Technology Management, Economics and Policy Papers

SEOUL NATIONAL UNIVERSITY
College of Engineering
Technology Management, Economics and Policy Program

Perspectives on the Decelerating Agricultural Society

Tai -Yoo KIM, Almas HEHMATI and Jihyun PARK

TEMEP Discussion Paper No. 2009:01

서 울 대 학 교
공 과 대 학, 기술경영경제정책 대학원과정
151-742 서울시 관악구 신림동 산 56-1

Technology Management, Economics and Policy Program
College of Engineering, Seoul National University
San 56-1, Shillim-Dong, Kwanak-Gu, Seoul 151-742 ,KOREA
Phone: ++82-2-880-9140, Fax: ++82-2-880-8389

Technology Management, Economics and Policy Program (TEMEP) is a graduate program at the Seoul National University. It includes both M.Sc. and Ph.D. programs which are integrated into the graduate program at the College of Engineering.

TEMEP Discussion Papers is intended to serve as an outlet for publishing research about theoretical, methodological and applied aspects of industrial economics, especially those related to the institute's areas of specialization, namely management of technology, information and telecommunication, health and energy industries, as well as development economics infrastructure. In particular submission of studies analyzing current technology and industry related issues and discussion of their implications and possible alternative policies are welcome. The objective is to gain insights into important policy issues and acquiring a balanced viewpoint of policymaking, technology management and economics which enable us to identify the problems in the industries accurately and to come up with optimal and effective guidelines. Another important aim with the series is to facilitate communication with external research institutes, individual researchers and policy makers.

Research disseminated by TEMEP may include views on information and telecommunication, technology management, energy, health and development economics policy, but the institute itself takes no institutional policy positions. When appropriate the policy views of the institute are disseminated in separate policy briefs. Thus, any opinions expressed in TEMEP Discussion Papers are those of the author(s) and not necessarily the institutes.

Editor: Almas Heshmati
Professor of Economics

Technology Management, Economics and Policy Program
College of Engineering
#37-306, Seoul National University
San 56-1, Shilim-dong, Kwanak-gu
Seoul 151-742 Korea

Phone: 0082-(0)2-880-5845
Fax: 0082-(0)2-886-8220
E-mail: heshmati@snu.ac.kr

Perspectives on the decelerating agricultural society[1]

Tai-Yoo KIM, Almas HESHMATI and Jihyun PARK

Technology Management, Economics and Policy Program
College of Engineering, Seoul National University
San 56-1, Kwanak-gu, Shinlim-dong
Seoul 151-742 South Korea

E-mail addresses: taiyookim@temep.snu.ac.kr,
heshmati@snu.ac.kr, april3@snu.ac.kr

January 2009

Abstract

In general, societies are divided into agricultural and industrial societies. This study presents perspectives on decelerating agricultural societies. Agricultural demand and supply play major roles in the development of societies. Three theories that describe an agricultural society and its deceleration patterns are described: the neo-classical production function and those articulated by Johnston and Mellor as well as induced innovation by Hayami and Ruttan. Two important cases of decelerating agricultural societies, medieval England and the U.S., are investigated through an examination of the process of agricultural society deceleration and ultimate replacement by an industrial society. The limitations of decelerating agricultural societies, with a focus on structural problems, impacts on industrial structure, and problems of agriculture in market and non-market areas, are discussed. The position of agriculture as described by economic development theory is established by analyzing the stages of economic development, the theory of structural change, and the theory of leading industry. Finally, the transition from an agricultural to a commercial society is described with a focus on the formation, development, value creation, and structural limitations of a commercial society.

JEL Classification: L16, O11, O47, O13

Keywords: Agricultural development; Agricultural society; Commercial society; Decelerating society; Economic growth; Induced innovation; Simple reproduction

[1] The authors would like to thank Seunghyun Kim, Dongook Choi, and Eungdo Kim for their excellent assistance as well as Rhona Davis and Noel Gaston for their comments on an earlier version of this paper.

1. Introduction

According to the neo-classical production function, the relationship between input and output shows diminishing returns to scale. Therefore, the rate of increasing output gradually decreases. Long-period economic growth can be regarded as the path of input according to time, which is determined by the production-function relationship between input and output. If a society is sluggish in technology development for a long time or its range of technology development keeps deceasing, then it will also show a gradual decrease in the rate of economic growth in the long run.

Agricultural societies before the Industrial Revolution showed a gradual decrease in the rate of economic growth. They were simple-reproduction societies different from the expansive reproduction[1] structure created by technology development and capital accumulation. As a result, the agricultural society attained the economic growth limit as time elapsed. At the end of an agricultural society era, the limit was overcome by expansive reinvestment of capital via trade and the appearance of a commercial society, which experienced a gradually increasing economic growth rate. However, commercial societies also reached the limit because the technology advancement that would keep up the expansive reproduction lagged behind.

In this article, we define a society experiencing a long period of declining economic growth as a "decelerating agricultural society." In this article, we explain the characteristics of an agricultural society that cause decelerating economic growth and investigate the effect of technology development over time on long-term economic growth. The economies that we discuss were pre-industrial societies based entirely upon agriculture; we define these economies as "pure agricultural societies." For example, before the Industrial Revolution, England was a purely agricultural society. Pure agricultural societies spanned a very long period in history: from the time when mankind first started to cultivate land, to the time when the Industrial Revolution occurred. The population of the agricultural society had been relatively stable for thousands of years. Meanwhile, agricultural technologies were developed gradually in these agricultural societies. However, technology advancement could not overcome the production constraints inherent in agricultural societies, such as limited land for cultivation. Therefore, in our view, sluggish technology development in agricultural societies is the result of a productivity decline, caused by production constraints, that is greater than the productivity growth induced by technology development.

This study on agricultural societies is a long-run analysis. The decelerating agricultural society is considered from a historical long-term analysis, in which the time spans considered are much longer than those in the usual long-term analysis used in economics. Therefore, we ignore economic factors that influenced production in the shorter terms within our study period and investigate the impact of technology advancement in history. The technologies in agricultural societies that are discussed here include all kinds of knowledge, skills, and tools developed for improving the agricultural productivity of farming.

We review the mechanism of a decelerating society using theories of Solow [1] and

Hayami and Ruttan [2] among those of other scholars who explained the relation between technology development and economic growth.

Solow [1] insisted that exogenous technology development shifts the production function. Hence each period has a different production function according to differing amounts or intensities of technology development. By expanding this theory, we explain the decelerating economic growth of an agricultural society. We can see the deceleration of economic growth by looking at the production function at different points in time and observing the slow technological development manifested by the trace of output according to input levels or the development of the output-input relationships over time.

Hayami and Ruttan [2] insisted that the long-term production function is restricted by technology development through an induced innovation model. This article shows the decelerating pattern of Hayami and Ruttan's meta production function applied to an agricultural society where the amount of technology development over time is small and the speed of development is reduced. An alternative approach to verify a decelerating society is to describe all developments of an agricultural society by reviewing the preexisting theoretical and empirical research of scholars who studied different aspects of that agricultural society's development.

Through the methods described above, we explain characteristics of a decelerating society: The main cause of deceleration is the speed and the amount of technology development over time. The theory and expected patterns are clearly supported by studies of commercial societies, which are discussed in the latter part of this study. We discuss the commercial society because it provides the mechanism for accumulating capital and it also represents the transition period between agricultural and industrial societies. Commercial societies faced limits due to the lack of technical ability to develop new products that create new demand. . Nevertheless some societies tried to overcome the decelerating pattern of economic growth through trade and capital reinvestment. Some commercial societies, which successfully established the Industrial Revolution and regarded technology development as their basis of economic growth, could achieve continual development and thus overcome the decelerating economic-growth patterns. By summarizing these historical cases, we confirm that the driving force of never-ending economic growth is technology development.

This study is organized as follows. In Section 2 the agricultural and industrial societies are defined. The important role of agricultural demand and supply in the development of societies is discussed in Section 3. Numerous theories that describe the rise of an agricultural society and its deceleration patterns are described in Section 4. The deceleration of an agricultural society and its replacement by an industrial society in England and the U.S. are investigated. Discussion of the limitations of the decelerating agricultural society is found in Section 5. The position of agriculture within economic development theory is established in Section 6 by an analysis of the different stages of economic development. The transition periods from the decelerating and accelerating commercial societies are discussed in Section 7. Finally, Section 8 summarizes this study.

2. Definition of an agricultural society

Societies are historically divided into agricultural and industrial types. Societies might be characterized by only one type, but in reality they are a combination of both. However, factor endowment and specialization in production result in societies with different degrees of the two components. For example, a society's agricultural employment as a ratio of total employment is an indicator of the importance of agriculture to that society. Another indicator is the agricultural share of production to the total value of production.

Agriculture is not only the act of farming and getting fruit by planting seeds and cultivating it with the power of nature but also raising and harvesting crops by soil cultivation and raising livestock. Stavenhagen [3] defined agricultural society as that in which the majority of a country's population is living in rural communities and has an agriculture-based economy. In an agricultural society, agricultural activities mainly cover production, and farmland and farmers are the important resources of the national economy.

Bowler [4] described the first agricultural revolution, which started thousands of years ago. People developed seeding agriculture through the power of man and animals. Agricultural communities were formed in the center of a farming civilization, and agricultural production supported population growth. Until the second agricultural revolution around 1650, labor intensive self-sufficient agriculture was the mainstream due to the lack of agricultural technology development. Normally, the land was shared. Toffler [5] and van Bath [6] also provide two other views about development waves in agricultural societies.

By focusing on aspects of food consumption, van Bath [6] divided Middle Age, Western Europe agricultural development from A.D. 500 to 1850 into two periods:

- From A.D. 500 to 1150, the Middle Ages were an era of direct agriculture consumption. Most people self-supplied while at the same time supplied a surplus of goods to the non-agricultural population group like the priests or the nobles.
- After A.D. 1150, the exchange of surplus production was expanding in the agricultural society. The commercial societies were adding other dimensions to agricultural society development. Therefore, markets were developing and prices were based on agricultural products.

Toffler [5] introduced the first wave of development, where an agricultural society is characterized by a focus on self-sufficiency and no incentives for increasing production.

- A society is characterized as self-sufficient when the main production pattern was production, through use of slaves, for self-consumption. Most produced Agricultural products were consumed by the producers and their families or by privileged minorities who could afford the food surplus.
- In an agricultural society, the majority of people were farmers living in small and half-independent communities. They had no way to preserve food for a long period and no roads to transport crops to distant markets. There was little incentive to develop production technology or produce more crops because even if they could do it, the outputs were aimed at consumption by their owners or the landlords.

- In this first period, commercial activities became increasingly important because some cities were dependent on the supply of food from agricultural rural communities.

Compared with an industrial society, an agricultural society is easy to define despite its complexity and multidimensions. The characteristic of self-sufficiency is of vital importance in understanding an agricultural society. However, because of the limited production by a single family, the society becomes a natural community with interdependency in many sectors and among many components. The interdependence leads to many forms of cooperative behavior among the economic society's members.

The economic community is characterized by the authority of the land. Agriculture and agricultural production are determined by the key production factor: land. If the right to control the land is given to specific people, the producers depending on the land are set in a community relationship. This dynamic will establish and determine the nature of the relationship within the community. The manor of Western Europe in medieval times is a representative example of the kind of economic community structure where land is controlled by specific persons.

Even though there were large cities and civilizations in the medieval agricultural society of Western Europe, the cities could not become the center of the agricultural society. They were constructed based on the manors of the agricultural district. The districts in turn formed a bigger society with complementary characteristics that generated self-sufficiency in a larger perspective. In other words, the agricultural districts, as smaller versions of the bigger society, were established with the economic surplus of agricultural production.

The fundamental difference between the medieval agricultural and industrial societies is that in the agricultural society economic surplus of agriculture was the basis of development in expanding commercial cities. Even though both agriculture and industry were developed in parallel and based on commerce, the development of the manufacturing industry was the significant base for expansive reproduction in industrial development and expanding commercial activities.

3. Characteristics of an agricultural society

In this section, the characteristics of an agricultural society will be examined from the viewpoints of short-term agricultural production, demand and supply of agricultural products, and the time and output relationships in the long term. From the short-term viewpoint, an agricultural society shows the characteristics of diminishing returns to scale and agricultural production is affected by factors such as regional location and economic situations. Also demand for agricultural products is inelastic to price and income changes, and the price is unstable due to inelastic supply. Because of these characteristics, the long-term economic growth decelerates over time.

3.1. Characteristics of production in an agricultural society

The general characteristics of an agricultural society differ among different societies. The differences are attributed to a number of factors that are briefly discussed below.

An agricultural society's short-term production function follows the neo-classical production function [6]. In other words, it shows diminishing returns to scale, where the rate of increasing output, as a result of increased input, decreases. The short-term production function is illustrated in Figure 1.

Insert Figure 1 here

The agricultural production function with two key input factors is defined as Y=F(Land, Labor), where the functional form F is quasi-concave and increasing in both arguments. In the short-run *land* is fixed and the *labor* is variable while in the long run all inputs are variable.

