects of Precipitation on Agricultural Production in Korea," *Yonsei Nonchong* (Yonsei Essays) Vol. 10 (1973), pp. 111—19.

APPENDIX I

Original Data

Year	Quarter	t	X_t	T_t	Y_t
1952	3	1	5.08	8.60674	−3.52674
1952	6	2	7.10	8.99824	−1.89824
1952	9	3	8.55	9.41441	−0.86441
1952	12	4	7.25	9.85523	−2.60523
1953	3	5	8.24	10.32072	−2.08072
1953	6	6	8.49	10.81087	−2.32087
1953	9	7	8.09	11.32568	−3,23568
1953	12	8	9.17	11.86515	−2.69515
1954	3	9	8.46	12.42928	−3,96928
1954	6	10	9.30	13.01808	−3.71808
1954	9	11	12.58	13.63153	−1.05153
1954	12	12	13.85	14.26965	−0.41965
1955	3	13	16.50	14.92242	1.56757
1955	6	14	19.00	15.61986	3.38013
1955	9	15	22.70	16.33196	6.36803
1955	12	16	19.80	17.06872	2.73127
1956	3	17	22.20	17.83014	4.36985
1956	6	18	26.70	18.61622	8.08377
1956	9	19	27.30	19.42697	7.87302
1956	12	20	27.30	20.26237	7.03762
1957	3	21	29.50	21.12244	8.37755
1957	6	22	30.40	22.00716	8.37928
1957	9	23	29.10	22.91655	6.18344
1957	12	24	27.10	23.85060	3.24939
1958	3	25	27.10	24.80931	2.29068
1958	6	26	27.90	25.79268	2.10731

Year	Quarter	t	X_t	T_t	Y_t
1958	9	27	27. 60	26. 80071	0. 79928
1958	12	28	26. 40	27. 83341	—1. 43341
1959	3	29	26. 20	28. 89076	—2. 69076
1959	6	30	28. 30	29. 97278	—1. 67278
1959	9	31	29. 50	31. 07945	—1. 57945
1959	12	32	28. 90	32. 21079	—3. 31079
1960	3	33	30. 40	33. 36679	—2. 6679
1960	6	34	31. 60	34. 54745	—2. 94745
1960	9	35	31. 70	35. 75277	—4. 05277
1960	12	36	31. 00	36. 98275	—5. 98275
1961	3	37	34. 60	38. 23740	—3. 63740
1961	6	38	35. 40	39. 51670	—4. 11670
1961	9	39	35. 50	40. 82067	—5. 32067
1961	12	40	35. 40	42. 14929	—6. 74929
1962	3	41	37. 20	43. 50258	—6. 30258
1962	6	42	38. 80	44. 88053	—6. 08053
1962	9	43	39. 20	46. 28314	—7. 08314
1962	12	44	39. 30	47. 71041	—8. 41041
1963	3	45	40. 70	49. 16234	—8. 46234
1963	6	46	45. 40	50. 63893	—5. 23893
1963	9	47	51. 50	52. 14019	—0. 64019
1963	12	48	51. 10	53. 66610	—2. 56610
1964	3	49	57. 90	55. 21668	2, 68331
1964	6	50	65. 40	56. 79192	8. 60807
1964	9	51	65. 30	58, 39182	6. 90817
1964	12	52	65. 00	60. 01638	4. 98361
1965	3	53	66. 60	61. 66560	4. 93439
1965	6	54	69. 20	63. 33948	5. 86051
1965	9	55	69. 80	65. 03802	4. 76197

Year	Quarter	t	X_t	T_t	Y_t
1965	12	56	70.00	66.76123	3.23876
1966	3	57	72.00	68.50909	3.49090
1966	6	58	75.70	70.28162	5.41837
1966	9	59	76.40	72.07881	4.32118
1966	12	60	76.10	73.90066	2.19933
1967	3	61	76.80	75.74717	1.05282
1967	6	62	78.90	77.61834	2.08165
1967	9	63	80.90	79.51417	1.38582
1967	12	64	81.80	81.43466	0.36533
1968	3	65	84.90	83.37982	1.52017
1968	6	66	85.80	85.34963	0.45036
1968	9	67	85.90	87.34411	−1.44411
1968	12	68	87.60	89.36325	−1.76325
1969	3	69	90.30	91.40705	−1.10705
1969	6	70	91.70	93.47551	−1.77551
1969	9	71	92.40	95.56863	−3.16863
1969	12	72	94.20	97.68641	−3.48641
1970	3	73	98.40	99.82885	−1.42885
1970	6	74	99.90	101.99596	−2.09596
1970	9	75	101.20	104.18773	−2.98773
1970	12	76	102.90	106.40415	−3.50415
1971	3	77	104.30	108.46524	−4.34524
1971	6	78	107.70	110.91099	−3.21099
1971	9	79	112.00	113.20140	−1.20140
1971	12	80	116.30	115.51647	0.78353
1972	3	81	122.40	117.85621	4.54379
1972	6	82	124.70	120.22060	4.47940
1972	9	83	125.70	122.60965	3.09035
1973	12	84	126.20	125.02337	1.17663

