Cattle and Pig Cycles in Australia
– Do They Still Exist?

by

Jim Longmire and Arlene Rutherford[1]

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ABSTRACT

Forces giving rise to cycles in the cattle and pig industries are reviewed. The dual roles of cattle (as beef machines or beef) and biological lags in livestock production are key factors giving rise to internally–fuelled cycles. However, the changing structure of livestock industries can dampen or interrupt the cyclical pattern. Using spectral and time–series analysis, the presence of cycles is tested using data from Australia since early this century. The analysis is set up to test whether the cycles are changing over time, in terms of their length and amplitude. It is concluded that the cycles for cattle and pigs still exist in Australia. The cattle cycle appears to be lengthening and strengthening whilst the pig cycle appears to have been dampened. The main cycle in cattle numbers has an average length of twelve years, while that for pigs is about four years.

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1 Senior Lecturer and Doctoral Candidate, respectively, Department of Economics, The University of Queensland, St Lucia 4072.

Cattle and Pig Cycles in Australia – Do They Still Exist?

Jim Longmire and Arlene Rutherford[2]

Background

Cattle and pig cycles have intrigued many people. They are phenomena which have been observed since early applications of economics to agriculture (Ezekiel 1927). The aim of this paper is to improve understanding of the cattle and pig cycles in Australia, and to assess what is happening to them over time. In particular, analysis is undertaken to test for the presence of such cycles and to assess if they are diminishing through time.

To provide a framework for considering the livestock cycles, the main factors giving rise to cattle and pig cycles in Australia are discussed. After introducing the concept of a cycle, some tests on the presence of these cycles in Australia are presented. For purposes of comparison, analysis is also undertaken on the presence (or absence) of cycles in sheep production in Australia. An attempt is then made to test whether the cattle and pig cycles have dampened or changed in length in the past two decades, in particular as the industries changed in structure. A final discussion alludes to why the presence of cycles is not contradictory with rational economic behaviour.

For the sake of brevity, a number on issues in the Australian beef and pigmeat markets are swept aside. As well, the livestock industries, markets and the livestock cycles are considered from an Australia-wide point of view. The focus of the cyclical analysis is on livestock numbers, slaughtering and production using longer-term historical data.

What Is a Cycle?

The Pocket Oxford English Dictionary defines a cycle as a 'round of events proceeding in regular succession'. A number of cycles surround our day-to-day living, such as: the motion of a pendulum, ocean waves, oestrus, wheel wobbles, AC electricity, biorhythms and sunspots. Some of these are perfectly regular and some much less regular.

The basic characteristics of a cycle are outlined in Figure 1. They are:

- length, the time for one complete round of the cycle
- frequency, the number of cycles per unit of time
- amplitude, half the difference between the peak of the cycle and the trough of the cycle
- phase, a particular time sequence of the cycle

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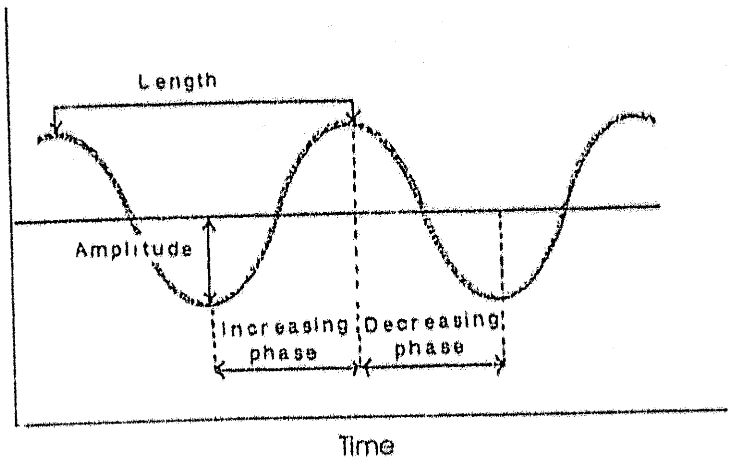
Figure 1 Characteristics of a Cycle



A notable economist, Boulding (1948, p.375) describes economic cycles as fluctuations in economic quantities (such as prices, employment and production) that have some degree of regularity and also have a fairly regular period of recurrence. Tomek and Robinson (1972, p.174) put it more simply: 'A cycle is a pattern that repeats itself regularly over a period of years.' Following this definition, regular seasonal patterns thus are not considered as cycles, which is standard practice in any introductory textbook on time series analysis. Two main types of economic cycles have been observed, business cycles and commodity cycles. Of the commodity cycles, the most commonly cited are for pigs and cattle, although cycles have been noted for such varied commodities as fish, potatoes, watermelons and cocoa.

In economics, the term 'cycle' can be used at two levels. In the more general sense it refers to the fluctuations in a set of economic quantities which result from the same cyclical forces in the market. The 'cattle cycle' in this sense refers to cyclical fluctuations in numbers, slaughterings and prices and other market indicators resulting from the same cyclical forces. In the more specific sense the term 'cycle' refers to cyclical fluctuations in a particular economic quantity, for example, cattle numbers. For this paper, unless otherwise stated 'cattle cycle' refers in the general sense to fluctuations in cattle numbers, slaughterings and prices which result from the same cyclical forces in the market.

Evidence on Cycles in Livestock Production

Numerous empirical studies overseas attest to the presence of livestock cycles (Breimyer 1955, Harlow 1960, Maki 1972, Kulshreshtha and Wilson 1973, Bartola 1977). Two main forces giving rise to the cycles have been proposed:

- livestock have a dual role in the production process as capital goods and as consumption goods (Jarvis 1974) and biological lags in production prevent the rapid adjustment of the capital stock

- current price and profit expectations are based partially on historical movements in prices, and the lagged adjustments in expectations give rise to "overshooting" and classical cyclical behaviour (Harlow 1960, Meadows 1970).

The cattle cycle in Australia was highlighted by Gutman (1950). It was analysed using spectral analysis by Hinchy (1978). The rationale for the presence of the cycle in Australia outlined in Reynolds (1977), who argued that it was likely to be sizeably shocked by random external factors. Griffith (1977) analysed the presence of the pig cycle.

The overwhelming evidence on livestock cycles is no reason to accept that they should persist. Indeed, one school of thought is that as producers and the industry learn more about cyclical behaviour, some producers will tend to go counter-cyclical and thus dampen the cycle through time. A better ability to forecast cycles would lead to this outcome. Another school of thought is that as the livestock industries restructure and become more intensive and specialised, there will be a more constant capital stock requirement and a more even flow of product on to markets. There will be fewer "marginal" producers who swing in and out of production and the cycles will eventually dissipate.

