INDUSTRALIZATION OF ANIMAL AGRICULTURE: SEASONALITY IN THE PORK, BEEF AND MILK MARKETS

By

Oya S. Erdogdu[1] David Hennessy[2]

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The economic concerns and the technological developments increased control over nature and nurture in the animal agriculture. That changed the seasonality pattern of the supply side and lead to structural change in the animal agriculture together with the demand side factors. In this study we focused on the supply side factors and document the 'industralization' of the animal agricultural production.

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“Farming is transformed from growing stuff to manufacturing biologically based specific attribute raw materials”
(Boehlje, 1999)

1. Introduction:

Agricultural production today is far more different than it was 50 years ago. It is being shaped by large corporations using modern manufacturing techniques in production, instead of small family oriented farms. A consistent, more uniform supply is being observed. Referring to the use of modern methods of manufacturing, production and distribution techniques, this transformation is called the ‘industralization’ of agricultural production.

The changes in the social structure and the living conditions in the 21st century pushed the household's preferences towards a more healthy, consistent, preparation friendly and less time consuming products. This tendency of the demand side for stable, uniform production is confronted by the supply side using high–tech methods of production in a factory style corporate farming environment. Using the developments in technology, producers are able to deal with their economic concerns –like economies of scale, economies of scope, risk management and market power – and satisfy the expectations of demand. The end result is the differentiated products, with the increasing complexity in production technique and the existence of huge corporations using modern manufacturing techniques in agricultural production.

The changing nature of demand together with the changes in supply (due to the utilization of technology) increased the quantity, quality and uniformity in production. Although the change in the market is a result of both the demand and the supply side factors, in this study we focused on the determinants of the transformation of the supply side. Following the argument that the industralization of agricultural production, (which caused changes in the pattern of seasonality) is in part a consequence of the increased control of the nature and nurture on the agricultural production, in this study we have documented the effect of this transformation on the seasonality pattern of animal agriculture –especially pork, beef and milk production.

The rest of the paper is as follows. Section Two will define the concept of seasonality and derives the origins and effects of controlling nature and nurture. Section Three gives information on the data set that is being used and Section Four documents the results of the analytical and statistical analysis. In Section Five we will try to open a discussion based on our results and ask and address some questions regarding the future of animal agricultural production.

2. Controlling Nature and Nurture:

Allen and Lueck (2000) argue that nature is “the main feature that distinguishes farm organization from ‘industrial’ organization”. Due to its very core of existence, agricultural production is defined and restricted by the forces of nature. Nature determines the properties, types, sequence and timing of the stages of production, creating a certain amount of stability and predictability in the process. Nature determines the time to plant, time to harvest, time to breed and time to farrow, and so creates a type of certainty in production. For example, in Iowa, USA April – June is the time to sow, whereas September –November is the time to harvest and spring has traditionally been the time to farrow for pigs. Note that, these are subject to weather conditions and so, can be different for different parts of the world and for different products.

However, nature not only governs certainty but also uncertainty in the agricultural production. The random forces of nature –unexpected changes in weather conditions, blizzard and storms –create unpredictable and unpreventable shocks to the system.

The forces of nature and so, the concept of seasonality is significant to understand the agricultural production process. For a producer of an agricultural product, "season" is the specific period of the year during which a given activity takes place. Hence, shaped by the forces of nature, seasonality determines the stages and the timing of a specific process as well as the time length and the total number of that period in a year. As can be expected, this creates cycles in the production over a given period of time. In this study we will not focus on the properties of seasonality or its impact on the production process or managerial decision but rather document the decreasing seasonality in the pattern of agricultural production. For that purpose our study is based on animal production rather than crop production mainly due to the issue of mobility. Allen and Lueck (2000) emphasise the high mobility of livestock during the growing stages and the fact that they can be reared indoors. This high mobility of livestock comparing to crop production allows the producer to exercise greater control over nature by using high–tech factory style production techniques. Thus, although seasonality is an issue for all types of agricultural production, in this study we will focus on the effect of an increased control over nature and nurture on animal production –beef, pork and milk – only[3].

