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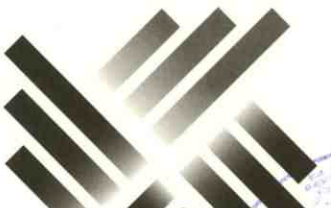
Statistics in Korea

History, Role in Economic Development and Current Statistical System

Edited by Moon-Sup Song and Myung-Hoe Huh



August 2001

Korea National Statistical Office

Foreword

Statistics find the fact of a past society and estimate the image of a future society. In these contexts, statistical techniques and methods have been continuously developed and improved by statisticians. Over the years statisticians have been gathered to exchange their views and to strengthen their relationship. It has been 114 years since statisticians from all over the world held the first International Statistical Institute Session in Rome in 1887. I would like to congratulate this historic meeting to be held in Seoul in 2001, which will be the first meeting of the 21st century.

With this as our motivation, we publish this book in order to introduce Korean statistics to international statisticians. Therefore, this publication contains the history, system, and activities of Korean statistics, and the relationship between statistics and Korean economy. Many experts contributed to each chapter of this book according to their specific fields of expertise. When the readers make use of this book, they should be aware that the views expressed by the authors do not reflect the official views of the National Statistical Office.

In conclusion, I hope this book will help all statisticians to better understand Korean statistics. I would like to express my deep gratitude to the editors and authors who contributed to this book.

August 2001

Young-Dae Yoon
Chair of the National Organizing Committee of 53rd ISI Session/
Commissioner of the National Statistical Office

Preface

This memorial volume for the 53rd Session of International Statistical Institute at Seoul Korea, August 2001, consists of three parts. Part I contains three writings in which the roles of statistics are examined in economic and industrial development since 1960's. One of the authors argues that the focus on strong political leadership, competent bureaucrats and favorable external conditions were key factors for the rapid economic development in Korea and that, in such progress, social and economic statistics played a vital role.

Part Ⅱ is on the history of statistics in Korea. Due to limited space, we selected three topics, i.e., population, precipitation and astronomical data, among possibly numerous choices. Three history papers discuss the under-enumeration issue in the population registry of the Chosun (Joseon) Kingdom (1392-1910), precipitation data from 1777 to 1907 measured by *Chugugi*, a Korean-made rain gauge, and the accuracy of Ancient Korean astronomical and meteorological data.

Finally, in Part Ⅲ, we present three papers on the current statistical system of Korea addressing the measures and efforts for the changing society, structural reformation of statistical system for official statistics and the chronology of statistical recording before and after 1945.

We hope that the nine papers presented here be helpful in understanding Korean statistics by the statisticians across the world.

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Contents

PART I

Korea's Growth Planning & Statistical Credibility

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Abstract: For most of the last three decades, casual observers, politicians, and academics all around the world marveled at the impressive growth rates achieved by South Korea's economy. Focus on strong political leadership, competent bureaucrats, and favorable external conditions driving several 5-year economic plans were considered key factors in a success that was often termed the 'miracle on the Han river'. Korea had become a model country for all aspiring aspirants of sustained economic growth.

Keywords: Democratic planning system, Political leadership, Discrepancy between the target growth rate and actual growth rate, Sustained growth, Statistical credibility.

1. Introduction

In this paper I argue that provision of quality statistics contributed much to Korea's economic growth. Also, I argue that if the credibility of official statistics is undermined, government policies will become ineffective.

To illustrate the role of statistics in economic development, I introduce a model of the democratic planning system. In this system, six organs operate collectively to produce the nation's long-term development plans. The six organs include top political leaders, three government agencies -- the planning office, the budget office, and the statistical office -- the press, and finally the specialist group.

To point out the importance of statistical credibility, we cite the Korean experience with economic difficulties resulting from mistreatment of official statistics. At times, the government officials try not to release some sensitive information. However, Korea has experienced an economic disaster by suppressing accurate official statistics on short-term foreign debt and foreign exchange reserves.

2. Korea's Growth Performance

Korea went through a total of seven rounds of five-year economic plan periods during 1962~96. Korea sustained high growth. Much credit should be given to the government for its planning strategy. Korea needed long-term development plans in order to receive aid from the US and to receive concessionary loans from the World Bank and the IMF (International Monetary Fund).