In an agricultural society, the ways of agriculture management are largely affected by regional and economic factors. These are described by [6]:

- It is affected by climate, quality of soil, and the condition of the agricultural water supply. The quality of soil determines what crops can be cultivated and the water supply condition determines whether the main source of livelihood will be stock raising or farming.
- In past agriculture societies, both farming and stock rising were not managed intensively. The area of land for cultivation was very limited because it was dependent on the extent of fertilization. The ways of recovering fertility of soil after land usage were (i) leaving the cultivated land fallow for quite a long time, (ii) leaving some part of land fallow for 1 year and then fertilizing enough by muck produced from agricultural communities, and (iii) fertilizing the mixture of humus soil from the non-cultivated land—wilderness and wild pasture—and the muck from agricultural communities; however, all of these were very restrictive alternatives for recovering the fertility of land.
- In the pre-Industrial Revolution period of Western Europe, the general ratio of harvest quantity to the quantity of sown seeds of some major crops, such as rye or wheat was, 1:3 or 1:4. Because of the low harvest/sown-seed ratio, a relatively large portion of the land had to be allocated for producing seeds needed for the next year. If the harvest/sown-seed quantity ratio is improved when the initial ratio is low, it has a big effect on the increase of harvest quantity by the cumulative effect (see [7]). However, cumulative effect decreases gradually with the increase of the ratio.
- In pre-Industrial Europe, reclaiming marginal farmland was the only way to increase agricultural production because the degree of agricultural technology development was low. However, indiscreet reclamation of marginal farmland deteriorated the fertility of land and lowered the harvest/sown-seed ratio. In the 13th century, the high degree of exploitation of marginal farmland led to a dearth of

farmland to reclaim.

3.2. Characteristics of an agricultural society in aspects of demand and supply

The demand of an agricultural society for major agricultural products has characteristics of inelastic price and income responsiveness [8]. Therefore, the expansive reproduction of an agricultural society is impossible because of the limited demand for agriculture where, at a certain level, it will not show further increases. The reasons for low or inelastic price and income elasticity of demand in agriculture are as follow:

- Most of the agricultural products are foods and necessities, and therefore demand for an agricultural product is generally inelastic to price changes. Also the income elasticity is low because the demand for agricultural products decreases relative to the improvement in economic conditions and is replaced by rapidly growing consumption of non-agricultural products.
- The facts that demand of agricultural products is inelastic to price changes mean that demand does not increase even though the agricultural products increase and the prices of the products decrease. Therefore, the capital accumulation coming from the agriculture does not grow in a sufficiently large extent.
- The demand for agricultural products is inelastic with respect to income changes. This implies that even if the national per capita income in a society increases, the increase of demand for agricultural products remains small due to the low income-elasticity of demand. As a result, the capital accumulation process is rather difficult and slow.
- For various reasons, the forecasting of agricultural supply is rather difficult, and the change of supply can be very large because controlling production quantity for factors such as temperature, rainfall, and insect conditions is impossible. This instability lowers the balanced economic growth in the long term.

The agricultural supply is highly affected by weather conditions, so it is difficult to forecast supply. Also, because a specific period is required for the growth of every agricultural product, the preparation period for the agricultural product is long. In addition, the production of the agricultural product is seasonal. These nature-related factors place constraints on the supply side. Therefore, the supply cannot be flexible to meet the real demand and price change of the agricultural product. Once the predicted price has determined the production quantity, which is done at seeding time, it cannot be controlled if the demand price changes at harvest. Therefore, due to the inelasticity of demand and supply, the economic characteristics of agricultural products may cause large fluctuations in their prices.

Ezekiel [9] introduced the cobweb model to examine the theoretical analysis of gradual change in equilibrium in one market and to determine whether the gradual equilibrium ultimately converges to the level of static equilibrium. According to this theory, the demand reacts rapidly to price changes. Meanwhile, because it is difficult for supply to react directly to price changes, a time difference ensues, and because of this kind of time difference, the real equilibrium price passes several instant equilibrium processes. So, price

and demand converge (Fig. 2A) or diverge (Fig. 2B) to the equilibrium point according to the sizes of elasticity of the supply curve and the demand curve. The phenomenon is named “cobweb” because the supply and demand curves take on the form of a cobweb.

The left-hand graph, Fig. 2A, illustrates a case where the price elasticity of supply is smaller than the price elasticity of demand. The equilibrium instantly fluctuates from Q to Q1 but it converges to equilibrium Q again by several subsequent chain reactions of demand and supply to the price change. The right-hand graph, Fig. 2B, shows the increasing or divergence of fluctuation when the instant equilibrium changes from Q to Q1 in a case where the price elasticity of supply is bigger than the price elasticity of demand.

Figures 2A and 2B illustrate that markets do not always move smoothly toward equilibrium. For instance, if current production decisions are based on past prices, then price may adjust to supply in the cobweb pattern shown here. Having received price *P*1 in the past, farmers will plan to supply only Q1 quantity of product. The Q1 amount will not meet market demand, and as a result the price will rise to P4. The high price induces farmers to plan for a harvest of Q3. At price P4, however, Q3 will not clear the market. The price will fall from P4 to P2, encouraging farmers to cut production back from Q3 to Q2. Only after several attempts do many farmers find the equilibrium price–quantity combination.

Insert Figure 2A and 2B here

According to the cobweb model described above, agricultural production shows unstable divergence because of late reacting of agricultural product supply for the rapid demand change. Figure 3 shows data about the development of the real price of livestock sold in the U.S. and production from 1875 to 1940. The change of livestock and milk cow prices shown in the graph reflects the change in livestock numbers. It can be seen that the alternation of price and production is diverging in the form of a cobweb. In this kind of divergence model, the demand and supply increase unstably until they meet the limit of resources, and then the price change drops to 0.

The critique offered here on the efficiency of perfect competition. In real life a competitive market system is not as efficient as ideal theoretical model but market forces have a stabilizing role as they push the market toward equilibrium. In the real world, prices do not move smoothly because market participants have only imperfect information. Production may be high and may generate loss, and then information to correct mistakes allows producers to achieve unsteady progress toward equilibrium. If current production decisions are based on past prices, price may adjust to supply in a cobweb pattern as the producers grope for the equilibrium Price-Quantity combination.

Insert Figure 3 here

3.3. Theory of decelerating society

The relationship between time and output in an agricultural society can be understood through the lens of technical change and the induced innovation of products and

production processes. From these two points of view, it is revealed that an agricultural society has a rate of production growth that decreases in the long term. However, the economic growth rate gradually decreases because of the simple reproduction structure and the existence of production-factor and technical limits. We previously mentioned land as a limitation factor of production. Below we analyze the decelerating development of an agricultural society, of the character described above, from the viewpoints of technical change and induced innovation models.

3.3.1. Viewpoint of neoclassical technical change

Solow [1] modeled how exogenous technology advancement shifts the neo-classical production function[2]. The short-term production function has the diminishing form as Figure 4 shows. In the figure, k is the ratio of capital input to labor input (K/L) where K is a capital input and L is a labor input. The production function of period t = 1 shows that output q_1 is feasible with regard to input level k_1. In addition, output level q_2 is feasible to input k_2 as a result of the development of technology in period t = 2 because the production function has shifted by technology advancement. This implies that output increases as the amount of q_2-q_1 when the time passes from t = 1 to t = 2.

Solow [1] defined the increasing part of output by the shift of production function except for the part that increased, according to the same product function, due to the increase of input that result from technical change. The reason for this kind of production-function movement is technology advancement.

Insert Figure 4 here

The Figure 5A shows the patterns of aggregate production function (APF) drawn for an agricultural society from the viewpoint of technical change. Each APF reflects the technology level of specific times. To apply Solow's [1] model to agricultural societies, land is used as a proxy for the capital input of industrial societies. Therefore, in this situation, k represents the land, which is the most important input-production factor in agricultural societies and equivalent to the capital input in industrial societies. The increase of k means that farmland area is enlarged. Fig. 5A shows that the degree of shift in APF is small in a pure agricultural society. The small level is due to sluggish technology advancement, and also it is seen that the agricultural society is decelerating because the positive annual shifting rate in production is gradually decreasing as time elapses.

Insert Figure 5A here

The second graph (Figure 5B) illustrates the trace of output at each period as calculated from the production function of each period shown in Figure 5A. We assume that the output levels are constant, and equidistanced time intervals are used to make a simple model that illustrates how agricultural technologies affect agricultural output over time.

From this point in the paper, we will define 'APF production expansion path' as a trace of production according to the time of each APF. At trace of production, the APF production expansion path illustrates when the APF shifts in response to technology change. The APF

production expansion path of Figure 5B shows the long-term production curve of an agricultural society.

Insert Figure 5B here

In Fig. 5B, q2-q1, q3-q2, and q4-q3 indicate that the increased amounts of production are decreasing over time because the range of short-term production-function shift is decreasing. The decreasing pattern is due to slow technology development in a purely agricultural society.

3.3.2. Viewpoint of induced innovation model

Hayami and Ruttan suggested the meta production-function form for the induced innovation model in agriculture [2]. This is one of the potential production functions suitable for describing agricultural production and society. As shown in Fig. 6, the meta production function is the envelope around the neo-classical production function. The meta production function is restricted by technology advancement in the long term. In other words, the output change is dependent on the increase of the output/input ratio according to time.

As is shown in Figure 6, the short-term production function of an agricultural society shows diminishing returns to scale. In the figure, A1 and A2 are the times used to establish each technological development, and B1 and B2 indicate the increased production through technology advancement. When the movement of the short-term production function gets smaller due to technology development, as expressed by the meta production function, the economic growth rate decreases and finally it reaches the limit and becomes sluggish. In conclusion, output according to time in an agricultural society takes a form similar to the short-term production function that shows a gradual decrease in the rate of increase.

Insert Figure 6 here

In a pure agricultural society, the technology advancement is very slow, and as a result, the movement range of the production function is very small and decreases gradually. Therefore, the graph clearly shows the diminishing relationship between phase-in input and output of an agricultural society. It thus reveals the decelerating relationship between output and time.

In sum, the movement of the neo-classical production function is caused by technology advancement according to time, which can be expressed by the APF production-expansion path, which is the trace of output, or by the meta production function, which is the envelope around the neo-classical production function. The decelerating characteristics of an agricultural society (i.e., the decrease of the economic growth rate according to time) can be explained clearly by the two curves in Figure 5.B and 6.

4. Theoretical explanations about a decelerating agricultural society

In this section, the opinions of Debertin [10], Johnston and Mellor [11] and Hayami and

Ruttan [2] will be featured as the theories that explain the decelerating nature of an agricultural society. Debertin [10] explained that agricultural production shows diminishing returns to scale, and the ratio of production factor, which has a high fixed cost, will cause production to be less than the maximum level. Johnston and Mellor [11] suggested that agriculture develops in three stages. In the first stage, the pure agricultural society has a very low increase of production. Hayami and Ruttan [2] explained the deceleration of increasing production of an agricultural society in the long term by using the induced innovation model.

4.1. Debertin's explanation of agricultural production

The neo-classical production function, as it applies to agricultural societies, explains the production relationship of a short-term production function that shows diminishing returns to scale. In Figure 7, in accordance with the Debertin's [10] explanation, the production function is illustrated by focusing on the marginal physical product (MPP), average physical product (APP), and total physical product (TPP) in production.

As the input (X1) increases, the production capacity of the input factor also increases at first. After reaching the point of inflection the accelerating production capacity starts to decelerate. Here the TPP is still at an increasing state. However, as the function passes its maximum point, even though the input of variable production factor (X) increases, the TPP decreases. In other words, more of an input factor, such as fertilizer, damages agriculture rather than providing a positive effect on the output[3].

In the case of agricultural production, the deceleration grows heavier because the rate of production factor, which is a fixed cost, is high and the production period is long [10]. Prior to the seeding moment, most of the production factors are variables, but after the seeding stage the variable production factors are considered fixed. Thus, when production factors are used, the accompanying production cost is regarded as fixed.

For a production function with two production factors like fertilizer and labor, when both factors are variable, the maximum production point is the point on the production possibility frontier where the overall profit is maximized and simultaneously it also satisfies the requirement of minimum production cost of the combined production factors. However, for the production function to treat only one input as a variable, the profit is maximized at the low level of output, which is less than the production maximization level. Therefore, non-maximization of production causes the growth to decelerate at a higher rate.

Insert Figure 7 here

4.2. Johnston and Mellor's stage theory of agricultural development

As mentioned previously, the Johnston and Mellor's [11] theory of agricultural development consists of three stages. The first stage is labeled as development of agricultural preconditions. Most of the agricultural sectors in underdeveloped countries are classified as belonging to the first stage. The sector is characterized as self-sufficient

family-centered agriculture. Productivity is low because of lack of resources, education, and technology. Even though it is not possible to increase productivity or total production in this traditional agricultural sector, there is the potential of productivity increases by technology changes.