Counter to these arguments is the historical perspective of Kindleberger (1987), who argues that humans have a propensity to overshoot in their decisions in financial markets. In the upswings, capital stock become over-priced. An unanticipated event then triggers a turn in the market which rapidly gives rise to financial crises as capital stock values are written down. The aftermath can be a lengthy period of prudence in which investors are slow to rebuild confidence and tend to under-value resources and capital stock, in relation to future earnings. The dramatic corporate losses experienced by some key players in the Australian business sector in the late 1980s and early 1990s, followed by the hesitancy of the business sector, is an example of such behaviour in action. Evidence of overshooting in foreign exchange markets in the short term adds weight to the phenomena described so insightfully by Kindleberger.

Cyclical versus Non-Cyclical Forces

In addressing this question, the first distinction to make is between forces in the livestock industries which are cyclical and those which are not. After all, only cyclical forces can fundamentally give rise to a cycle.

Forces which are more random than cyclical will at times tend to fuel the cycle and at other times tend to interrupt the cycle. An example of a force which is more random than cyclical is the incidence of rainfall. The impact of drought on beef supply in Australia is well-known. However, scientific evidence generally suggests the absence of regular long-term cycles in rainfall in Australia.[3]

Structural changes in the industry (changes of a more permanent nature rather than cyclical) can also affect the cycle. Griffith (1977) has argued that the traditional pig cycle in Australia was much less evident during the 1960s and early 1970s because the industry has become much more capital-intensive. On a similar basis, U.S. analysts have argued that the cattle cycle in the U.S. occurs mainly in the cow-calf sector (Williams and Stout 1964). A number of structural changes in the Australian beef industry have occurred: increased herd and property size and the emergence of more specialised breeding and fattening operations, including a sizeable lot feeding industry. The impact of these changes on the cattle cycle, however, is probably less than the impact structural changes had on the pig cycle as suggested by Griffith.

Internal Cyclical Forces and External Cyclical Forces

The second distinction to make is between 'internal cyclical forces' and 'external cyclical forces'. For the Australian cattle market, the major external force is export demand. It has already been argued that a cattle cycle is evident in the U.S. a. that U.S. prices of manufacturing beef exert a strong influence on Australian saleyard prices of cattle (Hinchy 1978). As a consequence, the U.S. cattle cycle is probably being transmitted through to the Australian market and the Australian producer. Factors influencing the transmission of the U.S. cycle through to the Australian market include the type of meat import law adopted by the U.S., the type of beef export diversification scheme operated in Australia and the proportion of total beef exports going to the U.S.

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[3] To the extent that longer-term rainfall cycles do exist in Australia, their presence is weak statistically in relation to the random fluctuations. The establishing of a regular relationship between Pacific Ocean temperatures and rainfall patterns in Australia by itself is not evidence of a regular cycle. A regular cycle in rainfall from the El Nino effect could be hypothesised if the differences in ocean temperatures occurred regularly. To the long-term weather forecasters chagrin, they do not.

The U.S. cattle cycle is probably also transmitted to the cattle markets of Canada, New Zealand, Mexico and Central America. But the demand for exports of Australian beef in other importing nations (such as Japan, South Korea, and South East Asia) is much less cyclical and more subject to random interference of a political nature.

Other external causes of livestock cycles in Australia may be:

- international and domestic business cycles impinging on demand for product, as Australian economic circumstances are increasingly linked to global circumstances

- cycles in weather patterns overseas.

Evidence on the latter is very mixed, as for Australia. Undoubtedly business cycles predominate internationally, but their regularity is subject to considerable debate, beyond the scope of this paper.

For the pig industry of Australia, oriented primarily to the domestic market, there is even less likelihood that a cycle could be fuelled from international sources. However, international forces still impinge heavily on producers' returns, directly through feed prices and indirectly through the general level of meat prices (driven by international prices of beef).

In hypothesising potential causes of livestock cycles in Australia, it can be argued that the various external factors impinging on the livestock markets are likely to be more random in effect. There is no reason why weather effects in Australia should be related to international business cycles, although they may be good reasons why export demand is linked to cycles in economic activities overseas.

What of the internal forces fuelling livestock cycles? There are three main ones:

- biological lags in production

- lags in formation of producer expectations of price and profitability

- the dual role of cattle in beef production, being either capital stock (beef machines) or realised output (beef).

Biological lags and lags in formation of price expectations are important in determining the length of a cycle (Meadows 1970, McClements 1970). Biological lags in a production also explain why the herd building phase of the cattle cycle is longer on average than the herd liquidation phase. But the key to understanding internally-fuelled cycles for cattle (and pigs) is the fact that cattle have a dual role in production. They either remain part of the beef producer's capital stock (if kept for breeding, rearing or fattening) or they are sold to generate current income. Simply, cattle are either beef machines or beef – pigs are pigmeat machines (or pigmeat). Producers are seen as investment managers attempting to manage, amongst other things, an investment portfolio of cattle (Jarvis 1974).

For beef, herd build-up can take a number of years and negative supply response in the short-term is a consequence of that. Because of these lags, the length of the beef cycle observed overseas, and earlier in Australia, has ranged between 8-13 years. Factors slowing rates of herd buildup for cattle are low rates of fertility (well less than unity), lengthy gestation periods (over 10 months) and lengthy time between birth of a female and first calving by the same female (typically two years or more). In contrast, most studies have found pig cycles to average four years in length, well less than beef. This can be explained by the much higher fertility of pigs (upwards of 20 surviving offspring per year), shorter gestation (about 4 months) and a somewhat younger age for sows at first reproduction.

It must be recognised that building livestock numbers involves a different process to running them down, in which additional stock (capital) can be readily sent to market. The upswing phase of a cycle in cattle numbers is thus likely to be typically longer and less rapid in terms of change than the downswing phase. For pigs this is less likely to be the case because of the additional "power" to rebuild herds, as compared to cattle.

The extent to which delays exist in the formation of producers' expectations is contentious, especially since the advent of the rational expectations hypothesis. This is difficult to refute, and modern communications mean that livestock producers incur few transaction costs in monitoring market prices and developments. As farm size grows, these transaction costs become an even smaller component of total costs so expectations should more closely match market developments than perhaps they did earlier this century. Nevertheless, there remains a tendency for forecasts (and thus expectations) to be based on recent past price movements in markets and thus for some lags to exist in the formation of producer pricer expectations.