Technological developments have facilitated human control of biological processes and have transformed farming toward a manufacture of biologically improved specific products using modern manufacturing and production principles and technological improvements. Boehlje (1999) argued that the ability to control the biological process, through antibiotics or genetic engineering, has created a more flexible, less risky environment and thus has allowed farmers to produce consistent, more feed efficient livestock. With the ability to control nature, producers have gained higher flexibility to respond to changes in consumer demand and have had an increased ability to set and sustain a certain quality level and the ability to reduce risks concerning food safety and contamination.

In general terms, the ability to control nature and thus the genetic input, allows the producer to change the order in the system through mixture or separation. The method of mixture/separation can be used at the farm level –which leads to herd heterogeneity, or at the processing level –which leads to heterogenous raw produce.[4] The profit maximizing producer performs a cost/benefit analysis to decide on separating (at cost) or working with the mixed types they purchased to satisfy the strong demand for consistent, preparation –friendly products.[5]

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[3] We did not use the data on broiler production since the transformation/ industralization of the chicken industry has been documented extensively.

[4] At the farm level there may be two different type of genetic improvement: homozygous traits, which are inherited from both parents and heterozygous traits, which are inherited from only one parent. Since, homozygous traits require both parents, they express a higher genetic stability than heterozygous traits (USDA, Economic Research Service web page, "Breed or not Breed Patented Animals", http://strategis.ic.gc.ca/SSG/ip00182e.html).

[5] Hennessy, Miranowski, and Babcock (2001) study problems dealing with economic costs of mixing.

On the cost side, the usage of genetics is subject to patent costs and costs associated with information and uncertainty. Patent costs are large asset –specific costs to achieve a genetic improvement of a given species. But more importantly, the biological improvement creates information costs due to uncertainty about the composition of the mixture or the uncertainty about the reaction of each type to a stimulation. Moreover, these uncertainties have significant impacts on commercial gains too. They create inefficiency in volume production and low quality and inconsistencies in the raw production, which would lead to unsatisfactory completion of the transformation process.

However, in general, the control of genetic input may decrease cost and improve commercial gains.

Together with the intense usage of genetic inputs, the increased ability to control the environment has allowed uniformity in production and has led to confined production systems.

Given incentives, variations in inputs cause variations in the performance of the product brought to the market at the same time (intra –temporal inconsistency) and at different times. Thus, inconsistency in production due to variations in input like nutrition and environment is declined by higher control of the production environment.

As Hurt (1994) argues confined production systems with increased control over the production environment such as improvements in nutrition, housing, handling equipment and management have encouraged higher and more uniform supply. Factory –style corporate livestock farming, using veterinary medicines, healthier diets and indoor environmentally controlled sheds has satisfied the needs and improved the health and the production conditions of the animals. The result was a healthy, uniform, larger supply.

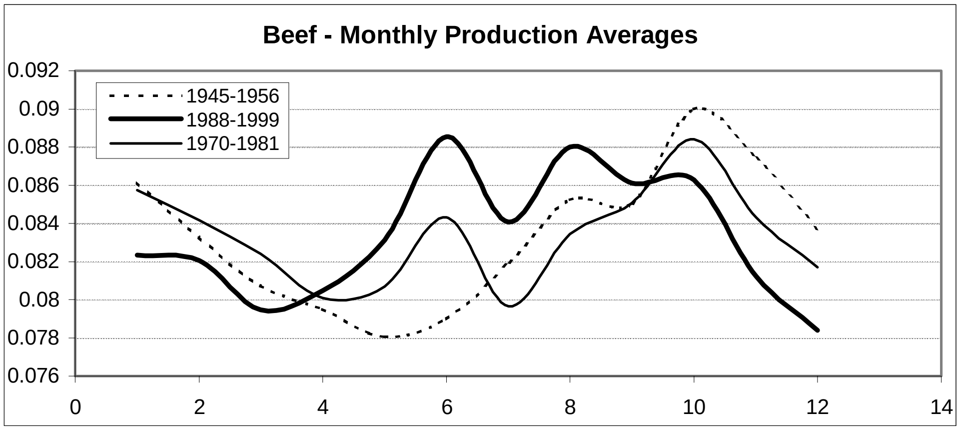
All these information argued that our ability to control nature and nurture lead to a structural change in the animal production, decreasing seasonality with more uniform and standard products. The rest of the paper aims at documenting this transformation using different analytical tools.