During the seven plan periods, five presidents have ruled Korea. President Park Chung Hee controlled the country from 1961 for 18 years, and was assassinated in October, 1979. The Korean constitution made Prime Minister Choi Kyu Ha automatically assume presidency upon the death of President Park. President Choi kept his presidential position until May 1981. During his short presidency, President Choi did not influence the economy much, acting merely as a care-taker in the power-transition period. General Chun exercised real power behind President Choi and as president peacefully transferred power to his military friend, General Roh Tae Woo in 1988. General Roh took power by free election. Having been complacent with his power legitimacy, President Roh did not do his best for the nation's economy. He easily compromised to workers' demands. Consequently, the national competitiveness rapidly began to weaken. After President Roh, civilian President Kim Young Sam controlled Korea for five years during 1992-97.

Let us briefly review Korea's economic conditions under the different political leadership (See Table 1). In the early 1960s, President Park laid the foundation for high-speed economic growth, and successfully initiated long

Table 1: Economic Performance by Regime

President	Date	5-Year Plans	Target Growth Rate %	Actual Growth Rate %
Park Chung Hee (Military)	1961.5 ~ 1979.10	1) 1962~66	7.1	7.8
		2) 1967~71	7.0	9.6
		3) 1972~76	8.6	9.7
		4) 1977~81	9.2	5.8
Chun Doo Hwan (Military)	1981.5 ~ 1988.2	5) 1982~86	7.5	8.6
		6) 1987~91	7.3	10
Roh Tae Woo (Military)	1988.2 ~ 1993.2	6) 1987~91	7.3	10
		7) 1992~96	7.5	7
Kim Young Sam (Civilian)	1993.2 ~ 1998.2	7) 1992~96	7.5	7

Sources: National Statistical Office, Various Issues of Annual Statistical Reports.

term planning for the first time. His planning strategy worked quite well, and the economy grew rapidly as he adopted the system of proper incentives and punishment. Consequently, the bureaucrats were induced to become enlightened, efficient, and competent throughout the entire period of his rule.

Former military general, President Chun accentuated the nation's economic freedom and prosperity because his political legitimacy was weak. As a result, bureaucrats were forced to become efficient and competent. President Chun also exercised strong leverage over the National Assembly and the government, getting his agenda easily passed in the legislature. Luckily, the international environment was very favorable for Korea as world energy prices and international interest rates were substantially low, and the Japanese yen value was kept at a high level relative to the U.S. dollar. So Korea could compete with Japan in exporting to the U.S and other countries. Owing to all of these favorable factors, Korea enjoyed high

growth, stable prices, and large trade surpluses during 1986 - 1989. It was about this time that Korean firms began to expand substantially and became internationally competitive.

As mentioned, when President Roh took over in 1988, the Korean economy already began to lose its dynamism. He overly compromised to the demands of the workers. Consequently, labor strikes occurred frequently and worker-management relations began to deteriorate rapidly. The macroeconomic indicators still looked fine, but the backbone of the economy began to fall apart.

When President Kim Young Sam took over the government, he did not notice that Korea was quickly losing its international competitive edge. He launched several large-scale reforms, including the financial real name system which caused much confusion among politicians and business leaders. His incomplete reform package soon invited strong resistance from various vested-interest groups.

3. The Growth Planning Model and Role of Statistics

3.1 Planning in the Capitalist Country

As mentioned in the previous section, Korea experienced seven rounds of five year economic plan periods during 1962~96. Fortunately, the first five-year plan worked out well. At that time, not many planning specialists were available. Planning technique was not sufficiently sophisticated. There was not enough statistical data.

Economic planning had long been considered something that could be expected only in socialist countries. After World War II, however, many countries in Africa and Asia adopted the planning strategy. These countries received economic aid from Western donor countries and received concessionary loans from international financial organizations.

There exists some similarity in the planning pattern between socialist and capitalist countries. However, there are a lot more differences in economic planning between the two camps of countries. First of all, economic goals in

democratic countries are determined by the majority of the people and top policy makers are elected by the people. Therefore, national goals and intermediate targets in the long-term plans reflect the overall preferences of the majority of the people.

Secondly, the planning process in capitalist countries is a lot more flexible. These economies heavily depend upon one another and their economies are affected by what happens domestically as well as in international markets.

When their initial projection of future state variables turn out to be a bit off the track, they change policy instruments, and revise forecasts of their target variables.

3.2 Korea's Growth Planning

As mentioned earlier, President Park initiated long term planning for the first time. At that time, internationally qualified scholars were not immediately available. So he had to rely on domestic bureaucrats and scholars. The first plan was not very sophisticated but it worked quite well. The actual average growth rate for the first five years was 7.8%, which surpassed the target growth rate 7.1%.