Traditional agriculture has a number of specific characteristics. For instance, the production increase is very slow because of the stagnation of rate of change in technology. The increase of income is not sustainable because the production is increased by more traditional inputs such as land, labor, capital, and so forth. Without the application of industrial technology, the continuous productivity increase cannot be realized even with partial farmland reform and fertilizer introduction, which are considered as innovations within a pure agricultural society.

The second stage is characterized as expansion of agricultural production based on labor-intensive, capital-saving techniques that rely heavily on technological innovations. An increase of agricultural productivity in this stage is achieved with the use of inter-complementary inputs. Institutional and nontraditional production-input factors such as technology, education, and extension services are increasingly utilized in the production process. In this stage, the more important factors for agricultural development are institutional factors, such as research, education, and technology diffusion, rather than the traditional physical resources, such as land, capital, and labor. Some agricultural technology is not obtained by farmers themselves but obtained through technology developed by public institutions financed by the government. This stage is affected by the industrial society and its development.

The third stage is referred to as expansion of agricultural production based on capital-intensive, labor-saving techniques. It is a dynamic agricultural development stage with capital intensive technology in which large-scale agricultural machinery substitutes labor input. It is a mechanical- technology advancement stage that saves agricultural labor by the support of policies that can bring gradual growth of production, distribution, and circulation. This is a characteristic of agricultural sectors in industrial societies.

Johnston and Mellor, with regard to the development of agriculture, agree that an increased rate of output increases deceleration in a pure agricultural society; this deceleration characterizes the traditional agriculture stage. Without going through the second and the third stages, which are the stages when technology and products of an industrial society are introduced to an agricultural society, the development of agriculture fundamentally cannot grow and deceleration cannot be escaped.

4.3. Hayami and Ruttan's agricultural development theory

4.3.1. Models of agricultural development

Five models of agricultural development are introduced here: exploitation, conservation, location, diffusion, and a high pay-off input. A sixth model is the induced innovation model, which is explained in the next section.

The exploitation model [2] is also seen as a frontier model where agricultural productivity increases through an increase in farmland. Early agricultural development in Africa, Asia, Europe, and the U.S. is characterized by the exploitation model. In these areas, the problem of food insufficiency caused by population increase was solved through the expansion of farmland.

Among other characteristics of the exploitation model, the presence of low productivities, caused by slash-and-burn farming or shifting cultivation, is observed, but so is agricultural development that is premised on the existence of extensive uncultivated land. In this traditional sector, resource development leads to the exportation of some of the first products yielded and this activity leads to sustainable economic development by trade. The theory is systemized with the first-products trade theory and surplus-product discharge theory [2]. The exploitation model characterizes the traditional decelerating agricultural society.

The conservation model is based on the practice of plantation rotation and livestock farming in England and the fertility of soil in Germany before England's agricultural evolution [12]. This theory is based on diminishing returns of the land considering the input of labor and capital. It informs a methodology designed to prevent the drop in agricultural productivity.

The land of England was classified and used as permanent farmland and permanent grassland. This model focuses on keeping the fertility of the land. It contributed to the 1% yearly growth of agricultural production, but the growth was not good enough to satisfy the explosively growing population and growing demand.

The location model [13] is also called the urban-industrial impact model. While regional differences of agricultural development that originate from differences in environments are not considered in the conservation model, the development level is different in location model and is in accordance with effects of commercial districts.

von Thunen [14] explained how agricultural density and labor productivity differ geographically around an isolated city. Vegetable farming in neighboring towns, grain farming in a farther region, and stock farming in the farthest region are elements of this model. Schultz [15] found that the agriculture factor and product markets located near the city, where the income level is increasing, are being managed most effectively in U.S today. These theories suggest that an agricultural society itself cannot achieve expansive reproduction and that the demand-pull of the urbanized population leads the development of the agriculture sector and thereby the accelerating or decelerating nature of the society.

The diffusion model is characterized by the expansion of improved farming methods. Under this model, reformed seeds and breeding stock are considered two of the essential factors for improving agricultural productivity. Additionally, differences are noted between farmland productivity and labor input productivity among farmers of the agricultural society.

This diffusion model focuses on the efficient extension of technological knowledge and reduction of productivity differences among different geographical locations and among

farmers of different specializations. This model is explained by the technology diffusion model introduced by Griliches [16]. This model proves that the introduction of industrial technology is a viable method to solve the deceleration problem of an agricultural society. The diffusion model, which insists that agricultural productivity can only be improved by introduction of developed industrial technology from the outside, is the theory that proves that the pure agricultural society is a decelerating society.

In the high pay-off input model, agricultural technology is strongly based on geographical characteristics and the level of development and absorption capacity of the agricultural society. The technology of advanced countries cannot be transferred directly to underdeveloped countries because of differences in weather, resources, and capability of the labor to understand and to adopt such technology. The failure in technology transformation is not because the farmers of the underdeveloped countries have lower productivity, but because their technological and economic opportunities are limited and their poor status is continued. Schultz [17] as well as Hayami and Ruttan [2] developed this theory.

Overall agricultural productivity is increased by three main factors: investments in inputs, which create an agricultural test-bed for new knowledge; an industrial sector for developing, producing, and selling new technological inputs; and farmers who efficiently use the modern agricultural inputs. The agricultural policy of industrial societies based on this high pay-off input model is associated with a high agricultural growth rate, and it has provided the necessary condition for modern economic growth. This model theoretically proves that the introduction of industrial technology could overcome the deceleration of an agricultural society.

4.3.2. Hayami and Ruttan's induced innovation model

The induced technology innovation model was suggested by Hayami and Ruttan [2]. In this model, technology innovation is the most important factor for agricultural development. According to the model, induced innovation by private and public sectors, interaction between technology innovation and system development, as well as the dynamic relationship between technology innovation and economic growth are among the most important factors of agricultural development.

The induced technology innovation model was applied to an empirical study that explains the process of agricultural development in Japan and the U.S. The results suggest that both countries made rapid progress in the modernization of their agriculture, but the two countries show different characteristics in modernization and progress.

In Japan, the yield per unit of land area was high in the early stage of development and this was mostly because of improved seeds and sufficient access to fertilizer input. In the U.S., even though the yield per unit of land area was not as high as that of Japan, the substitution of machinery for unskilled labor was a successful practice, and as a result, the labor productivity in American agriculture increased dramatically compared to that of Japan and other countries.

The difference in natural resources and the relative cost differences in production factors among countries could also explain the differences in the development process. In this model, technology development is not determined entirely exogenously but can be explained endogenously by factor endowment conditions.

In this model, the long-term trend of agricultural production is expressed by the meta production function, which is the envelope of neo classical production functions that is shifted by technology advancement. However, the technology innovation in a pure agricultural society is very slow so that the moving range or shift of the production functions by the force of technology innovation is narrow [2]. Therefore, the shape of meta production functions shows a decelerating form according to time.

4.4. Summary of theories explaining a decelerating agricultural society

The scholars who have studied the economic growth of agricultural societies, including those whose theories we have examined so far, explain that a pure agricultural society shows evidence of inefficient economy and the society stagnates with gradually decreased speed of growth in the long run. Debertin [10] insisted that, due to the high ratio of fixed production factors in agriculture, production is always under the maximized level (i.e., optimal production is not achieved). This inefficiency of short-term production is accumulated in the long run so that it causes a negative effect in the form of a reduction in the speed of growth.

Johnston and Mellor [11] explained the development of agriculture with three phases. They also supported the idea that the decelerating growth of an agricultural society is characterized by outputs that seldom increase due to remarkably low production power and stagnated technology levels in the pure agriculture (stage one) phase.

Hayami and Ruttan [2] showed that all models that had been invented, such as the exploitation, conservation, location and high pay-off input models, fail to incorporate the ability of the agriculture sector to induce production increases through technology development. Hence they described the efforts to accomplish economic growth in agricultural society as being focused on trying to increase production by increasing input factors such as labor and land. Hayami and Ruttan [2] insisted that the most important factor in the development of an agricultural society is the technological innovation referred to in their induced innovation model. However, at the same time, they admitted that agricultural development through technology development is decelerating and mentioned that the amount technology development shifts in the production function is gradually reduced in the long run.

With the support of the discussion above, based on opinions of various scholars who dealt with the economic growth of an agricultural society, we can conclude that an agricultural society decelerates in the long run.

5. Limitations of a decelerating agricultural society

Because of its self-sufficient structure, an agricultural society cannot achieve the desired economy of scale, and it shows limitations on growth, such as those caused by the inability to sustain capital accumulations. In modern times, agriculture is shown to be inferior to other industries in terms of structures, inelasticity of demand, stiffness of supplies, and so forth. For these reasons, the hypothesis of the stages of economic growth insists that the transition from an agricultural to an industrial society moves the society to a more developed state. As a result, limitations of the agricultural society are ensured.

In this section, we discuss the limitations of a decelerating agricultural society. In particular, we focus on structural problems in agriculture, agricultural problems, and their impact on the industry as well as in market and non-market areas of the economy.

5.1. Scale structural problems

Three structural problems of agriculture are distinguished: economies of scale in traditional agriculture, practices based in the neo-classical theory of farming, and the approaches in development economics. Basically, the traditional agriculture structure cannot achieve economy of scale because it is based on peasant and family farms. Thus, the inability to take advantages of economies of scale in production is considered as an important structural problem and a hindrance to the growth of the traditional agriculture.

Schultz [15] indicated that the behavior of the peasant is rational but he/she is unable to achieve agricultural production equilibrium. This inability is attributed to a number of natural and institutional characteristics of agriculture including: (i) uncertainty inherent in agricultural products, (ii) risk-aversion of the producer whose low income discourages investment in technology development, (iii) heterogeneity between family farms and employment, (iv) characteristics of land that the peasant owns, and finally (v) an incomplete capital market.

Limitations of technology development and explanations of the treadmill effect [18] apply to a traditional agricultural society.

To have continuous development of an economy, capital should be accumulating as technology advances, and thereby, the positive cycle of expansive reproduction should be formed. This cycle can be made by developing technology (i.e., accumulating capital). However, in an agricultural society, which is under demand inelasticity, capital accumulation is impossible. Eventually, the lack of economic growth decelerates in the society.

This phenomenon is called treadmill effect. It is explained in detail in Figure 8. There is only one way to increase the income, by reducing the production cost, because the increase of output due to agricultural productivity improvement does not guarantee the increase of agricultural revenue. In other words, capital is not accumulating because the surplus of capital goes to investment for continual cost reduction.

Insert Figure 8 here

5.2. Technology structure problems

Agriculture, because of its characteristics, meets the economic growth limits as deceleration of production increases. As a result, it can break through the limit through the use of industrial technology.

Three theories can be used to explain the break-through phenomenon. First, Schultz [15] indicated that the relative importance of agricultural products decreases as the economy grows because income elasticity of agricultural products is less than that of industrial products.

Second, according to the development economics approach [11], economic growth is a result of the movement of resources from agriculture to industry. In other words, economic growth is achieved by transferring the input factor from a simple reproduction sector to an expansive reproduction sector.

Third, the Kelley et al. [19] and the Yamaguchi and Binswanger [20] models contributed to the literature on the agricultural problems and industrial structure through an equilibrium theory. Because the relative importance of the agricultural sector is decreased as the economy is developing, the improvement rate of industrial technology contributes much more to the economic growth than the improvement rate of agricultural technology. Even though agriculture is considered a basic industry and necessary to attain economic development and to increase the employment rate through interactions between agriculture and industry, in the equilibrium theory, constraint of demand, which is attributed to the low income elasticity, acts as the fundamental limit of agricultural growth.

5.3. Market structure problems

Agriculture has growth limits with respect to wealth accumulation and expansive reproduction. Production of organic matter and mechanization of production are difficult tasks. As previously mentioned, it is rather difficult for producers of agricultural products to respond to changes in market conditions quickly, and the demand is therefore inelastic in product or price dimensions.

The agricultural industry is vulnerable for several reasons. First, the two factors that most affect the demand of agricultural products are income and population, and therefore, these demand factors are important in price decisions. Second, the relationship between income and consumption of agricultural products follows Engel’s law [21]: Little relative increase in agricultural product demand will be seen as the income level increases at a relatively fast rate. The relative importance of agricultural production decreases as the economy grows further, even when the gross national product per capita increases. Engel’s law is the basis for labeling the industry as a developmentally inferior.

5.4. Position of agriculture within the economic development theory

Referring to economic development theory [22], agriculture is always the precondition society for industrialization. Therefore its development is limited, and therefore, agricultural inputs are transferred to an industrial society, which is a better stage for economic development.

The economic development stages theory of Marx and List, the theory of structural change by Fisher and Clark, and the theory of leading industry as discussed by Rostow [23] support these hypotheses.

Marx's economic development theory consists of five sequential stages: primitive communism, ancient slavery, medieval feudalism, industrial capitalism, and socialism. He emphasized the growth of agricultural productivity as a precondition to the industrial capitalism that follows and the role played by technology.