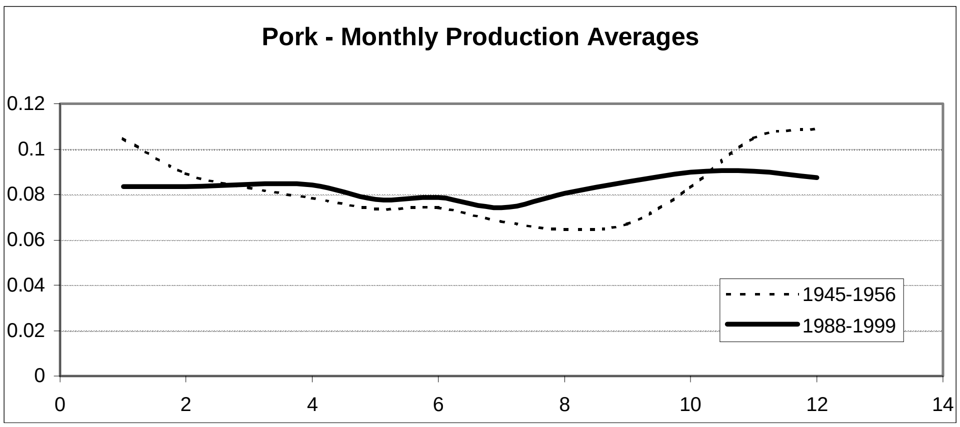
3. Data:

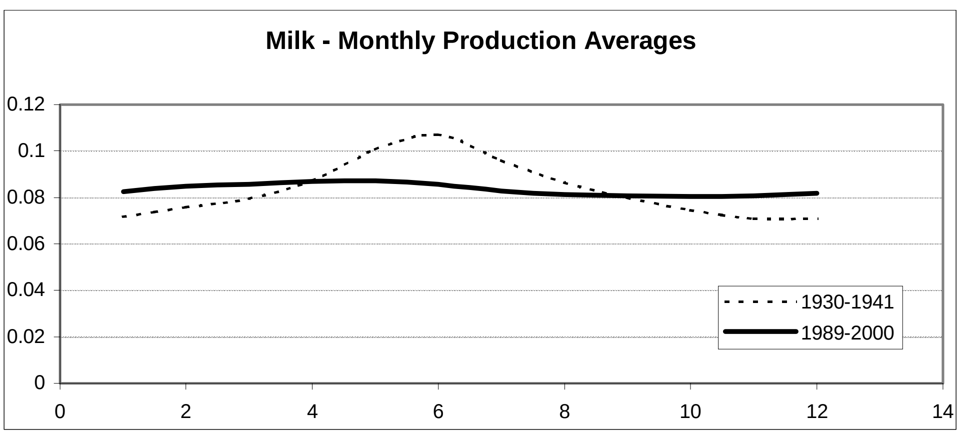
The data on monthly production of pork, beef and milk are obtained from the web page of the United States Department of Agriculture, USDA. The monthly milk production data is obtained for the period 1930 –2000 (except 1960 –1963), and the monthly beef and hogs production data are for the period 1944 –1999 (except 1982).

The series we gathered are monthly calculations from the first to the last day of the month. Therefore, first we normalised the monthly data to 30 days per month to decrease the noise in the system. Then, to detect the decreasing seasonality in the production we calculated Herfindahl –Hirshman index (HHI), performed Lorenz curve analyses and conducted model stability/structural change tests.

We graphed the normalized monthly production shares, calculated the 12–year averages for each month and compared the trend for different periods of time. The graphics below are for the monthly production averages of beef, pork and milk for the earliest and the latest time periods in our data.







The increasing smoothness in production is very clear for pork and milk production. The production shares are closer to each other in comparison to their corresponding values over either time periods. The most dramatic change has occurred in milk production. The significant importance of summer time production in the 30's is replaced with rather constant production shares in 2000, which indicates a relatively stable milk production.