Empirical Analysis

With this background, empirical analysis is now presented on the presence (or absence) of cycles in livestock numbers, slaughterings and production in Australia. Three types of analysis were employed:

- spectral analysis in which the cycles of different frequencies in data can be singled out and the contribution of each cycle in explaining overall variation can be quantified.

- autocorrelation analysis in which regular patterns can be deciphered between levels or changes in variables over time.

- lead-lag analysis between key variables.

Autocorrelation analysis and lead-lag analysis are undertaken in the time domain. In contrast, spectral analysis is undertaken in the frequency domain.

By operating in the frequency domain, spectral analysis breaks variation in a data series down into a series of sine waves of different frequency, and says how much variation is explained by each wave. In order to appreciate the analysis in simple terms, a spectrum which is roughly horizontal, with no obvious peaks and troughs is what would come from white noise, or data with no regular cycles. A strong peak in the estimated spectrum would indicate the presence of a regular cycle at this frequency (frequency is the number of cycles per unit of time, and thus reflects the inverse of the length of a cycle). Normally, the data for spectral analysis should span at least 6 lengths of the cycle. Thus for the beef cycle, the data should span approximately 80 years.

Autocorrelation analysis permits us to assess whether regular cycles in data can be observed across time. This involves analysing the autocorrelative process associated with a particular time series. A regular cycle will be revealed as a regular pattern in the residuals, where the current values of a variable, y_t, are hypothesised to be a function of all previous values, y_{t-1} to y_{t-n}. The absence of a regular pattern in the residuals implies the absence of cycles or other forms of autocorrelation.

Lead-lag analysis involves quantifying the cross-correlations between variables y and x, for different leads and lags of each variable. The cross-correlation function shows at which lag the two variables are best correlated. This is widely used in causal analysis in economics, although strictly speaking the relationships found are not causal. A cross-correlation function displays correlations at both negative and positive lags. A negative lag indicates that the first series follows the second. A positive lag indicates that the first series lags the second.

In all the analysis reported, data were analysed on a first-difference basis. That is, the change from year-to-year, rather than the actual levels of variables. This is done to make the data approximately stationary. All analysis was undertaken using the time-series and spectral analysis facility termed SPSS+TRENDS, a 1990 addition to SPSS/PC+.

Data on livestock numbers, slaughtering and production were obtained from Australian Bureau of Statistics (ABS) for Australia overall. The years for which data were obtained were:

- numbers of cattle, pig and sheep: million head, 1904 to 1992[4]
- slaughterings of cattle (and calves), pig and sheep (and lamb): million head, 1912 to 1991 for cattle and sheep and 1928 to 1991 for pigs[5]
- production of beef (and veal), pigmeat and sheepmeat: thousand tons, 1916 to 1991 for pigmeat and 1931 to 1991 for beef and sheepmeat.

All data were cross-checked and latest available data were obtained from up-to-date ABS sources.

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4 Livestock numbers in early years were reported by ABS as at 31 December, but more recently as at 31 March. The assumption was taken that livestock numbers at 31 December equalled livestock numbers on the following 31 March for the years in which the 31 December count was reported.

5 The slaughterings and production data were reported on a July–June basis, and data for year 1991 means for year ending June 1991.

Results

Autocorrelation Functions

The autocorrelation functions for the first difference of cattle, pig and sheep numbers are shown in Figure 2. For cattle, evidence of strong negative autocorrelation peaking at 8 years and weaker positive autocorrelation peaking at 14 years indicates the presence of a cycle. For pig numbers, the autocorrelation function suggests the presence of a 4 year cycle, with striking negative autocorrelation at 2 years. For sheep numbers, the results are more muted, with positive autocorrelation in year 1 being most significant. The presence of cycles for cattle numbers and pig numbers has strong statistical support, since the peak autocorrelations are at least two standard errors from the mean.

The autocorrelation functions for the first difference of slaughterings of cattle, pigs and sheep are presented in Figure 3. For cattle, a complete cycle of 14 years length and a half cycle of 7 years is indicated. For pigs, a cycle of 4 years in length is indicated. Autocorrelation functions were plotted for production of beef, pigmeat and sheepmeat and these revealed less striking, although similar, patterns to the patterns revealed in Figure 3.

Spectral Analysis

The spectra for the first difference of cattle, pig and sheep numbers are presented in Figures 4 to 6. The peaks in the spectrum are at abou [illegible] and 24 years, the longer cycle possibly capturing some of the effects of tw [illegible] A weaker cycle in cattle numbers of about 4 years length is detectable. For p [illegible] s, a clear cycle of about 4 years duration can be detected and a weaker cycle of 1[illegible] years length is also present. This weaker cycle may be caused by interactions between the cattle cycle and the pig cycle, analysed later in this paper. A weak cycle in sheep numbers is detected with length ranging between 4 to 6 years and a long-swing cycle of 30 years is also detected, although this can have no statistical strength, since the data span less than three cycles of this length.

The spectra for the first difference of cattle, pig and sheep slaughterings are presented in Figures 7 to 9. These indicate the presence of a 12-13 year cycle in cattle slaughterings, as well as a weaker cycle of 4-5 years duration. For pig slaughterings, a cycle of 3.7-4 years length is observed. For sheep slaughterings, weaker cycles of length of less than 3 years and of 4.5 years are observed. Generally, these results correspond closely with the cycles in livestock numbers. Spectra for first differences in beef, pigmeat and sheepmeat production were also obtained. However, these indicated much weaker evidence of cycles, and were dominated much more by white noise. Thus the cycles observed in slaughterings do not transmit that strongly through to cycles in production. This can only occur because of variations in average slaughter weights over different phases of the cycle. This may be due to two things: difference in the mix of stock slaughtered at different phases of the cycle or differences in average slaughter weights caused by droughts or industry restructuring.

Spectral Analysis: Data Up To 1970

The spectra for the first difference in cattle numbers and in cattle slaughterings using data up to 1970 only are presented in Figures 10 and 11. These indicate some very striking differences with the equivalent spectra for cattle numbers (Figure 4) and slaughterings (Figure 7). Firstly, for cattle numbers there are less pronounced peaks for the shorter data set, with weaker cycles present at 4.5 years, 7 years and 12 years. Secondly, the spectrum for cattle slaughterings reveals a very pronounced peak at just over 7 years length with weaker cycles at 3, 5 and just over 9 years. The nature of these spectra in comparison with those presented suggests that the cattle cycle has not dampened in the past 20 years, and may in fact have strengthened and lengthened.