APPENDIX II

Derived Statistics

t	Y_t	$\hat{Y}_t$
1	−3. 5267400	−4. 5211770
2	−1. 8982400	−4. 5877487
3	−0. 8644100	−4. 5023502
4	−2. 6052300	−4. 2675766
5	−2. 0807200	−3. 8905613
6	−2. 3208700	−3. 3827595
7	−3. 2356800	−2. 7596005
8	−2. 6951500	−2. 0400192
9	−3. 9692800	−1. 2458790
10	−3. 7180800	−0. 4013094
11	−1. 0515300	0. 4680277
12	−0. 4196500	1. 3357179
13	1. 5675700	2. 1753961
14	3. 3801300	2. 9615504
15	6. 3680300	3. 6702938
16	2. 7312700	4. 2800911
17	4. 3698500	4. 7724140
18	8. 0837700	5. 1323033
19	7. 8730200	5. 3488246
20	7. 0376200	5. 4153986
21	8. 3775500	5. 3900026
22	8. 3928300	5. 0952310
23	6. 1834400	4. 7182180
24	3. 2493600	4. 2104181
25	2. 2906800	3. 5872609
26	2. 1073100	2. 8676806

t	Y_t	$\hat{Y}_t$
27	0. 7992800	2. 0735410
28	−1. 4334100	1. 2289725
29	−2. 6907600	0. 3596357
30	−1. 6727800	−0. 5080544
31	−1. 5794500	−1. 3477339
32	−3. 3107900	−2. 1338895
33	−2. 9667900	−2. 8426337
34	−2. 9474500	−3. 4524327
35	−4. 0527700	−3. 9447574
36	−5. 9827500	−4. 3046491
37	−3. 6374000	−4. 5211726
38	−4. 1167000	−4. 5877489
39	−5. 3206700	−4. 5023553
40	−6. 7492900	−4. 2675858
41	−6. 3025800	−3. 8905752
42	−6. 0805300	−3. 3827765
43	−7. 0831400	−2. 7596221
44	−8. 4104100	−2. 0400419
45	−8. 4623400	−1. 2459051
46	−0. 5238930	−0. 4013354
47	−0. 6401900	0. 4680025
48	−2. 5661000	1. 3356913
49	2. 6833100	2. 1753696
50	8. 6080700	2. 9615274
51	6. 9081700	3. 6702745
52	4, 9836100	4. 2800738
53	4. 9343900	4. 7724012
54	5. 8605100	5. 1322943
55	4. 7619700	5. 3488203

t	Y_t	$\hat{Y}_t$
56	3.2387600	5.4153989
57	3.4909000	5.3300074
58	5.4183700	5.0952411
59	4.3211800	4.7182315
60	2.1193300	4.2104345
61	1.0528200	3.5872791
62	2.0816500	2.8677054
63	1.3858200	2.0735668
64	0.3653300	1.2289977
65	1.5201700	0.3596598
66	0.4503600	−0.5080260
67	−1.4441100	−1.3477081
68	−1.7632500	−2.1338568
69	−1.1070500	−2.8426150
70	−1.7755100	−3.4524179
71	−3.1686300	−3.9447437
72	−3.4864100	−4.3046403
73	−1.4288500	−4.5211685
74	−2.0959600	−4.5877492
75	−2.9877300	−4.5023599
76	−3.5041500	−4.2675957
77	−4.3452400	−3.8905881
78	−3.2109900	−3.3827949
79	−1.2014000	−2.7596415
80	0.7835300	−2.0400666
81	4.5437900	−1.2459288
82	4.4794000	−0.4013633
83	3.0903500	0.4679742
84	1.1766300	1.3356665

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