4. Methodology:

In order to verify the industralization process of the animal agricultural production statistically, we calculated the HHI index, Chow and CUSUM statistics.

4.1.Herfindahl –Hirshman Index (HHI):

Actually, HHI is a tool for market structure analysis. HHI is not a very common analytical tool in agricultural economics. One application can be found on the web page of USDA where the economics research service used HHI to calculate the concentration measure for the beef packing industry (USDA, 1998).

HHI measures the degree of concentration in an industry. We used it to capture any changes in the pattern of seasonality. HHI has the advantage over other concentration measures since it works with the all firms in the market, not a few, and it takes into account the relative distributional shares of the market held by all firms.

Based on the Jensen Inequality the HHI is calculated using the sum of squares of the market shares of all firms. The index is:

$$HHI = 10{,}000\sum_{i=1}^{K} w_i^2 \qquad i = 1,\ldots,K$$

where, w_i is the market share of the firm i.

In this paper we used the HHI to measure the degree of spread of production over 12 months for beef, pork and milk production. HHI is calculated for each year by summing up the square of each month's share in total production. Then, we calculated the 12 –year averages of that sum. Thus, for the time period 1945-1956 the HHI index is calculated as:

$$HHI = \frac{1}{12}\sum_{j=1945}^{1956}\sum_{i=1}^{12} s_{i,j}^2$$

where, $s_{i,j}$ is the i^{th} monthly production share in the j^{th} year. Note that our calculation is a little different from the original form. Since working with decimals is not a concern for us, we did not multiply the summation result by 10,000 but we preferred to take the averages to minimize the noise in the system.

Table below summarises our calculation of the HHI for beef and pork averaged over the time periods: 1945 –1956, 1958 –1969, 1970 –1981, 1983 –1994, 1988 –1999 and the HHI for milk production averaged over the time periods 1930 –1941, 1941 –1952, 1948 –1959, 1963 –1974, 1971 –1982, 1981 –1992, 1989 –2000[6].

HHI - Beef		HHI - Pork		HHI - Milk	
1945-1956	0.084035	1945-1956	0.086944	1930-1941	0.085029
1958-1969	0.08353	1958-1969	0.084153	1941-1952	0.085543
1970-1981	0.083536	1970-1981	0.083995	1948-1959	0.084893
1983-1994	0.083542	1983-1994	0.083977	1963-1974	0.083811
1988-1999	0.083534	1988-1999	0.082635	1971-1982	0.083591
				1981-1992	0.083453
				1989-2000	0.083416

If each month of each year had equal shares of production, 1/12, the index would take the value: $HHI = \frac{1}{12}\sum_{j=1945}^{1956}\sum_{i=1}^{12}(0.08333)^2$ = 0.0833. At the other extreme, if the

[6] The calculations we used before grouping the data, that is the sum of squares of monthly shares for each year, $\sum_{i=1}^{12} s_i^2$ are available upon request.

production had been composed in only one month at each year – $s_{i,j} = 1$ and $s_{k,j} = 0$ for all $k \neq i$, the index would take the value: $HHI = \frac{1}{12}\sum_{j=1945}^{1956} 1 = 1$.

As is seen from the table, all the indexes decrease over the time period and move towards the value of 0.083. This indicates a change in the production process such that the production is now spread over the whole year equally.

4.2. Lorenz Curve:

Another analytical tool we used to capture the changes in the pattern of seasonality in agricultural production is the Lorenz curve. In economics, Lorenz curves are used to investigate the state of income distribution. They show the proportion of total income received by a given percentage of the population.

To draw Lorenz curves we first sorted the normalized monthly shares for a given year in an ascending order and grouped the data in 12 –year time periods. Beef and pork production data is grouped as: 1945 –1956, 1958 –1969, 1970 –1981, 1983 –1994, 1988 –1999, whereas the milk production data is grouped as: 1930 –1941, 1941 –1952, 1948 –1959, 1963 –1974, 1971 –1982, 1981 –1992, 1989 –2000[7]. For each 12 –year time period we summed the lowest share of each year. This process is repeated from lowest to highest shares. At last, we cumulated these values and divided each sum by 12 to represent them as a 1/12 share.