The spectra for the first difference in pig numbers and pig slaughterings using data up to 1970 are presented in Figures 12 and 13. For pig numbers, a much more pronounced peak in the spectrum at a cycle of 4 years length can be observed in comparison with Figure 5. As well, the cycles of longer length are less pronounced on the spectrum. For pig slaughterings up to 1970, there is a very pronounced peak at about 4 years and this dominates the spectrum more than the same cycle revealed in Figure 8. This implies that the pig cycle is dampening over time, as found by Griffith (1977).

Lead-Lag Analysis

The cross correlations between slaughterings with numbers, for cattle, pigs and sheep are shown in Figure 14. There are large positive autocorrelations at negative lags −3 to −1, indicating that changes in cattle numbers lead changes in cattle slaughterings. By definition, the identity linking slaughterings to cattle numbers implies that one additional animal slaughtered will lower cattle numbers by one. However, in the broad cycle, cattle slaughterings follow numbers. The same conclusion can be drawn for the cross correlation function for pigs. Here the strong positive correlations at lags −2 and −1 imply that changes in pig slaughterings follow changes in pig numbers.

The cross correlations between cattle numbers with pig numbers and cattle numbers with sheep numbers are presented in Figure 15. These show the extent to which the cycles in numbers are related. Positive correlations between cattle numbers and pig numbers at lags of −4 to −2 indicate that changes in cattle numbers follow changes in pig numbers, a somewhat surprising result. The negative correlation at a 2 year lag probably results from the much shorter length of the pig cycle compared to cattle. These differences in length may explain why the cattle cycle appears to follow the pig cycle, rather than lead it. Changes in cattle numbers also appear to follow changes in sheep numbers, which may be less surprising given the importance of sheep in livestock production in Australia. Negative correlations at positive lags is some indication of substitution of sheep for cattle in production.

Changes in cattle slaughterings appear to follow changes in pig slaughterings, with a 5 year lag, and some negative correlations are observed at the lags -2 to -1. The pattern of cross correlations between cattle and sheep slaughterings are more random, although a detectable negative correlation occurs at lag 1, also an indication of switching between sheep and cattle through different levels of slaughtering of both.

Overall, the lead-lag analysis indicates that there are linkages between the cycles for pigs and cattle, and to a much weaker extent between changes in numbers and slaughterings of cattle and sheep.

Conclusions

This paper has analysed data concerning livestock cycles in Australia. The data indicate that the cattle and pig cycles still exist. For sheep, it is difficult to conclude that strong regular cycles exist. The spectral analysis suggests that for cattle a 12-year cycle is present, while for pigs it is a 4-year cycle. These lengths correspond with earlier findings and with known capacity to build livestock numbers. These results also suggest that strong cross effects exist between the various cycles, although the results indicated that the pig cycle is leading the others - a rather surprising result. Perhaps this stems from the fact that there may be considerable harmonic effects between the main pig and cattle cycles, resulting from the result that the main pig cycle is 4 years and the main cattle cycle is about 12 years in length. The comparison of the spectra up to 1970 with spectra up to the early 1990s suggests that the pig cycle is dampening. This corresponds with earlier findings and would result from a restructuring of the pig industry to larger specialist units in which variations in pig numbers are less likely. In contrast, despite restructuring of the cattle industry, the cattle cycle appears to be lengthening and strengthening.

The final question to ask in this paper is why do producers not go counter-cyclical. One obvious reason is that while clear cycles may be observed in cattle numbers and slaughterings, the presence of cycles in prices of beef, pigmeat and sheepmeat remains an open question. Only if cycles in prices exist would countercyclical actions be worthwhile. However, it may not even be worthwhile then. To buy cattle at the trough of a cycle and to sell them at the peak would require holding an additional stock of cattle for a period of 6 years. At real interest rates of 5-10 percent, the stock of cattle would have to appreciate in value by between 35% and 60% to justify the investment. One suspects that a review of past price movements would indicate such a strategy to be loss making. For pigs the same applies. The main follow up research deriving from this paper is to test for the presence of cycles in prices of livestock products.

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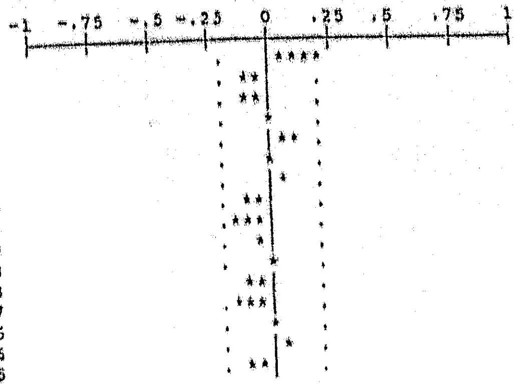
Figure 2

Autocorrelations: Sheep Number, 1904 to 1992

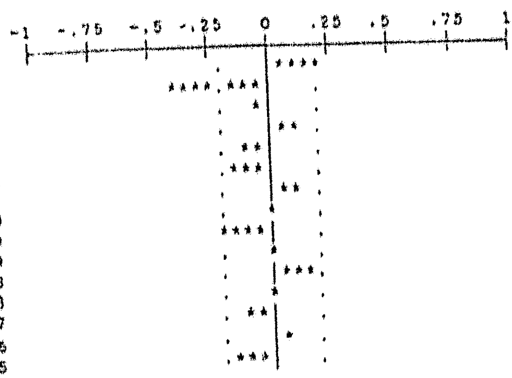
Lag	Auto- Corr.	Stand. Err.
1	.182	.104
2	-.089	.104
3	-.103	.103
4	.006	.102
5	.105	.102
6	.010	.101
7	.072	.101
8	-.122	.100
9	-.134	.099
10	-.060	.099
11	.020	.098
12	-.120	.098
13	-.150	.097
14	[illegible]	.096
15	.038	.096
16	[illegible]	.095



Plot Symbols: Autocorrelations * Two Standard Error Limits .