In List's four stages theory, economic development is divided into four stages: savage, pastoral, agricultural, and agricultural-manufacturing commercial. For the economic development of a society where agriculture and industry coexist, the agricultural sector must produce a surplus over base exports to develop the national industry. According to List, the development of other industries is more important than agricultural development.

Fisher and Clark suggested the theory of structural changes. In their view, any society has to pass through structural changes of industry. In other words, as the economy grows, labor and investment shift from the primary (agriculture, mining, forestry) to the secondary (manufacturing and construction) to the tertiary sectors (services, commerce, transportation).

Rostow's five-stages reflect a theory of leading industry [23]. The sequence of Rostow's five stages of economic development is traditional society, precondition for take-off, take-off, drive to maturity, and mass consumption. In Rostow's view, modernization of economy passes through each of these stages and the technology innovation of leading industries is the most important factor in the leap between any two stages.

6. Countries experiencing a decelerating agricultural society

In this section, we confirm that a pure agricultural society's economic growth decelerates for a long time. This is done by inspecting the agricultural production changes of European countries during the 500 years of the Middle Ages and America's 200 years of increased agricultural productivity from the late 18^{th} century to recent times.

6.1. Agricultural production of Medieval European countries

This section is based on Allen [24]. Figure 9 shows the agricultural output per capita of nine countries: Austria, Belgium, England, France, Germany, Italy, Netherlands, Poland and Spain in medieval times from 1300 to 1800. The numerical value of the output per capita of 16^{th} century England is set to 1, serving as the reference to which the other data are relatively calculated. According to these data, agricultural output per capita of

European countries was sluggish during the Middle Ages.

Insert Figure 9 here

Looking through the changes of the agricultural productivity of seven countries, Austria, Belgium, England, France, Germany, Italy, Netherlands, Poland and Spain during the same period, one sees that the agricultural productivity per laborer is sluggish or decreasing except in England and the Netherlands. The reason for exceptional increases in the agricultural productivity of England and the Netherlands after 1600 is the decrease of the agricultural population. The rural population declined due to the revitalization of the urban economy and population convergence to the cities.

6.2. Agricultural production of Italy

Figure 10, by Federico and Malanima [25], shows the index of the total agricultural productivity of Italy from 1300 to 1870. When the total agricultural productivity from 1860 to 1870 is set to 100, the total agricultural productivity between 1300 and 1820 (520 years) was sluggishly reaching index levels of 40 to 60. The agricultural productivity fall between 1300 and 1400 was caused by the plague, which broke out between 1348 and 1349. At that time 40% of the population of Italy died and the number recovered slowly after 1400. The authors mention that agricultural production increased little by little, but the data show that the agricultural production was sluggish in simple reproduction until 1820, just before Italy became an industrial society.

Insert Figure 10 here

6.3. Total crop production of medieval England

Figure 11 shows the information on total crop production in England from 1540 to 1860, which is estimated on a million-bushel basis [26]. Until 1770, the total production of crops decreased gradually. Clark suggested that the increase in crop production was caused by a sudden decrease in wages in the late 18^{th} century and the introduction of industrial technology. The Industrial Revolution helped agricultural production escape a decelerating trend.

Insert Figure 11 here

6.4. Agricultural productivity of the United States of America

The development of the agricultural productivity of the U.S. from 1755 to 1975 is reported in Fig. 12. According to Plucknett [27], the period is divided into four disproportionately distributed sub-periods: hand labor, horsepower, mechanical power, and scientific power. The patterns show that the pure agricultural society experienced decelerating growth over 160 years (i.e., the three sub-periods until 1930). However, after the development of industrial technologies, the decelerating pattern vanished and accelerating growth started to emerge with the effects of industry development: equipment, fertilizer, and improved seeds.

In less than 45 years the productivity index rose from over 50 to 110, more than doubling the agricultural production in the U.S. The graph also shows that neither the Civil War nor the world wars (WWI and WWII) negatively impacted the productivity of agriculture.

Insert Figure 12 here

7. Transition from an agricultural to a commercial society

Commercial society does not exist in isolation. It is a transition society between agricultural and industrial societies. The production base of the economy is agriculture but the commercial society is capable of expansive reinvestment of wealth by accumulating the agricultural surplus capital originating from the development of trade. However, its production base, agriculture, is limited in creating new demand. So the commercial society also has limited growth. In this section, formation, development, and limits of a commercial society will be examined, and it will show that developing new products and generating new demand through technological advancement are the essential factors to an accelerating society. This section discusses the transition period from the decelerating society and the accelerating society; that is, it addresses the commercial society that exists during the transition period between the agricultural and industrial societies. The emphasis is on the formation, development, value creation, and structural limitations of the commercial society.

7.1. Formation of a commercial society

The formation of a commercial society is discussed in Abu-Lughod [28]. Commerce is an act of purchasing a product or a service through selling or exchanging the product between people, businesses, or countries [29]. The commercial society appeared in Europe around the 14^{th} century with the increase of agricultural output and vigorous commercial activities to exchange surpluses. With the development of oriental trade through the Silk Road and navigation improvements, geographical discoveries (called the “Age of Discovery”) continued from the 15^{th} through the 17^{th} centuries. Europe prospered in this period, attributing to the formation of the commercial society.

At the end of the agricultural society period, as the population grew, a surplus of agricultural products was produced by advanced agricultural technology, and as a result, the commercial economy was developed. After 1050 in Europe, as the equipment and technologies related to agriculture continued to be developed, the agricultural output grew such that it was increased 3 to 4 times by the 1300s. Commerce became active through the surplus of agricultural products in this period. In particular, the demands for imported spices and luxuries increased because people had met their essential needs and had surpluses that could be sold to buy non-necessity products. The commercial society adds value by transporting the value created by the agricultural society to places where consumer utility is high.

7.2. Development of a commercial society

The commercial society overwhelmed the medieval European agricultural society via enlargement of cities, increased population, increased market activity, and so forth. While it was impossible to accumulate capital in the agricultural society due to inelasticity of agricultural demand and supply over time, the commercial society solved the problem through trade. When agricultural products are transported to places where the demand was high and traded, the value of the product can be more higher. As a result, producers could earn more profits, and this made expansive reinvestment of capital possible. Therefore, the commercial society carried out accelerated economic growth.

The market was activated through the trade of surplus agricultural products and resulted from the inflow of population to the cities (see Table 1). Unlike in the agricultural society, which had limited resources, the land in the commercial society showed a positive cycle structure and the city population increased explosively. This cycle revitalized the market again. The development that led to nearly all commercial activity was concentrated in the cities.

With regard to Europe, Allen [24] mentioned that 4.4% of the total population of England lived in cities in 1300 but it increased to 9.7% in 1600 and to 16.9% in 1700. By 1300, as much as 20.8% of the population was living in the most commercially developed Italian city-states of the 13^{th} and 14^{th} centuries. By 1400 in Spain, which led the Age of Discovery in the 1500s, 26.3% of the population lived in cities.

Insert Table 1 here

Active cultural exchange is another factor promoting a commercial society. As the exchange between regions became more active by the development of commerce, a commercial society naturally inspires cultural development and exchange. The representative examples for medieval Europe are Venice and the region along the Silk Road. Venice had a period of prosperity as a rich commercial city from the 13^{th} to the 15^{th} centuries while seizing the trade of the Mediterranean Sea and oriental countries. The national force of Venice, which had been a small city-nation, became large enough to rule the whole Mediterranean Sea. The people of Venice had contributed in the exchange of goods between the East and the West by following the routes from the Mediterranean Sea to the Indian Ocean as indicated in Figure 13.

Insert Figure 13 here

In addition, from the result of cultural interchange between the western and oriental countries, the culture nurtured by the Silk Road subordinated the culture of regional countries.

Possession of a strong army is another factor enhancing the formation and development of a commercial society. In the European agricultural society, the army had only the minimum defense mechanism to guard the regional ground from those who steal grain. In the commercial society, the importance of a strong army arose, because a defense mechanism was required to protect the exporting and importing of goods to and from distant markets and production places. Possession of a strong army to protect a nation’s commercial route,

merchants, and markets was also necessary to establish new commercial routes.

The growing number of people who were willing to invest capital in commercial activities was another factor contributing to the development of the commercial society in Europe. Because expansive reinvestment was possible in the new society, it was a good environment for a growing population who invests its capital. Commenda and Societas, enterprises developed in the Mediterranean countries in medieval times, are representative examples of expansive reinvestment.

Development of the currency economy was a final and major step. Transaction costs were reduced by making exchange easier. It brings activation of the barter system and hence the currency economy plays an important role in the development of commercial society.

7.3. Limitations of a commercial society

Three forms of limitations characterize the commercial society. They are associated with limitations of value creation, transportation, and product quantities. Each of these limitations is described below in more detail.

7.3.1. Limitations of the value creation in a commercial society

In a commercial society, value is created by expansive reinvestment of commercial capital so the value created increases exponentially, like a compound interest graph (see Figure 14). Therefore, although the major products are agricultural, value creation accelerates in a certain period. However, the accelerating development of growth in a commercial society is limited because of the technical, physical, and economic reasons for maintaining an agricultural society. That is, the basis for value creation in the commercial society is the agricultural society.

Insert Figure 14 here

7.3.2. Limitation of transportation

The profit of a commercial society is directly related to transportation because commerce is attributed to the transportation of products. In the 1700s, the Netherlands used its 400 miles of canals and waterways, which were more efficient than land routes. The growth of gross domestic product (GDP) per capita from 1500 to 1700 was as follows: the Netherlands 52%, England 28%, and France 15%. In 1293, the overseas trade of Genoa was 3 times greater than the total production quantity of France, which was a strong nation at that time.

Commerce was directly related to transportation, but transportation had its limits. Trade through land transportation quickly reached the limit of product quantities because of restrictive road conditions and obstacles (mountains, rivers, deserts, etc.). In practice, long distance transportation by land route is more expensive than sea transportation. For sea transportation, materials that were used to make the ship were limiting factors. The

problem with material obtainment was aggravated by the fact that a wooden ship could not be longer than 60m nor weigh more than 1,600 tons. Additionally, the quantitative expansion of sea transportation was limited because the area of a paddle, the length of the sail, and the power supply were limited. Even though the cost of water transportation was cheaper, travel by sea was slower than by land.

7.3.3. Limitation of products

The commercial society itself cannot create products, which are the bases of value creation. Businesses were using products from the agricultural society. In the 15th and 16th centuries, the development of the European commercial society was based on the exploitation of new land and simple merchant trade and not by production of goods. (See Figure 15.)

The number of items or number of traded products was not enough for sustaining acceleration because simple merchant trade of imported spices, agricultural, and homemade handicraft products characterized the period. Development stalled at a certain stage because no more products were developed from the new technologies that can create new demand.

Because the basis of value creation in commercial society was the agricultural product, commercial society went into ruin with the advent of the industrial society. This fact is clearly seen in the cases of Spain and England. Portugal and Spain were unlike England during the phase of industrial development limited. In Spain and Portugal, expansive reinvestment was limited because new demand was not created with new products in the commercial society. A historical lesson suggests that the basis of value creation for expansive reproduction is essential to maintain sustainable development.

Insert Figure 15 here

In the 16th century, Spain accumulated enormous national wealth by geographical discoveries during the Age of Discoveries. However, it was chased by the Netherlands and England, which were developed in the wool manufacturing industry while Spain was basically an agricultural country mainly involved in merchant trade [30].

Increasing imports of precious metals caused an increase in the amount of currency in circulation, and prices rapidly rose. This “price revolution” formed advantageous conditions in development of commerce. However, Spain lacked manufacturing technology and skilled workers, so the production increase could not catch up to the increased demand. Hence imports increased, and it caused unbalanced trade and increased debt (see Table 2). As a consequence, Spain started to weaken (see [31]).

Insert Table 2 here

Insert Figure 16 here

England started to accumulate wealth by gradually substituting the wool, which was the major export product, to processed goods, which yielded a higher value-added price (see Figures 17A and 17B).

Insert Figure 17A here

Insert Figure 17B here

England, by producing various products besides wool, such as steel, zinc, silk, glass, among others, became strong. The development of industry brought the Industrial Revolution. (See Table 3)

Insert Table 3 here

In 1588, England started to get ahead of Spain due to the Invincible Armada victory. In particular, England took over Jamaica, which was a Spanish colony, in 1655. This shows the historical evidence that the power of England was greater than that of Spain [33].

Figures 18A and 18B show that the GDP per capita of England, which was successfully industrialized, was growing at an accelerated rate from 1500 to 1820, while the GDP per capita of Spain and Italy, which had stayed in a commercial society, had stagnated. The graphics clearly show that a commercial society not accompanied by the industrialization process has limited growth.

Insert Figure 18A here

Insert Figure 18B here

Simple merchant trade, which was centered around Spain, did not transfer into an accelerating industrial society. Meanwhile, industrialized England entered into an accelerating society and this made the economic power of Spain and England experience reverse fortunes over time.