Although we draw the Lorenz curves for all the time periods mentioned above, due to practical reasons the tables you will see below are for a selected two time periods –earliest and latest time periods. Note that in each graph there are 45 –degree lines, to represent the equal distribution.

Using the graphs we can easily argue that the distribution becomes more equal as the Lorenz curve moves towards the equal distribution (45 degree) line. Thus, figure 2 clearly indicates the decreasing seasonality in production. The proportion of production at a given time period, has followed a more equal pattern in recent times. This movement of Lorenz curves towards the equality line is very clear especially for pork and milk production. This trend supports the argument that the seasonality in animal production has tended to decline.

4.3. Model Stability Tests:

The decline in seasonality implies an underlying structural change in production process which we can detect using Chow and CUSUM statistics. While we do regression analysis, we implicitly assume that the coefficients are the same over the whole data set. Chow tests can detect the existence of time dependency in the model.

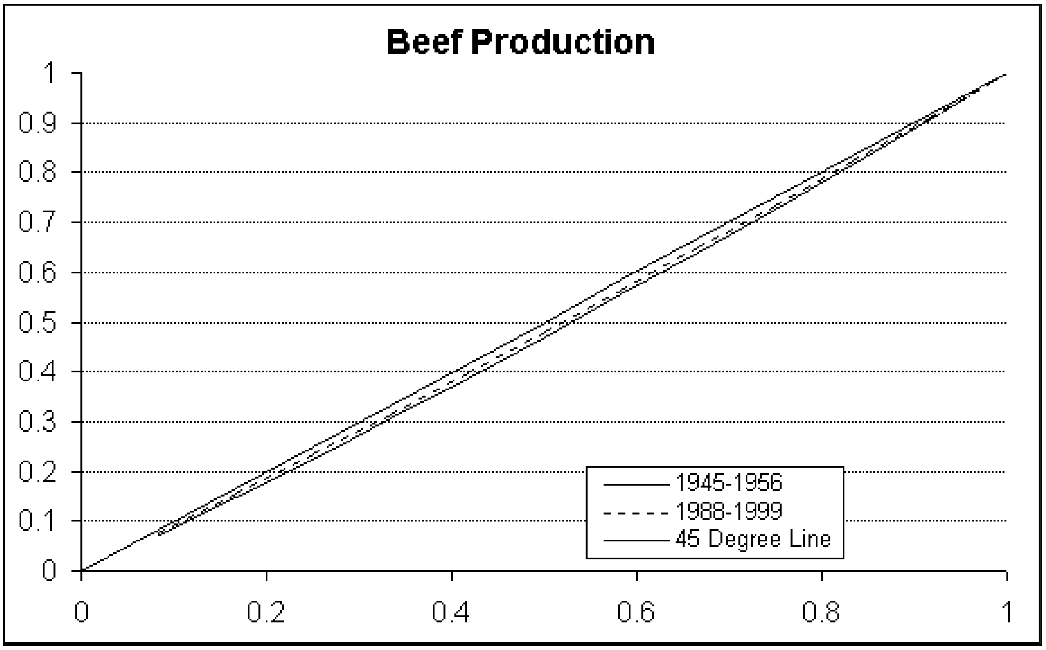
To test for structural change in our problem, we regressed the monthly production share on a constant term and the dummy variables:

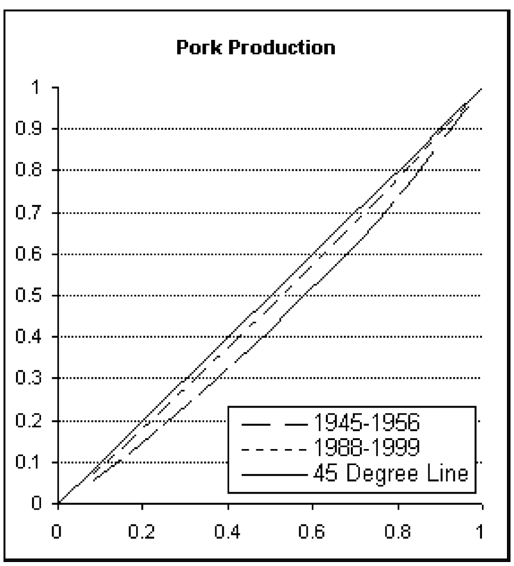
$$y_t = c + \sum_{i=1}^{11} \beta_i M_i + \varepsilon_t$$

Note that, to prevent the dummy trap, we used 11dummies instead of 12. The dummy for the month with less production share is excluded from the regression.