Autocorrelations: Pig Numbers, 1904 to 1992

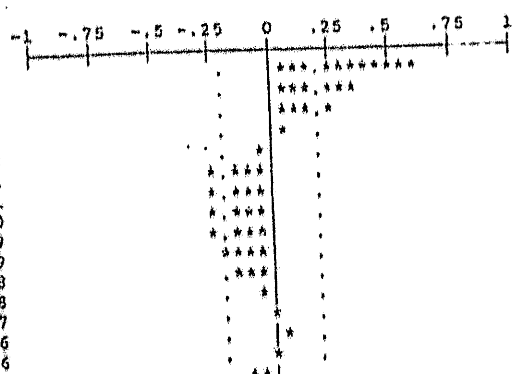
Lag	Auto- Corr.	Stand. Err.
1	.198	.104
2	-.375	.104
3	-.053	.103
4	[illegible]	.102
5	[illegible]	.102
6	-.127	.101
7	.104	.101
8	.006	.100
9	-.216	.099
10	.003	.099
11	.159	.098
12	-.019	.098
13	-.100	.097
15	.063	.096
16	-.162	.095



Plot Symbols: Autocorrelations * Two Standard Error Limits .

Autocorrelations: Cattle Numbers, 1904 to 1992

Lag	Auto- Corr.	Stand. Err.
1	.598	.104
2	.339	.104
3	.242	.103
4	.072	.102
5	-.074	.102
6	-.251	.101
7	-.274	.101
8	-.228	.100
9	-.257	.099
10	-.190	.099
11	-.133	.098
12	-.032	.098
13	-.001	.097
14	.036	.096
15	-.020	.096
16	-.086	.095

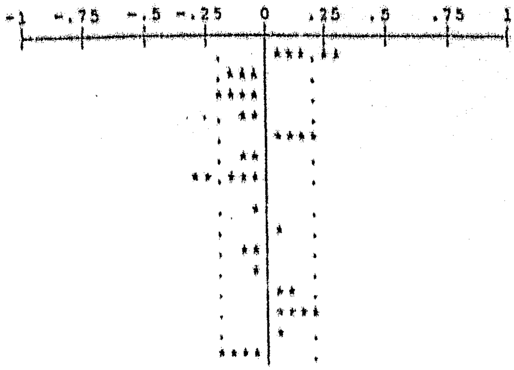


Plot Symbols: Autocorrelations * Two Standard Error Limits .

Figure 8

Autocorrelations: Cattle Slaughterings, 1912 to 1991

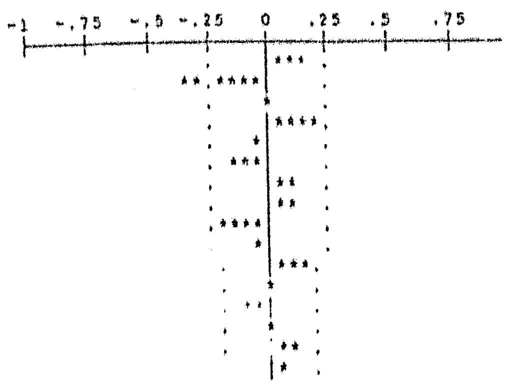
Lag	Auto-Corr.	Stand. Err.
1	.294	.110
2	-.150	.109
3	-.185	.108
4	-.075	.108
5	.180	.107
6	-.105	.106
7	-.278	.105
8	.111	[illegible]
9	-.069	.104
10	.066	.103
11	-.082	.103
12	-.057	.102
13	.107	.101
14	.208	.100
15	.035	.100
16	-.188	.099



Plot Symbols: Autocorrelations * Two Standard Error Limits .

Autocorrelations: Pig Slaughterings, 1928 to 1991

Lag	Auto-Corr.	Stand. Err.
1	.135	.122
2	-.369	.121
3	-.014	.120
4	.182	.119
5	-.074	.118
6	-.166	.117
7	.117	.116
8	.082	.115
9	-.206	.114
10	-.068	.113
11	.145	.112
12	-.011	.111
13	-.113	.110
14	-.010	.109
15	.112	.108
16	.029	.107



Plot Symbols: Autocorrelations * Two Standard Error Limits .

Autocorrelations: Sheep Slaughterings, 1912 to 1991

Lag	Auto-Corr.	Stand. Err.
1	-.131	.110
2	-.196	.109
3	-.049	.108
4	-.022	.108
5	.054	.107
6	-.131	.106
7	.034	.105
8	-.005	.105
9	.000	.104
10	.143	.103
11	-.025	.103
12	-.028	.102
13	-.006	.101
14	-.153	.100

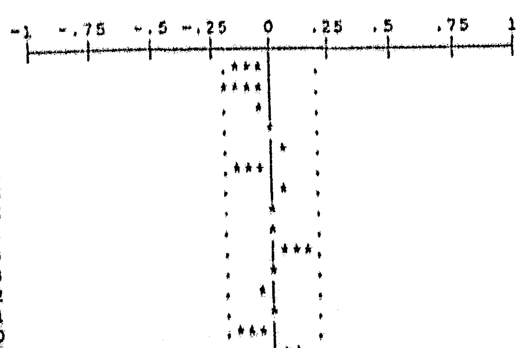
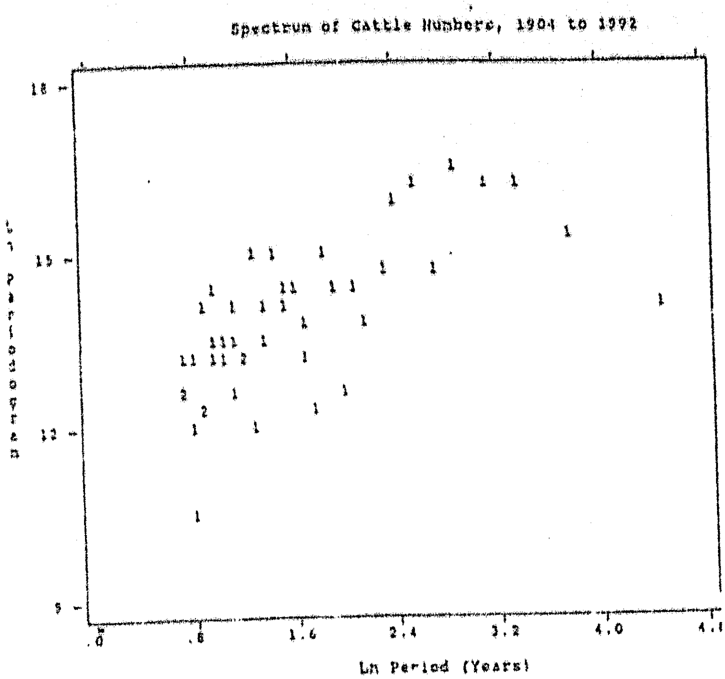