During the 18 years of his rule, President Park supervised four 5-year economic plans. Except for the last one, all plans were successful. The economy performed more than expected. As shown in Table 1, Korea's average target growth rate in the first plan period was 7.1%. But its actual growth rate turned out to be 7.8%. This was a remarkable performance as a first try. However, the target growth rate for the second plan period was not adjusted upward. The planners were not sure about the robustness of their planning model and the target growth rate for the second period (1967~71) was set at 7.0%. But later the actual growth rate was 9.6%. This was a great achievement and the planners decided to raise the target growth rate to 8.6% for the third period (1972~76). Again, at the end of the third plan period it turned out that the actual growth rate exceeded the target growth rate. The government and planners became confident about Korea's growth potential and they further raised the target growth rate for the fourth period to as high

as 9.2%.

This was a great mistake, because they were overly confident about the nation's growth potential. The actual average growth rate at the end of the fourth period dropped sharply to 5.8% and they had not realized that Korea was so susceptible to domestic and foreign shocks. In 1979 President Park was assassinated and in 1980 Korea was critically hurt by the first world-wide oil shock and bad crop in the same year. As a result, Korea experienced a negative growth of –5%. After this, the target growth rate was pulled down to a low level. The planners must have believed that Korea's proper long-term growth rate was around 7.5%.

We can point out several reasons for such economic success - strong political leadership, a favorable external economic environment, and competent bureaucracy. First of all, political leadership played an important role. The planning strategy received strong support from the people. Secondly, the external economic conditions were conducive to high growth. Third, President Park adopted the system of proper incentives and punishment so that bureaucrats were induced to become enlightened, efficient and competent.

There are other factors that contributed to Korea's high growth and among them is planning strategy. The successful operation of the planning system should be given much credit for Korea's economic success.

3.3 Six Major Agents for Economic Planning

There are six major agents that are involved in the formulation of long term economic plans. They are top political leaders, the planning office, the budget office, the statistical office, the media, and the specialist group. Figure 1 shows how the nation's economic planning system has worked. Let me briefly explain the role of each group as follows :

1) Top Political Leaders

Political leadership plays the most important role in the planning process. The main actor is the national President. The President and his top aides set multiple national goals, and rank them by the order of political importance.

The national goals include GNP growth, price stability, equal opportunities, equitable income distribution, employment growth, clean environment, etc.

In a democratic country, political leaders try to adopt the goals that best reflect the majority of voters. At times, however, national goals may not be the best ones for the entire society. For example, if low class people

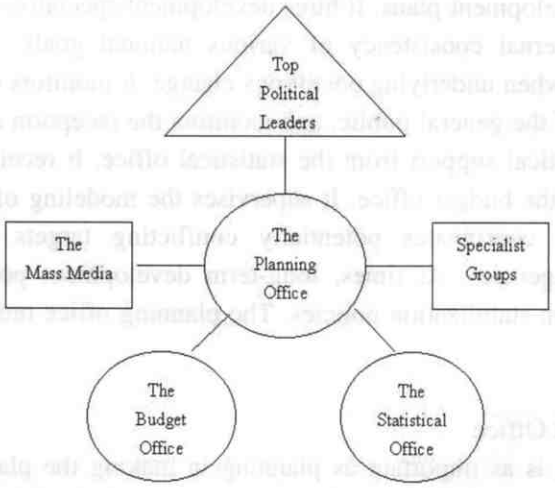

Figure 1: Korea's Economic Planning System

Figure 1 looks like a walking robot. The activation of the six organs produces internally consistent economic plans. Figure 1 illustrates the following points. Long -term development plans can be prepared after active interactions among various planning organizations. Top political leaders take full charge of the planning process. National goals reflect the general preferences of the public at large. The specialists help the planners to design long-term plans by providing special knowledge and planning techniques. Three government agencies cooperate with one another. The planning office plays the central role. However, the budget and statistical offices play an equally important role. The mass media also plays a critical role in checking the potential adverse effects of the plans and influences the prioritization of national goals.

demand equity rather than efficiency, then high and sustained growth cannot be expected. In this situation, political leaders face a challenge. If the national leader wants to escape poverty, then the country may have to forego some degree of unequal income distribution for some time.