The reason the commercial society could not sustain accelerating economic growth is that a commercial society is part of an agricultural society that relies on reinvestment of capital without industrial technological development. This is why Spain failed to achieve unstoppable economic growth. As we may confirm with the case of England's industrial revolution, to accomplish ceaseless accelerating economy development, creation of demand is required to pull the development. New demand is created through development of new products according to the development of new technology. Hence we can confirm the fact that, for any society or any country, the essential factor to accomplish ceaseless economic growth is technological development.

8. Summary and conclusions

Agricultural societies, which have existed for thousands of years since civilization originated, have maintained self-sufficient economic activities without any particular technological advancement. In an agricultural society, one of the major methods to increase the agricultural production is to improve the harvest/sown-seeds quantity ratio or cultivate new farmland. These efforts had large effects in the early stages of the European agricultural society, but the effects gradually waned. Also the agricultural society had a structural limit: All surplus values were used for the maintenance of the status quo and not for the reinvestment of surplus production.

For the reasons mentioned above, the historical general economic growth trend of the agricultural society shows a gradual decrease in the development rate over time in terms of agricultural output and productivity. The reason for the decelerating pattern is because an agricultural society is incapable of developing new products or generating new demands by technological innovations. In the process of accelerating economic growth, a positive cycle structure—new products are developed by technology innovation and this generates new demand, and this production causes capital accumulation, and the accumulated capital, in turn, is reinvested in technology innovation that improves production—of an expansive reproduction must be made. However, simple reproduction agriculture was far different from this ideal structure.

The commercial society started to accumulate capital by generating new demand through trade. Expansive reinvestment of accumulated capital for larger and expanding trade made the commercial society show accelerating economic development over time. However, without development of new products to continuously support this process, expansive reinvestment of capital from the merchant trade could not maintain the accelerated growth pattern. Commercial countries that pursued economic development by trade were outrun by the industrial countries that developed new products by technology innovation. The development led to the vanishing commercial society.

In this study, we prove by a number of well-established theories and several cases that the agricultural society is a decelerating society (i.e., the rate of economic development gradually decreases). We verify that a commercial society that has an agricultural background quickly meets the limit, even though an acceleration of economic development has been experienced. From the discussion above, it is clear that without technology innovations that bring new product development and the subsequent creation of new demand, the economic growth of the agricultural society reaches the limit.

References

[1] *Journal.* Solow, R.M., Technical Change and the Aggregate Production Function, Rev. Econ. Stat. 39 (3) (1957) 312 320.

[2] *Book.* Hayami, Y., Ruttan, V.W., Agricultural Development: An International Perspective, The Johns Hopkins University Press, Baltimore, MD, 1971.

[3] *Book.* Stavenhagen, R., Problemas etnicos y campesinos, Mexico: Instituto Nacional de Indigenistas. Consejo Nacional para la Cultura y las Artes, Mexico, 1982. In Spanish.

[4] *Book.* Bowler, I., Agricultural Change in Developed Countries, Cambridge University Press, New York, 1996.

[5] *Book.* Toffler, A., The Third Wave, Bantam Books, New York, 1990.

[6] *Book.* van Bath, B.S., De Agrarische Geschiedenis van West-Europa 500-1850, Gysbers & Van Loon, Amhem, 1960. In Dutch.

[7] *Journal.* van Bath, B.S., The yields of different crops in relation to the seed c. 810-1820, Acta Historiae Neerlandica 2 (1967) 26 106.

[8] *Journal.* Johnson, D.G., The nature of the supply function for agricultural products, Am. Econ. Rev. 40 (4) (1950) 539 564.

[9] *Journal.* Ezekiel, M., The cobweb theorem, Q. J. Econ 52 (2) (1938) 255 280.

[10] *Book.* Debertin, D.L., Agricultural Production Economics, Macmillan, New York, 1986.

[11] *Journal.* Johnston, B.F., Mellor, J.W., The role of agriculture in economic development, The Am. Econ. Rev. 51 (4) (1961) 563 593.

[12] *Book.* Leighty, C.E., Crop rotation soils and men: yearbook of agriculture 1938, U.S. Department of Agriculture, Government Printing Office, Washington, DC, 1938.

[13] *Journal.* Ruttan, V.W., The impact of urban-industrial development on agriculture in the Tennessee Valley and the southeast, J. Farm Econ. 37 (1) (1955) 38 56.

[14] *Book.* von Thunen, J.H., Isolated State, Pergamon Press, Oxford, UK, 1966.

[15] *Book.* Schultz, T.W., The Economic Organization of Agriculture, McGraw-Hill, New York, 1953.

[16] *Journal.* Griliches, Z., Hybrid corn: an exploration in the economics of technological change, Econometrica 25 (1957) 501 522.

[17] *Book.* Schultz, T.W., Transforming Traditional Agriculture, Yale University Press, New Haven, CT, 1964.

[18] *Book.* Gabre-Madhin, E., Barrett, C.B., Dorosh, P., Technological change and price effects in agriculture: conceptual and comparative perspectives, Markets, Trade, and Institutions Division Discussion Paper 62, International Food Policy Research Institute, WASHINGTON, D.C., 2003.

[19] *Book.* Kelley, A.C., Williamson, J.G., Cheetham, R.J., Dualistic Economic Development: Theory and History, University of Chicago Press, Chicago, IL, 1972.

[20] *Journal.* Yamaguchi, M., Binswanger, H., The role of sectoral technical change in development of Japan, 1880-1965. Am. J. Agr. Econ. 32 (1975) 269 278.

[21] *Journal.* Engel, E., Die Lebenskosten belgischer Arbeiterfamilien frueher und jetzt.. Ermittelt aus Familienhaushaltsrechnungen und vergleichend zusammengestellt. B. Int. Statist. Inst. 9 (1895) 57. (In German)

[22] *Book.* Yoo, B.S., Agricultural Economic, Sungkyunkwan University Press, Seoul,

Korea, 1998.
[23] *Book.* Rostow, W.W., The Stages of Economic Growth, a Non-Communist Manifesto, Cambridge University Press, Cambridge, UK, 1960.
[24] *Journal.* Allen, R.C., Economic structure and agricultural productivity in Europe, 1300-1800, European Review of Economic History 3 (2000) 1 25.
[25] *Journal.* Federico, G., Malanima, P., Progress, decline, growth: product and productivity in Italian agriculture, 1000-2000, Econ. Hist. Rev. 57 (3) (2004) 437 464.
[26] *Journal.* Clark, G., Yields per acre in English agriculture, 1250-1860: evidence from labour inputs, The Econ. His. Rev. 44 (3) (1991) 445 460.
[27] *Book.* Plucknett, D.L., Sources of the next century's new technology, In: Anderson, J.R. (Ed.), Agricultural Technology: Policy Issues for the International Community. CABI Publishing, New York, 1994, p. 343-373.
[28] *Book.* Abu-Lughod, J.L., Before European Hegemony: The World System A.D. 1250-1350, Oxford University Press, New York, 1989.
[29] *Book.* Sinclair, Collins Cobuild English Dictionary for Advanced Learners, fifth ed. Harper Collins, New York, 2006.
[30] *Book.* Wallerstein, I.M., The Modern World-System: Capitalist Agriculture and the Origins of the European World-Economy in the Sixteenth Century, Academic Press, New York, 1976.
[31] *Book.* Cipolla, C.M., Before the Industrial Revolution: European Society and Economy, 1000-1700. Routledge, London, 1993.
[32] *Journal.* Phillips, C.R., The Spanish wool trade, 1500-1780. J. Econ. His. 42 (4) (1982) 775 795.
[33] *Book.* Kim, S., History of International Trade, Sukjung, Seoul, Korea, 1995. (in Korean)
[34] *Book.* Pamuk, S., Estimating GDP per capita for the Ottoman Empire in a European comparative framework, 1500-1820, 2007, Retrieved from www.ekh.lu.se/ehes/paper/pamuk-lund.pdf (accessed August 2008).

Footnotes

[Footnote 1] Simple reproduction is where there is no accumulation of capital and no sustained increase in productivity. We use the term “expansive reproduction” to describe the case where capital is accumulated to facilitate an increase in production. We will discuss below how expansive reproduction is a feature of industrial and commercial societies.

[Footnote 2] In the view of Debertin [10], agricultural production follows the model of neo-classical production function. We now describe Solow’s model of technical change and the aggregate production function. Although Solow applied the model to an industrial society accumulating capital, the analogy with an agricultural society is straightforward.

[Footnote 3] However, a profit-maximizing farm will never produce when MPP < 0. That is, the declining part of the TPP schedule is irrelevant, and without loss of generality it can be deleted.

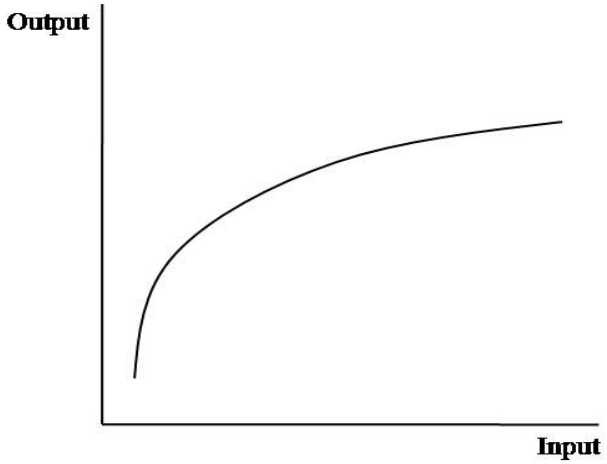
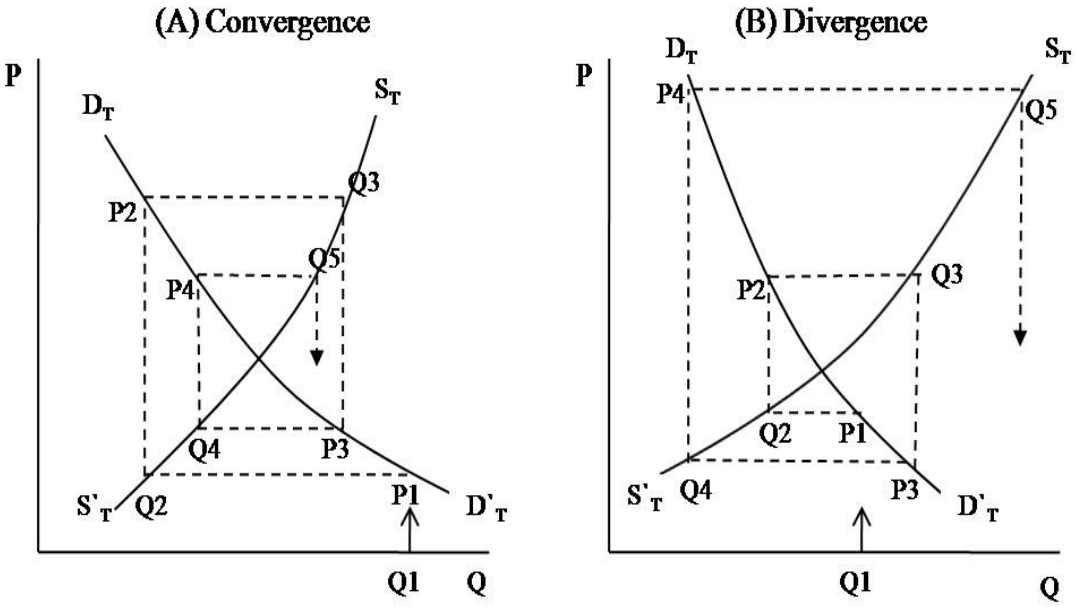


Fig. 1. Short term production function showing diminishing returns to scale.



Figs. 2A and 2B. Cobweb adjustments in price and demand.

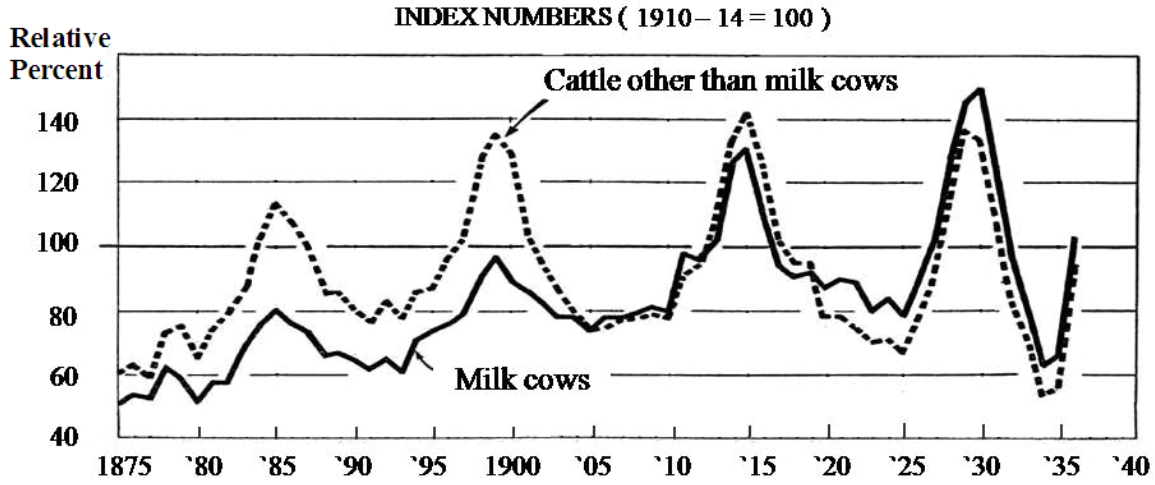


Fig. 3. Divergence patterns of purchasing power per head of milk cows and other cattle, 1875 to 1940.