Figure 4



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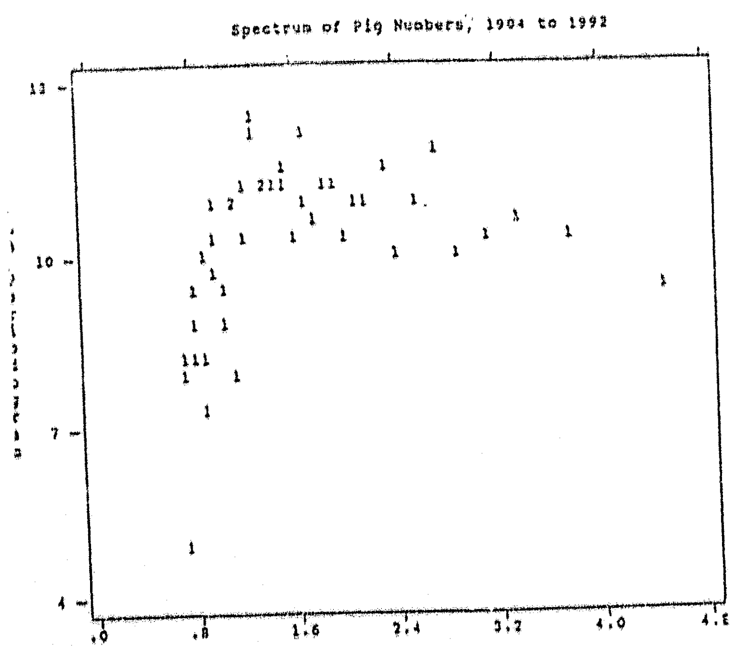

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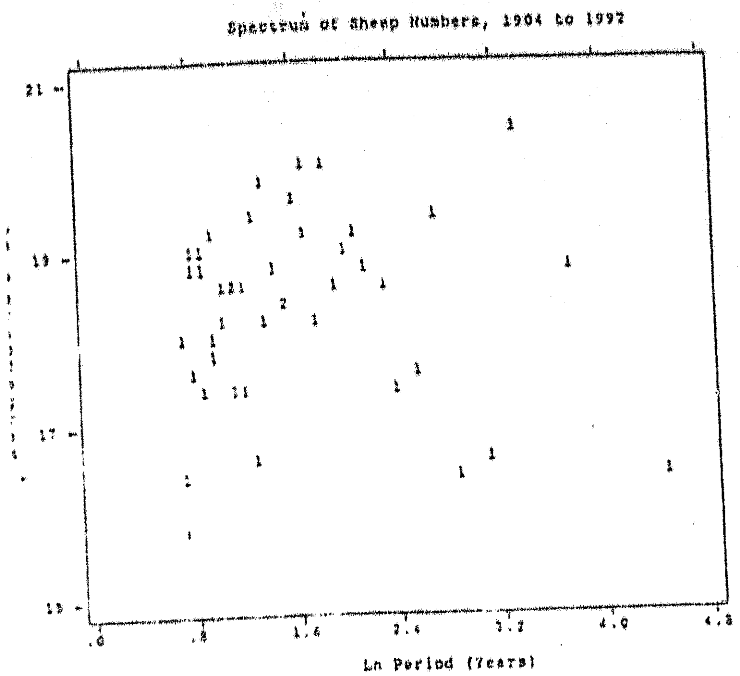

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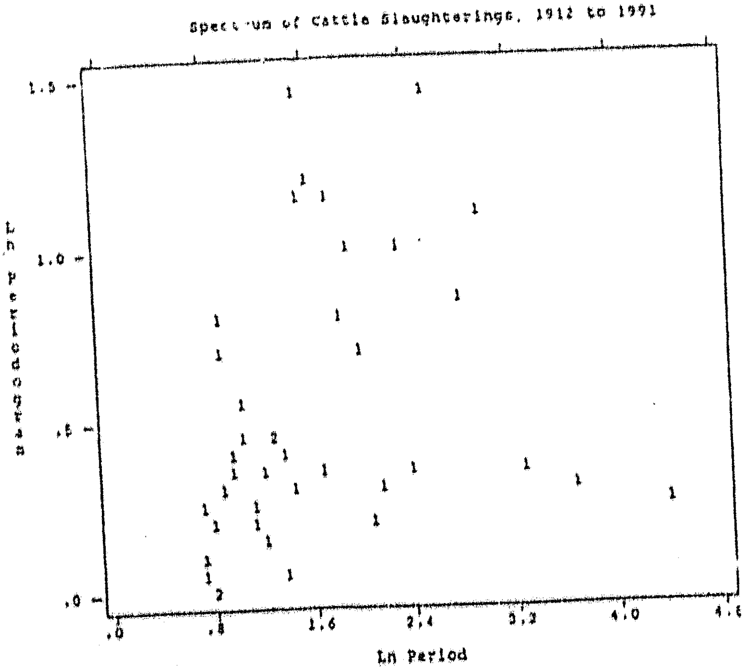
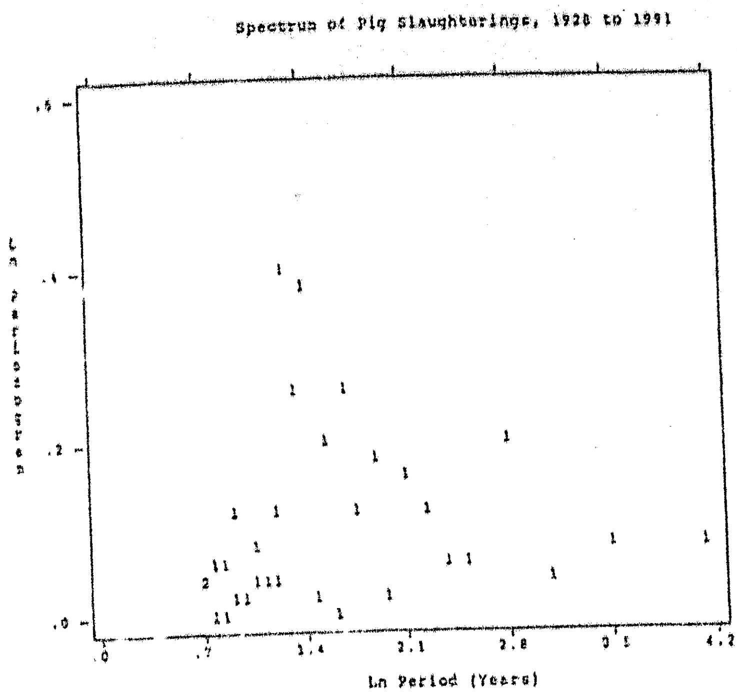