[7] We used the specified time period to use as much information as possible with the 12-year period cycles.

Lorenz Curves





Thus, for beef we excluded the dummy for November, for pork we excluded the dummy for October and for milk production we excluded the dummy for March.

The Chow test statistics are calculated for different periods of time. For beef and pork the test statistics are used to see if the coefficients of the regressions are different for the periods: 1944 –1961 and 1962 –1998, 1944 –1974 and 1975 –1998. For milk the statistics is calculated for the periods: 1930 –1961 and 1962 –2000.

The results are summarised in the table below.

Beef Production:

Hypothesis:	*Chow Test:*
$H_0 : \beta_{1944-1981} = \beta_{1983-1999}$	Chow Test: 4.19
$H_0 : \beta_{1944-1961} = \beta_{1962-1981}$	Chow Test: 1.19
$H_0 : \beta_{1983-1992} = \beta_{1993-1999}$	Chow Test: 0.53
$H_0 : \beta_{1944-1981} = \beta_{1983-1991} = \beta_{1992-1999}$	Chow Test: 46.65
$H_0 = \beta_{1944-1971} = \beta_{1972-1981} = \beta_{1983-1999}$	Chow Test: 5.23

Pork Production:

Hypothesis:	*Chow Test:*
$H_0 : \beta_{1944-1981} = \beta_{1983-1999}$	Chow Test: 5.85
$H_0 : \beta_{1944-1961} = \beta_{1962-1981}$	Chow Test: 27.55
$H_0 : \beta_{1944-1981} = \beta_{1983-1991} = \beta_{1992-1999}$	Chow Test: 4452.44
$H_0 = \beta_{1944-1971} = \beta_{1972-1981} = \beta_{1983-1999}$	Chow Test: 622.41

Milk Production:

Hypothesis:	*Chow Test:*
$H_0 : \beta_{1930-1959} = \beta_{1963-2000}$	Chow Test: 228.45
$H_0 : \beta_{1930-1945} = \beta_{1946-1959}$	Chow Test: 5.37
$H_0 : \beta_{1963-1982} = \beta_{1983-2000}$	Chow Test: 43.92
$H_0 : \beta_{1930-1959} = \beta_{1963-1981} = \beta_{1982-2000}$	Chow Test: 315.65
$H_0 : \beta_{1930-1945} = \beta_{1946-1959} = \beta_{1963-2000}$	Chow Test: 259.04

Each Chow statistics for pork and milk production is greater than the critical value of 1.75 at 5% significance level.[8] Therefore, we rejected the null hypothesis of same coefficients, and concluded that the coefficients obtained on regression for the given two time periods are significantly different from each other. That is, a structural change has occurred in pork and milk production in the last 50 years.

As for beef production, the test indicates a structural change between 1944 –1981 and 1983 –1999. The same result is achieved when we divided our sample into three different time periods. However, a more detailed analysis reflects the slow transformation in the beef production that has also seen in the table on monthly average production shares. The Chow tests did not reject the null hypothesis of no structural change for the time periods, 1944 –1961 and 1962 –1981 and similarly for the periods 1983 –1992 and 1993 –1999[9]. That is, the test concluded that no change has occurred in the seasonality pattern of the beef production.

The Chow test checks for structural change in the markets for specified periods of time. In this study we also did the CUSUM test and searched for the existence of stability without restricting ourselves to specify the cut off periods of time in the data. Note that the CUSUM test has a lower power than the Chow test.