Source: Ezekiel, M., The cobweb theorem, Q. J. Econ 52 (2) (1938) 255 280.Fig. 6, p. 270 (data from the U.S. Department of Agriculture). [9]

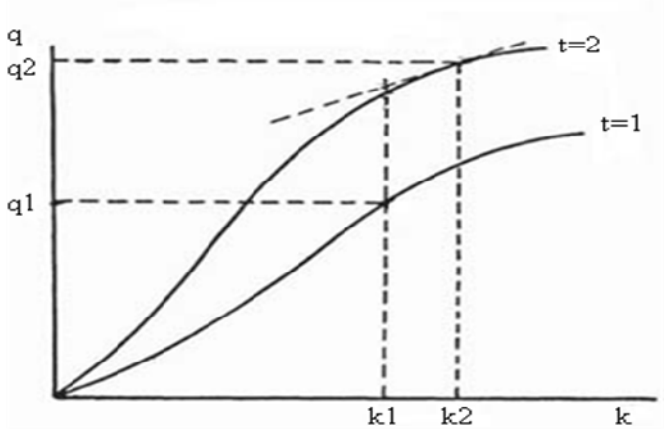


Fig. 4. Shift of aggregate production function by exogenous technology advancement.

Source: Solow, R.M., Technical Change and the Aggregate Production Function, Rev. Econ. Stat. 39 (3) (1957) 312 320., Fig. 1, p. 313. [1]

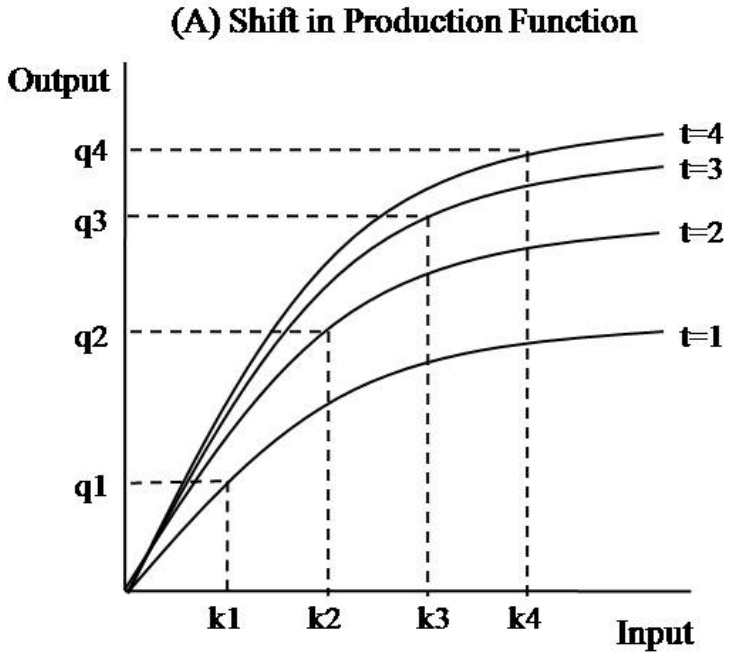


Fig. 5A. Relationship between output and time of an agricultural society seen by shifts in APFs over time.

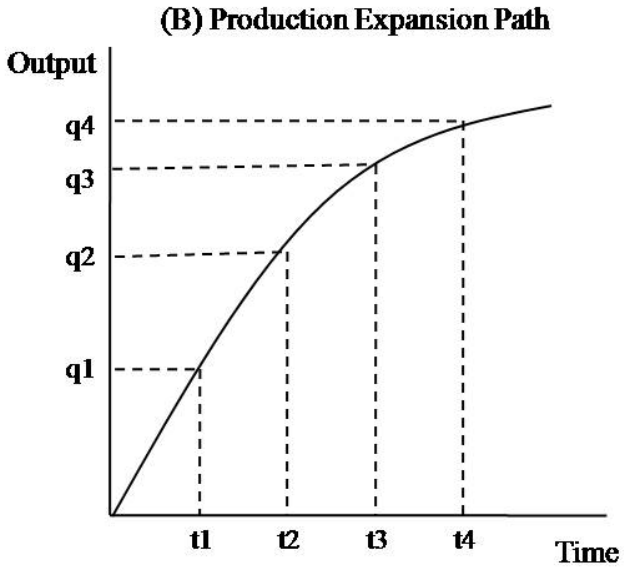


Fig. 5B. Relationship between output and time of an agricultural society seen through a production expansion path.

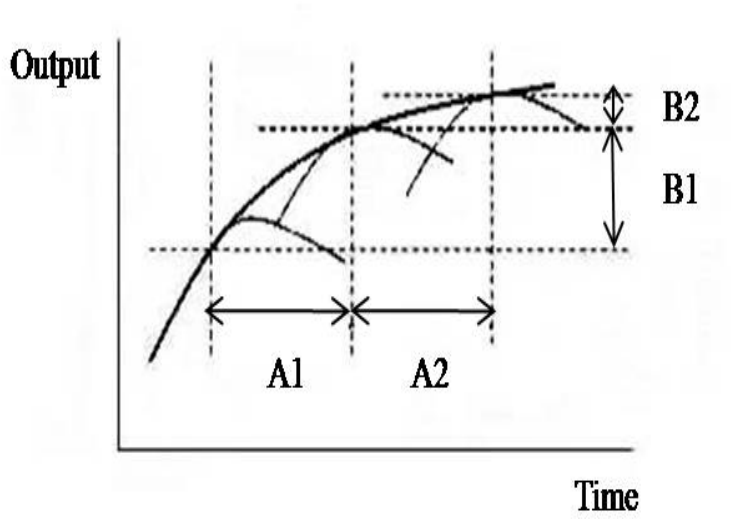


Fig. 6. Relationship in an agricultural society between output and time per the induced innovation model.

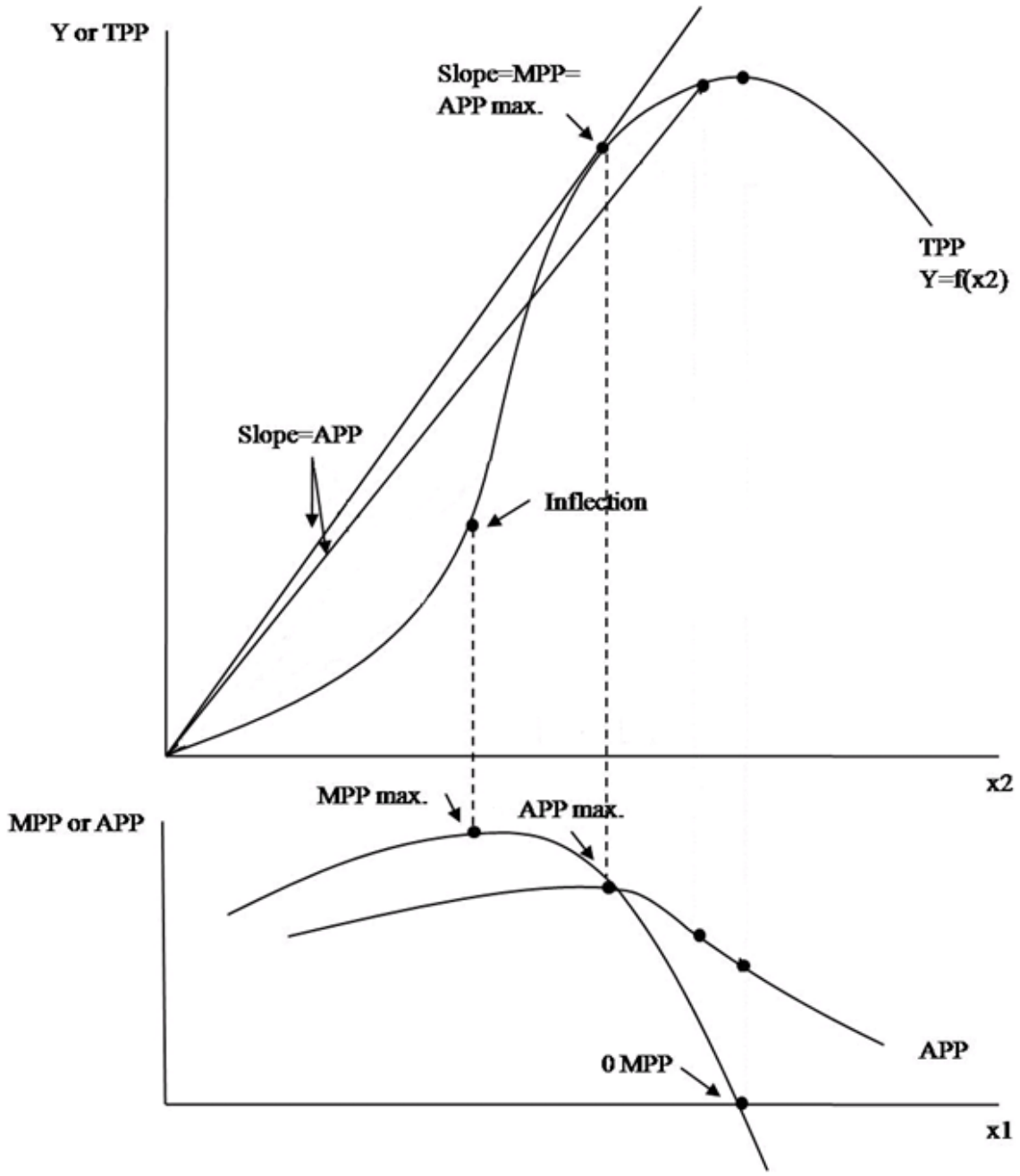


Fig. 7. General forms of the neo-classical production functions.

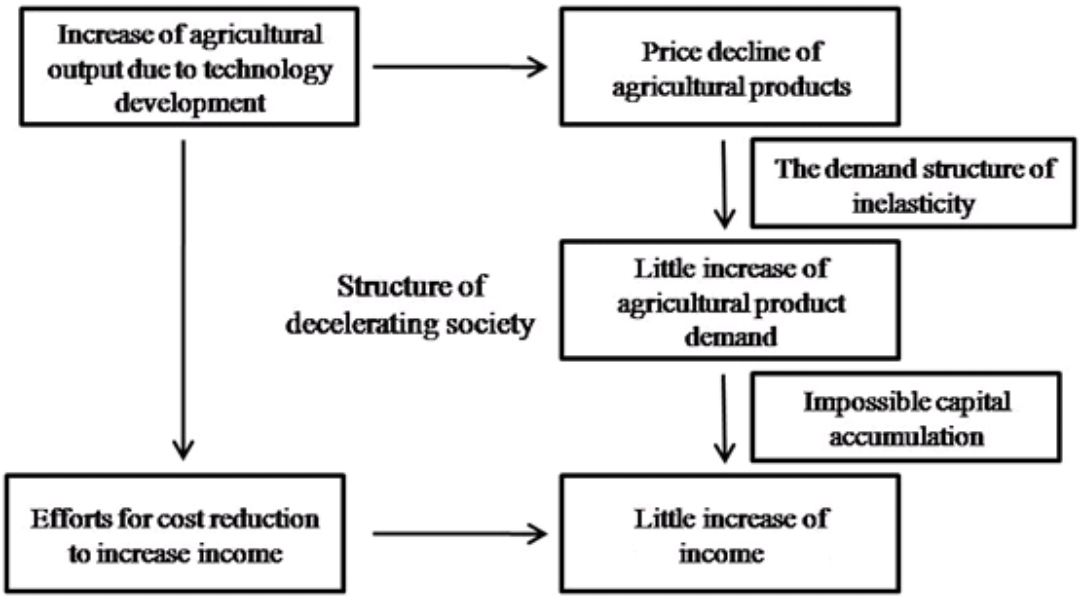
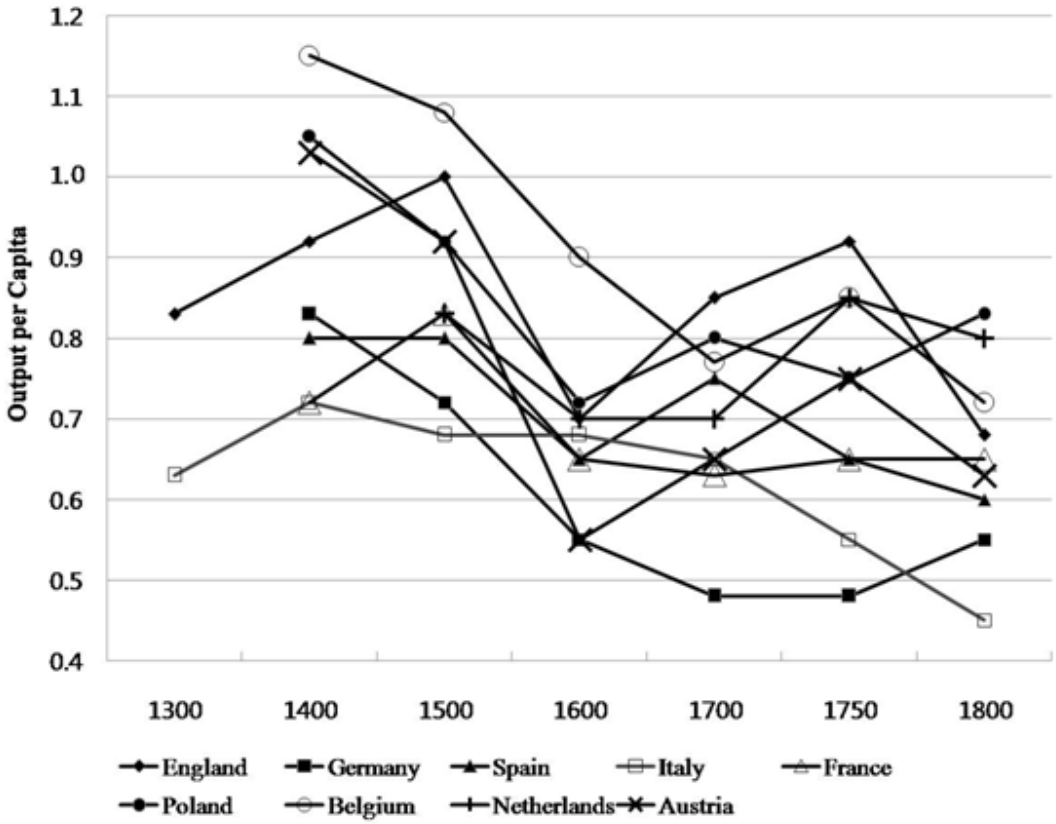