Figure 8



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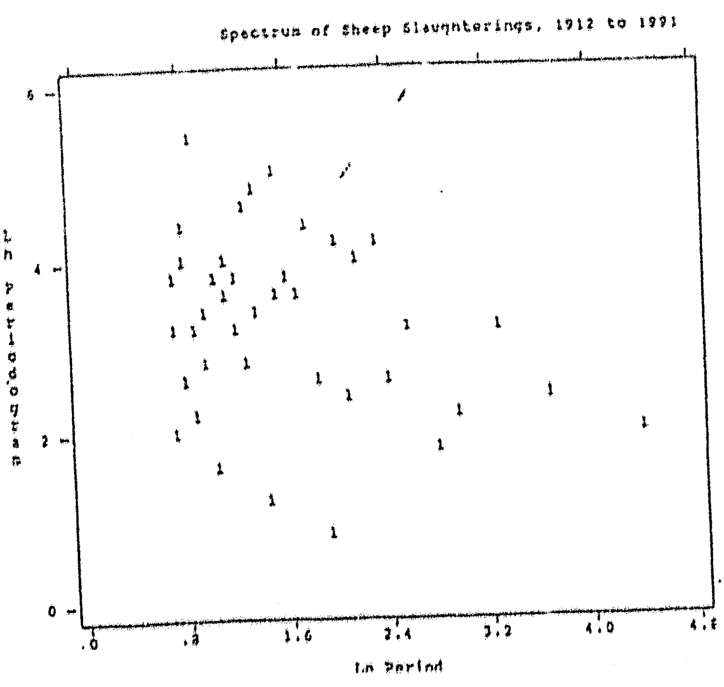