Our results show that for all the three production series the CUSUM statistics moves inside the confidence bounds, indicating that no structural change has occurred

[8] The critical value for 0.01 significance level for $F_{12, \infty}$ is 2.20

[9] We did the Chow test for many different combinations of time periods. The results were same as the ones that are mentioned here.

in the beef, pork and milk production[10]. Regarding the generality of the null hypothesis, this is not very surprising since our previous results indicated a very slow transformation process, which may be still going on.

5. Discussion:

In this study we have documented the structural change in the animal agriculture, which caused decreasing seasonality from both the demand and the supply side of the market. We argued that the economic concerns and the technological developments lead to higher control over nature and nurture in the animal agriculture and thus, lead to changes in the seasonality pattern of the supply side. Due to the existence of factory style large manufacturing firms producing various, uniform products –instead of small family farms – the term 'industralization' is used to refer to this transformation in the agricultural sector.

In this study we used different analytical tools, –HHI, Lorenz curve, Chow and CUSUM tests – to document the industralization of the animal agricultural production. However, there are still lots of questions that need to be answered by economists.

First, it is important to document how effective the existent policies have been on the structural change of the animal agriculture. To document the impact of these policies on innovation and implementation of the scientific knowledge and the role of policies to encourage/ discourage vertical integration is crucial to decide on the direction of future actions.

Secondly, it is important to analyse the impacts of this new production structure on technological developments, bio –security, national and international market structure and prices and environment.

It is argued that the usage of technological developments in the animal agriculture created uniformity in production. Is this a two –way road? Does uniformity encourage/discourage technological developments and innovative attempts? If so, what would be the effect on market structure, quality, quantity and prices, and so the role of government? How and how much regulation should be there? As the Dioxin case in Belgium and Starlink case in Iowa pointed out that there is important bio –security issues regarding the usage of veterinary medicines and genetic improvement techniques in large corporations with high division of labor. What would be the regulations on the usage of veterinary medicines, genetic inputs and the patent rights? Are these regulations effects the pattern of seasonality in animal agriculture?

With the globalisation, the international effects of the decreasing seasonality in domestic markets become an important issue too. The effects of seasonality on the price, quantity and quality in the international markets should be analysed as well as the consequences of policies on the usage of biological improvement techniques and the medicine.

At last, similar to the arguments on the usage of genetics in human development process, there are arguments on the effect of high control of nature and nurture on animal wealth. Animal rights activists question if it is fair to genetically and environmentally restrict the natural development process, like the case in factory style animal production.

These are some further research topics.

[10] We used TSP for statistical analysis and the plots for the CUSUM test are available at request.

REFERENCES

Allen, Douglas and Dean Lueck. "*Family Farm Inc*.", Choices, first quarter 2000, p. 13 –17.

Boehlje, Michael. "*Structural Changes in the Agricultural Industries: How Do We Measure, Analyze and Understand Them?*", American Journal of Agricultural Economics, 81 (number 5 1999), p. 1028 –1041.

Brewer, Clarence. "*The Trend of Concentration in the Pork Industry: A Brief Explanation of Why It' s Happening*", unpublished notes, 1999

Brown, R., J. Durbin and J. Evans. "*Techniques for Testing the Constancy of Regression Relationships Over Time*" Journal of the Royal Statistical Society, Series B, 37, 1975, p.149-172

Bugos, Glenn. "*Intellectual Property Protection in the American Chicken –Breeding Industry*", Business History Review, 66 (Spring 1992), p. 127 –168.

Drabenstott, Mark. "*Industralization: Steady, Current or Tidal Wave*", Choices, fourth quarter 1994, p. 4 –8.

Greene, William. "*Econometric Analysis*", Prentice Hall Int., 1997

Hall Robert and Lieberman, M. "*Microeconomics: Principles and Applications*" South-Western College Publishing, 2001.

Hennessy, David and Jutta Roosen. "*A Model of Seasonal Production, with Application to EU Milk Policy*", working paper, 2001

Hurt, Chris. "*Industralization in the Pork Industry*", Choices, fourth quarter 1994, p. 9 –13

United States Department of Agriculture Economic Research Service, http://www.ers.usda.gov