2) The Planning Office

The planning office plays the central role and carries out a variety of important functions. It takes the responsibility to formulate and implement long-term development plans. It hires development specialists and lets them check the internal consistency of various national goals. It revises the original plan when underlying conditions change. It monitors changes in the preferences of the general public, and monitors the reception of the press. It receives statistical support from the statistical office. It receives budgetary support from the budget office. It supervises the modeling of development planning and coordinates potentially conflicting targets among other government agencies. At times, long-term development policies conflict with short-term stabilization policies. The planning office must resolve this problem.

3) The Budget Office

Budgeting is as important as planning in making the plans successful. Without budgetary support, development plans are futile. The budget office takes charge of government revenue and spending. It receives expenditure plans from all government agencies and allocates limited funds among the agencies. There is keen competition for government funds. When domestic spending exceeds domestic revenue, the gap is filled by a combination of issuing bonds, raising taxes, and borrowing from abroad.

The official name and the location of Korea's budget office have changed a few times. When it was first established, it was under the jurisdiction of the Ministry of Rehabilitation at bureau level. Later it went under the Ministry of Economic Planning Board, and it has now been promoted to the Ministry of Planning and Budget.

4) The Statistical Office

Like the budget office, the statistical bureau was initially under the Ministry of Rehabilitation. Later it went under the Ministry of Economic Planning Board. Finally in 1990, it became an independent agency with a new name, the National Statistical Office. The Assistant Minister is the head of the Office. Historically, the statistical agency has been steadily expanding and this means that the role of official statistics is becoming more and more important.

5) Specialist Groups

In the formulation of long-term development plans, specialist groups play an important role. They give advice to the planning office and to long-term policy makers.

The specialist group includes experienced specialists in the fields of economics, sociology, demography, and statistics. They are invited from internationally renowned universities and world organizations. They work on a fixed term appointment and go back to their old position when their mission is accomplished. In the case of Korea, the planning agency relied not only on foreign specialists but also on domestic specialists who had been trained overseas.

Well-qualified development specialists belonged to government research institutions. Many of them were established in the early 1970s and include KDI (Korea Development Institute), KIET (Korea Institute for Industrial Economics & Trade), KIEP (Korea Institute for International Economic Policy), and KREI (Korea Rural Economic Institute). Among these institutions, KDI played the central role. The KDI President is appointed by the national President at the recommendation of the Minister of the EPB (Economic Planning Board). Since its inception in 1971, the KDI has helped the planning office formulate long-term development plans and other government policies.

6) The Mass Media

In a democratic society, the role of the mass media is unquestionable. It closely watches the behavior of government officials and political leaders. If the national goals and policies set by the government are biased towards a

small number of interest groups, the mass media points out the problems and tries to correct them.

The national goals should reflect the preferences of the majority of the population. In reality, however, that is not always the case. Even if national goals truly reflect the preferences of the majority voters, the government agents may not want to pursue them. They tend to seek their own interest, and this is referred to as the principal-agent problem. When the preliminary development plans are made, the journalists and critics check the feasibility of the plans and try to point out the adverse effects of the policies.

If the press is too friendly with power groups and work with corrupt officials and business leaders, reform policies will not be implemented in a socially desirable way.

3.4 Statistical Importance in Planning

In designing development plans, planners use planning models. Since the planners deal with uncertainties of future variables and complexity of multiple national goals, they try to select the most appropriate planning models. The planning models can be classified into two categories -- the economy-wide, macro-planning model and the sector, micro-planning model. On the surface, models tend to be simple. However, if they can make consistently good projections of the key macro variables, they are worthwhile using.

Korea has adopted several planning models. They include the Harrod-Domar growth model, the two-gap model, and the input-output model.

The simple growth equation derived by Harrod and Domar is :

$$g = s/v .$$

Here, g denotes growth rate, s the national savings rate, and v, the capital/output ratio. Given the information of the national savings rate and the capital/output ratio, we can predict the GNP growth rate. For example, if the value of s is 20 percent and that of v is 3, then the target growth rate becomes approximately equal to 7.3%.

In Korea, the planners have had a strong tendency to set the target

growth at a level between 7 and 8 %. One reason may be that the historical average value of the saving rate and that of the capital ratio are about the same as those used in our example. Another reason may be the fact that with the average annual growth rate of 7%, the GNP doubles every 10 years.

The two-gap model is another useful model that is widely used in economic planning. The two gaps are the savings gap and the trade gap. The savings gap is the difference between domestic savings and domestic investment whereas the trade gap is the difference between exports and imports. Using the two-gap model, the planners make projections of exports and imports and check the availability of domestic resources and the requirement of foreign resources.