Figure 10

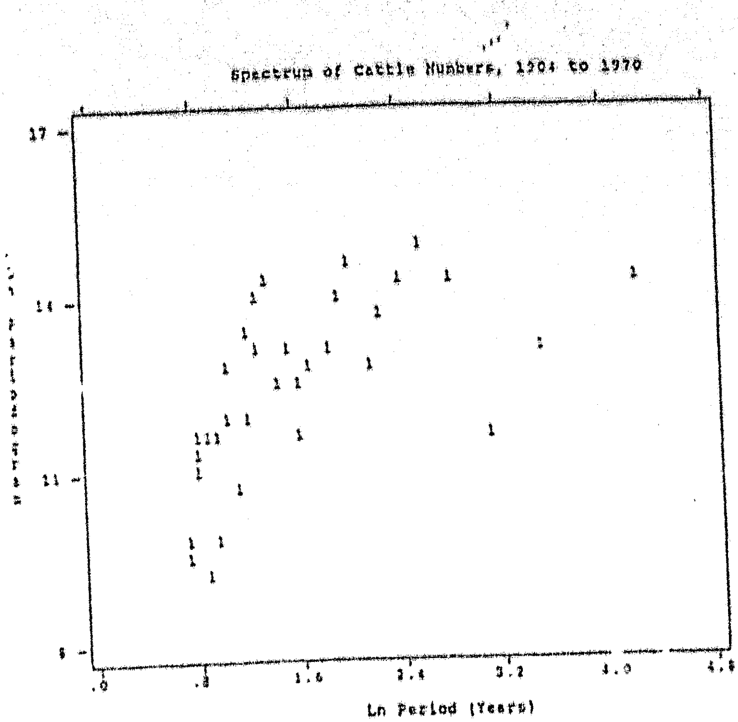


Figure 11

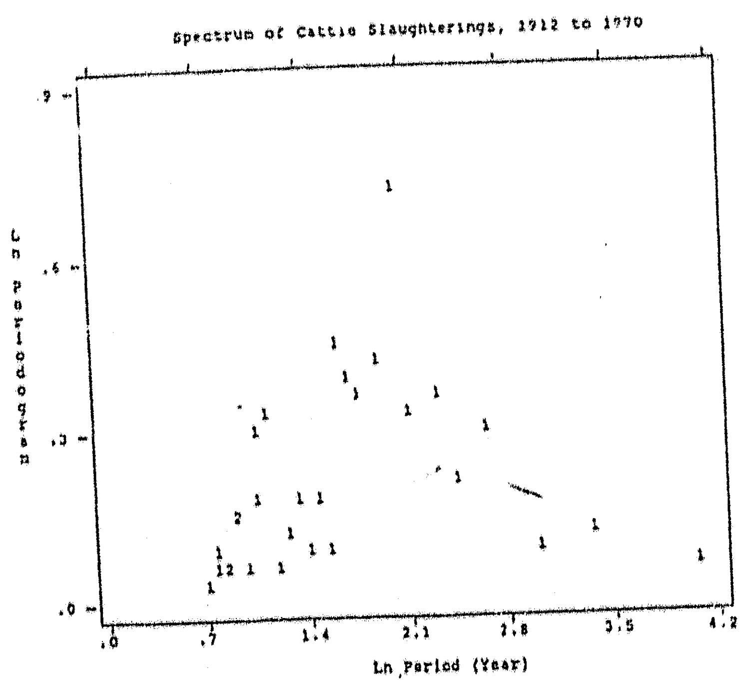


Figure 12

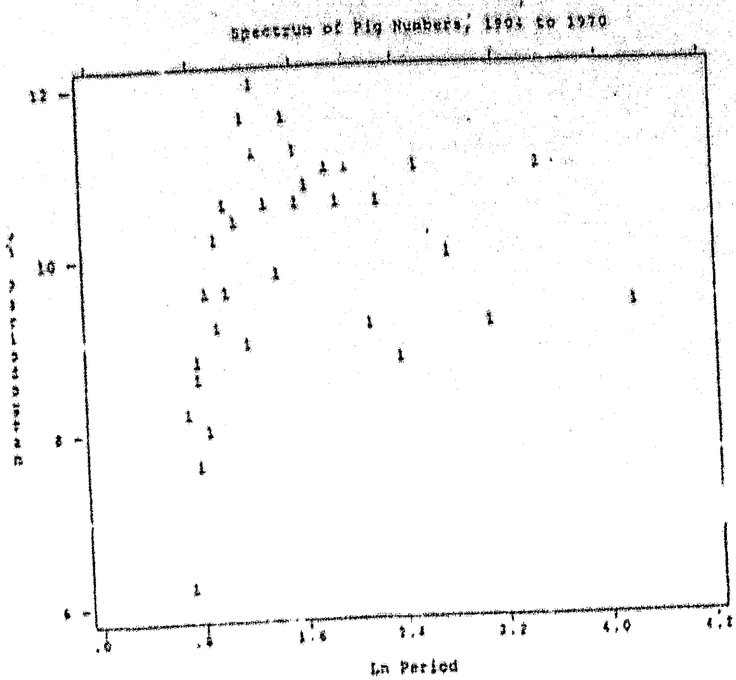


Figure 13

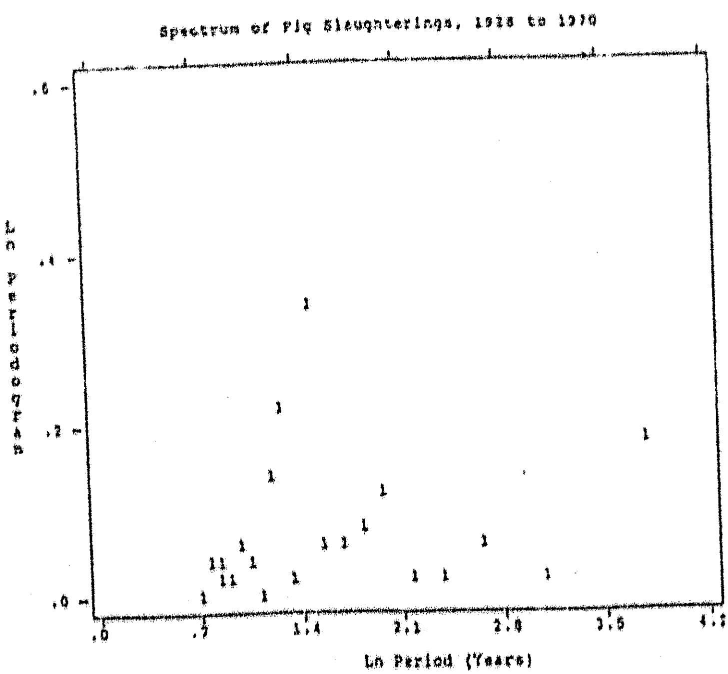


Figure 14

Cross Correlations: Cattle Slaughterings with Cattle Numbers

Lag	Cross Corr.	Stand. Err.
-7	-.031	.117
-6	.122	.116
-5	.126	.115
-4	.157	.115
-3	.418	.114
-2	.527	.113
-1	.560	.113
0	.170	.112
1	-.173	.113
2	-.077	.113
3	-.045	.114
4	-.1[illegible]0	.115
5	-.249	.115
6	-.184	.116
7	-.024	.117

Plot Symbols: Autocorrelations * Two Standard Error Limits .

Cross Correlations: Pig Slaughterings with Pig Numbers

Lag	Cross Corr.	Stand. Err.
-7	-.190	.132
-6	-.209	.131
-5	.120	.130
-4	.060	.129
-3	-.450	.128
-2	-.121	.127
-1	.757	.126
0	.462	.125
1	-.220	.126
2	-.016	.127
3	.181	.128
4	-.017	.129
5	-.192	.130
6	.057	.131
7	.138	.132

Plot Symbols: Autocorrelations * Two Standard Error Limits .

Cross Correlations: Sheep Slaughterings with SHeep Numbers DSHOS

Lag	Cross Corr.	Stand. Err.
-7	.071	.117
-6	.001	.116
-5	.113	.115
-4	-.173	.115
-3	.064	.114
-2	.119	.113
-1	.474	.113
0	.157	.112
1	-.274	.113
2	-.115	.113
3	[illegible]	.114
5	-.159	.115
6	-.048	.116
7	.052	.117

Plot Symbols: Autocorrelations * Two Standard Error Limits

Figure 15

Cross Correlations: Cattle Numbers with Sheep Numbers

Lag	Cross Corr.	Stand. Err.
-7	.187	.110
-6	.130	.110
-5	.218	.109
-4	.136	.108
-3	-.024	.108
-2	-.065	.107
-1	.093	.107
0	.204	.106
1	-.138	.107
2	-.319	.107
3	-.174	.108
4	-.130	.108
5	-.153	.109
6	-.083	.110
7	.015	.110

Plot Symbols: Autocorrelations * Two Standard Error Limits .

Cross Correlations: Cattle Numbers with Pig Numbers

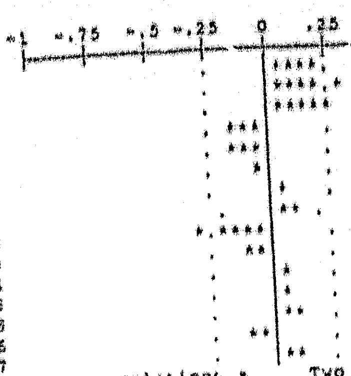
Lag	Cross Corr.	Stand. Err.
-7	.069	.110
-6	-.012	.110
-5	.098	.109
-4	.284	.108
-3	.265	.108
-2	.203	.107
-1	.033	.107
0	.157	.106
1	-.061	.107
2	-.307	.107
3	-.127	.108
4	.011	.108
5	-.048	.109
6	-.140	.110
7	-.026	.110

Plot Symbols: Autocorrelations * Two Standard Error Limits .

Figure 16

ross Correlations: Cattle Slaughterings with Sheep Slaughterings

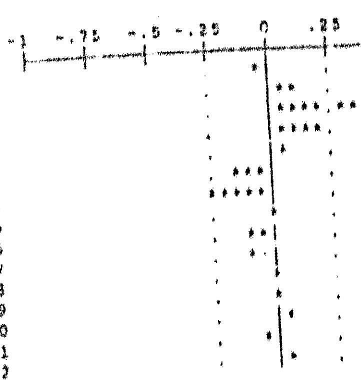
Lag	Cross Corr.	Stand. Err.
-7	.222	.117
-6	.317	.114
-5	.252	.115
-4	-.140	.115
-3	-.164	.114
-2	-.069	.113
-1	.067	.113
0	.104	.112
1	-.294	.113
2	-.080	.113
3	.026	.114
4	.039	.115
5	.081	.115
6	-.076	.116
7	.085	.117



Plot Symbols: Autocorrelations * Two Standard Error Limits .

ross Correlations: Cattle Slaughterings with Pig Slaughterings

Lag	Cross Corr.	Stand. Err.
-7	-.067	.132
-6	.107	.131
-5	.350	.130
-4	.193	.129
-3	.000	.128
-2	-.150	.127
-1	-.244	.126
0	.013	.135
1	-.113	.126
2	-.077	.127
3	.008	.128
4	.005	.129
5	.062	.130
6	-.045	.131
7	.070	.132



Plot Symbols: Autocorrelations * Two Standard Error Limits .