Fig. 8. The structure of decelerating society.
This graph is constructed from Gabre-Madhin, E., Barrett, C.B., Dorosh, P., Technological change and price effects in agriculture: conceptual and comparative perspectives, Markets, Trade, and Institutions Division Discussion Paper 62, International Food Policy Research Institute, Washington, D.C., 2003. [18]



.

Fig. 9. Agricultural output per capita, 1300-1800 (England in 1500 = 100) as in Table 1. Data from Allen, R.C., Economic structure and agricultural productivity in Europe, 1300-1800, European Review of Economic History 3 (2000) 1 25., Table 6, p. 17 [24]

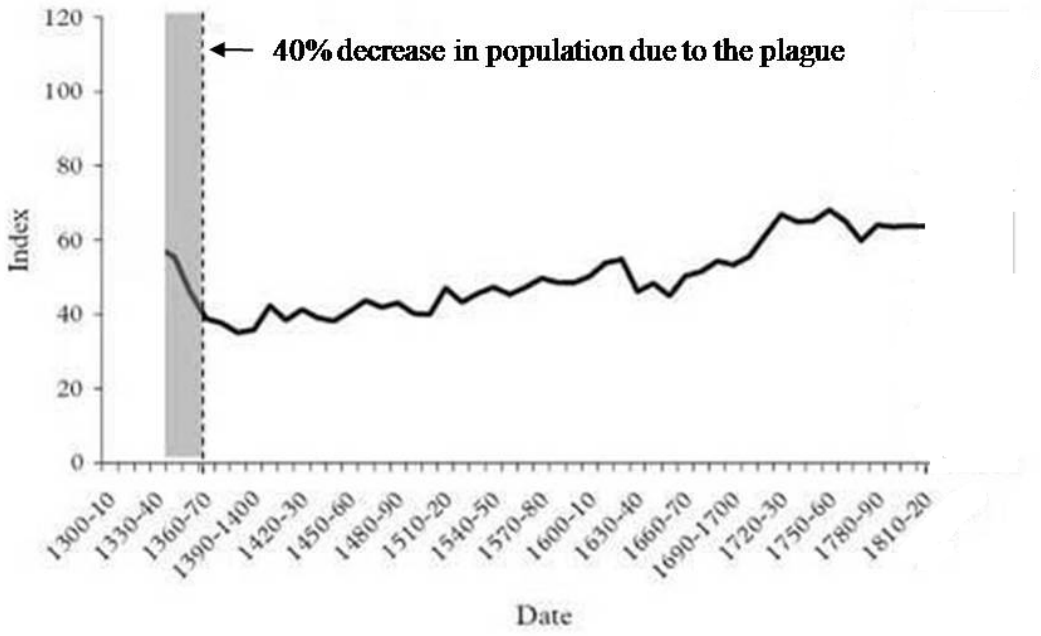


Fig. 10. Gross agricultural product in Cuneo Italy, 1300-1870 (1860-70=100)

reproduced from Federico, G., Malanima, P., Progress, decline, growth: product and productivity in Italian agriculture, 1000-2000, Econ. Hist. Rev. 57 (3) (2004) 437 464, Fig. 8, p. 448. [25]

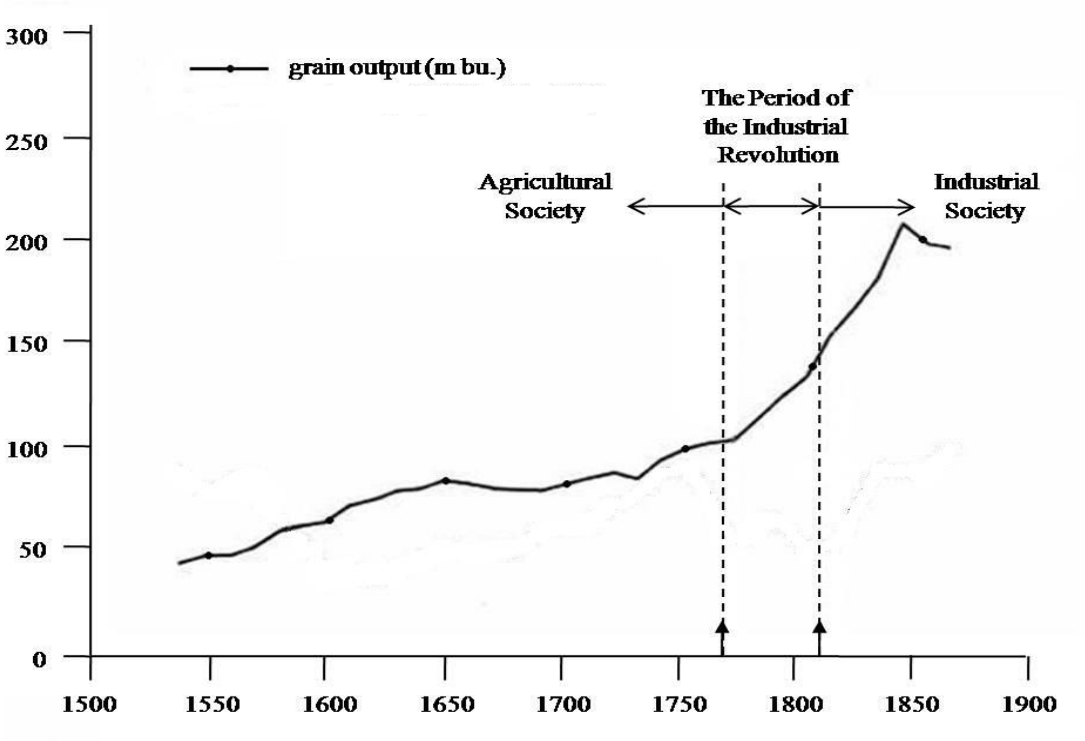


Fig. 11. Grain output at constant consumption per output, England, 1541-1860.

Source: Clark, G., Yields per acre in English agriculture, 1250-1860: evidence from labour inputs, The Econ. His. Rev. 44 (3) (1991) 445 460, Fig. 1, p. 446. [26]

Notes: Output is measured in the equivalent of millions of bushels of wheat. The grain wage is an index with 1845-54 = 100. At the dates indicated by arrows on the horizontal axis the grain wage was at similar levels.

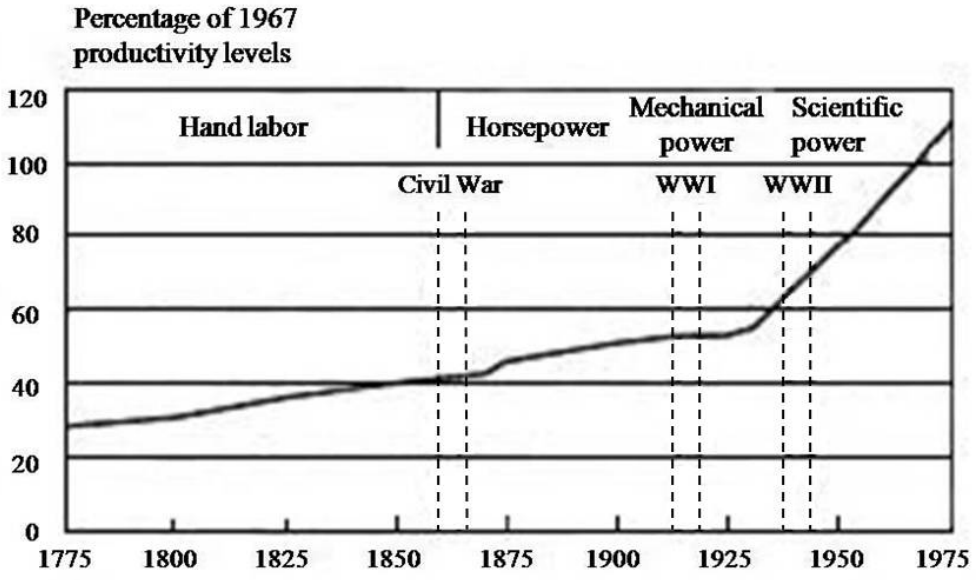


Fig. 12. Agricultural productivity levels of the U.S.

Source: Plucknett, D.L., Sources of the next century's new technology, In: Anderson, J.R. (Ed.), Agricultural Technology: Policy Issues for the International Community. CABI Publishing, New York, 1994, p. 343-373. [27]

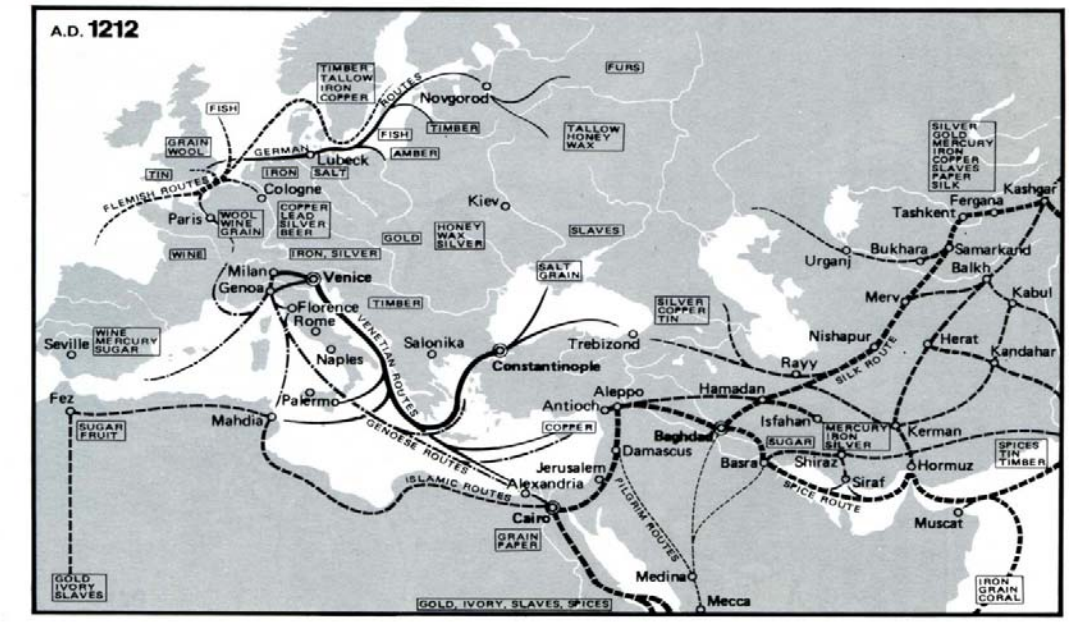


Fig. 13. Development of commerce and exchange between regions.

Source: Abu-Lughod, J.L., Before European Hegemony: The World System A.D. 1250-1350, Oxford University Press, New York, 1989, Fig. 5, p. 139. [28]

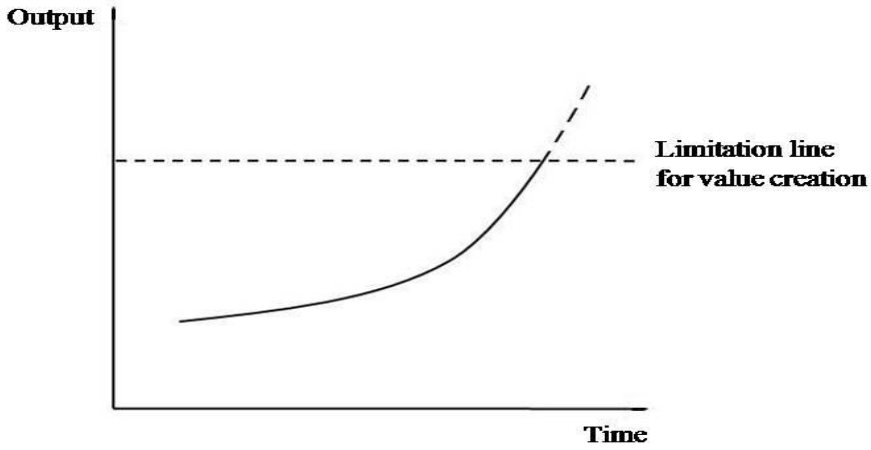


Fig. 14. Relationship between output and time in accelerating the commercial society.

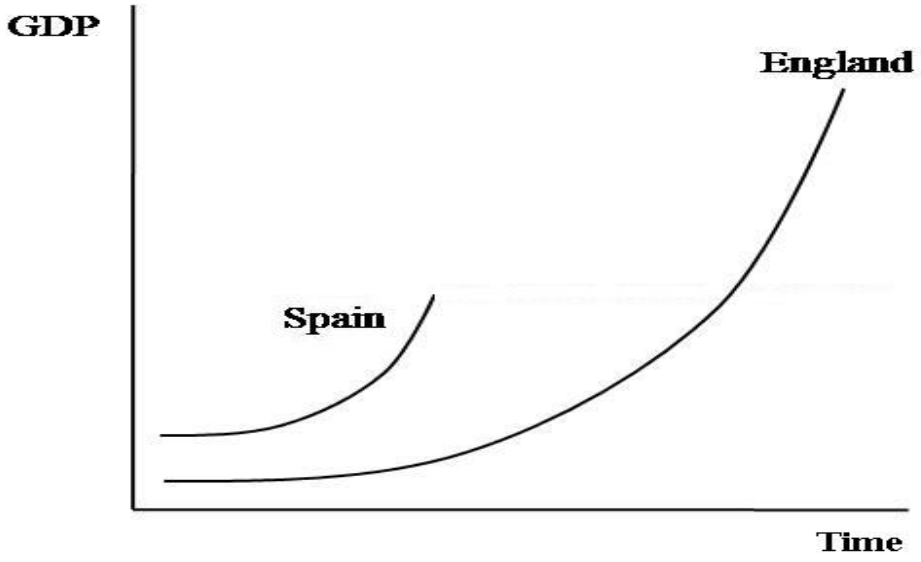


Fig. 15. Limitations of products in medieval European commercial society.

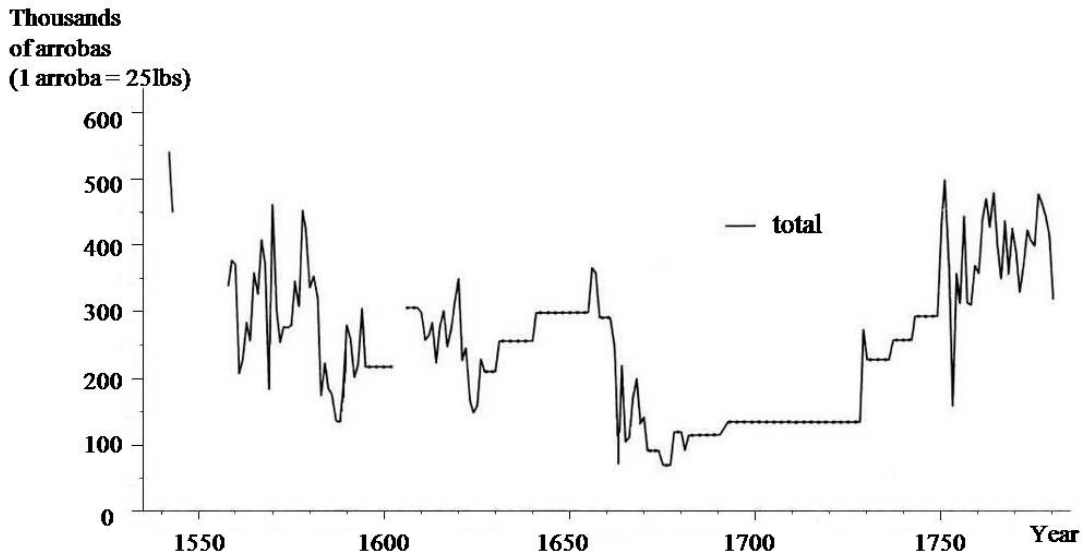


Fig. 16. Spain's wool exportation trend between 1540 and 1780

Source: Phillips Phillips, C.R., The Spanish wool trade, 1500-1780. J. Econ. His. 42 (4) (1982) 775 795, Fig. 1, p. 778. [32]

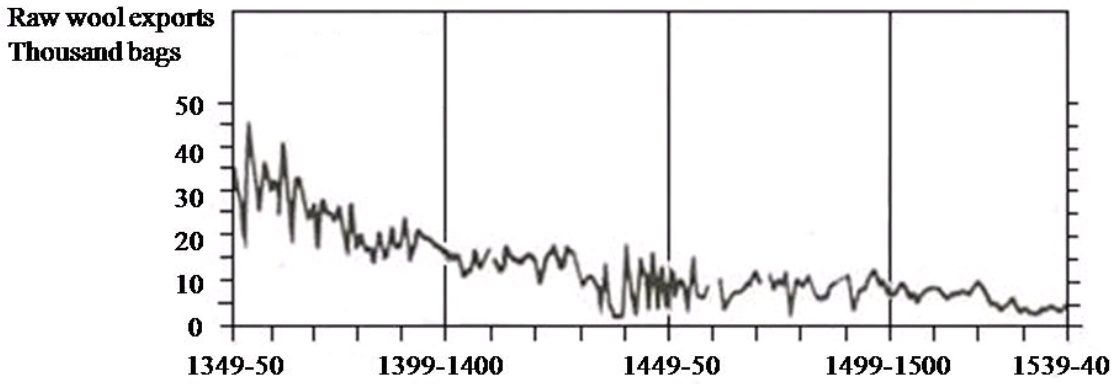


Fig. 17A. Wool imports of England.

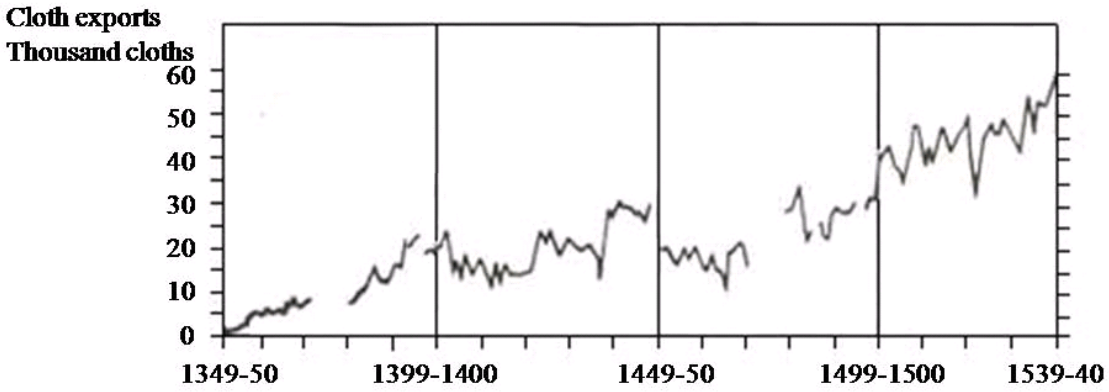


Fig. 17B. Woolen clothes imports.

Fig. 18A. GDP per capita in England, 1500-1820.

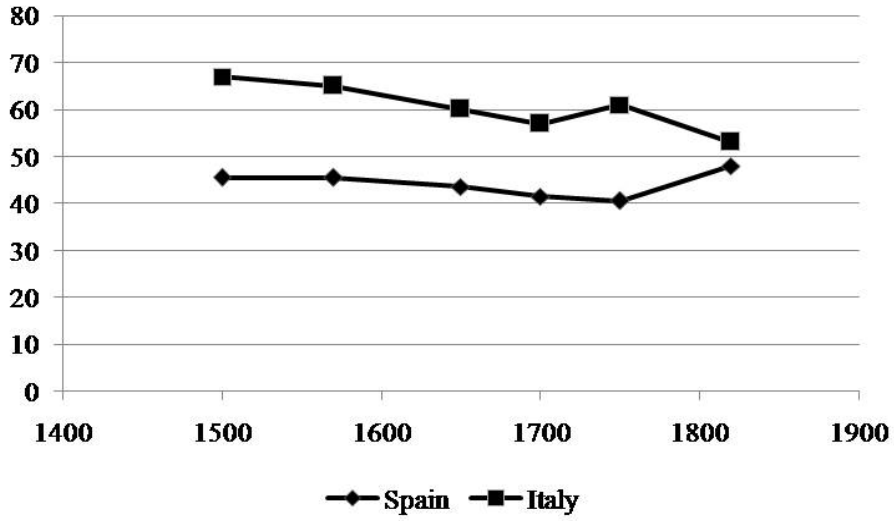


Fig.18B. GDP per capita in Italy and Spain, 1500-1820.

Source: Pamuk, S., Estimating GDP per capita for the Ottoman Empire in a European comparative framework, 1500-1820, 2007, Retrieved from www.ekh.lu.se/ehes/paper/pamuk-lund.pdf (accessed August 2008).reproduced. [34]

Table 1

Estimated population distribution, 1300-1800 (millions)

	Total	Urban	Rural non-agricultural	Rural agricultural
England				
1300	5.0	0.22	0.96	3.82
1400	2.5	0.20	0.46	1.84
1500	2.5	0.18	0.46	1.85
1600	4.4	0.43	0.96	3.03
1700	5.2	0.88	1.47	2.86
1750	6.0	1.39	1.95	2.70
1800	9.1	2.61	3.23	3.23
Spain				
1400	6.0	1.58	0.88	3.54
1500	7.5	1.38	1.22	4.90
1600	8.7	1.85	1.37	5.48
1700	8.6	1.75	1.44	5.41
1750	9.6	2.05	1.59	5.96
1800	13.0	2.54	2.20	8.26
Italy				
1300	11.0	2.29	1.74	6.97
1400	8.0	1.93	1.21	4.87
1500	10.0	2.21	1.56	6.23
1600	13.3	3.00	2.27	8.03
1700	13.4	3.03	2.49	7.88
1750	15.5	3.49	2.88	9.13
1800	18.5	4.06	3.75	10.69

Source: Allen, R.C., Economic structure and agricultural productivity in Europe, 1300-1800, European Review of Economic History 3 (2000) 1 25, Table 2, p. 8. [24]

Table 2
Spain (Castile) debt

Year	Debt (million ducats)	Interest
1515	12	0.8
1560	35	2.0
1575	50	3.8
1595	85	4.6
1623	112	5.6
1667	130	9.1

Source: Cipolla, C.M., Before the Industrial Revolution: European Society and Economy, 1000-1700. Routledge, London, 1993, Table 10.1, p. 240. [31]

Table 3

Melting furnace and steel production of England from 1530 to 1709

Year	No. of melting furnaces	Avg. production per melting furnace (ton)	Total production (1,000 ton)
1530-1539	6	200	1.2
1540-1549	22	200	4.4
1550-1559	26	200	5.2
1560-1569	44	200	8.8
1570-1579	67	200	13.4
1580-1589	76	200	15.2
1590-1599	82	200	16.4
1600-1609	89	200	17.8
1610-1619	79	215	17.0
1620-1629	82	230	19.0
1630-1639	79	250	20.0
1640-1649	82	260	21.0
1650-1659	86	270	23.0
1660-1669	81	270	22.0
1670-1679	71	270	19.0
1680-1689	68	300	21.0
1690-1699	78	300	23.0
1700-1709	76	315	24.0

Source: Cipolla, C.M., Before the Industrial Revolution: European Society and Economy, 1000-1700. Routledge, London, 1993, Table 10.8, p. 264. [31]

TEMEP Discussion Papers

2009-01: Tai-Yoo Kim, Almas Heshmati and Jihyun Park, “Perspectives on the decelerating agricultural society”.