Another model that has been used frequently to predict the production in various industrial sectors is the input-output table. The input-output table shows the flow of goods and services between industries. At the practical level, any product that moves from one industry to another can be viewed as an intermediate product. Unlike other planning models, this model requires the use of vast amount of statistical data. Due to the nature of the input-output table, the amount of data expands exponentially as the number of industry increases and it requires the use of high-power computers. For example, if the economy has 400 industries, the number of production coefficients to be estimated will be 400x400 and computers with high-speed and vast storage must be available to compute the inverse matrix for the input-output table.

As the economy expands over time, the planning model needs to be further developed and sophisticated. This, in turn, requires even more amount of data and more improved statistical techniques.

The expansion of the statistical database, development of new official statistics and improvement of statistical techniques, can make the planning model more powerful and more sophisticated. In this way, the growth of GNP and the development of statistics can go together, influencing each other in a positive way.

3.5 Efficient Production of Databases

There are several government organizations which compile and produce official statistics. They include the National Statistical Office (NSO), the Bank of Korea (BOK), the Ministry of Finance and Economy (MOFE), and other government agencies. Among these, the NSO is the most important one and it is in charge of all official statistics in Korea.

The economic database covers a broad range of statistics. It includes national income, finance, trade, industries, services, agriculture, etc. Producing economic statistics is expensive and all economic data cannot be produced at one time. As the economy grows, it can raise the amount of statistical data. The statistical agencies gradually expand the database for official statistics and gradually improve the quality of the data.

Korea was liberated from Japan in August 1945. It was under Japanese colonial rule for 36 years. The historical evolution of official statistics since 1945 is as follows. Various statistics began to appear in different years : The statistics of money and finance were first produced in 1947; the producers and consumer price indices in 1949; public finance in 1950; the balance of payments and the input-output table in 1957; the industrial production index in 1960; corporate management analysis in 1962; regional income in 1964; the flow of funds and trade indices in 1965; national wealth in 1968.

Still, however, such databases as national capital stock and income distribution are very hard to compile. It will take a while before these official databases are made available to the public on a regular basis.

4. Statistical Credibility

Official statistics should carry with them authority and credibility. The sources of statistical data must be clear and correct. Otherwise people would not trust official statistics. Then they would not trust government policies.

Often statistical credibility is questioned in developing countries. Inflation, income distribution, and foreign debt are good examples. Due to difficulties in obtaining accurate data about earned income, true estimation

of income and wealth distribution is almost impossible. Due to the discrepancy between reported prices and the actual prices, people tend to be suspicious about the government's monetary policy. Information of short-term external debt was regarded as a financial secret and the government tried not to release the information outside.

Once consumers and data users start questioning the credibility of official data, the effectiveness of the government policy immediately starts to weaken. For example, if people do not believe in the official price indices, monetary policy cannot achieve its inflation target or the interest rate target. In theory the rate of money supply directly affects inflation, exchange rates, and the interest rate. So suspicion of price and interest rate data would jeopardize the effectiveness of monetary policy.

Some housewives felt that the official consumer price index(CPI) indicated very little of what they felt in the market. They felt that the reported inflation was more or less underestimated

Sometimes, people question the credibility of official data due to their negligence or ignorance. Their questioning of statistical credibility turns out to be unjustified in some cases. There exist discrepancies between changes in the price index and changes in the actual prices for various reasons: 1) When the prices of food items increase, the official price index does not show it immediately. In the case of fresh food items, for example, increases in their prices are not effectively captured in the computation of the CPI because the expenditure share of fresh food is so small. 2) An increase in household expenditure due to an increase in household income is not the consequence of inflation but the consequence of productivity increase. Nevertheless, people tend to believe that actual inflation has gone up whenever they find their living costs went up. They tend to forget that their living standard is rising over time.

To restore statistical credibility and to relieve the concerns of housewives, the government's statistical agencies have tried to reduce the gap between the official price index and the prices that consumers feel in the market. In this connection, the National Statistical Office (NSO) began to publish a few supplementary price indices such as the consumer price index for living necessaries (CPIL) and fresh food price index (FPI). These indices

began to exist from April 1998. The HPI measures the changes in the prices of 154 consumer items that directly affect the household's living cost. The FPI measures the changes in the prices of 47 fresh food items.

During the 1997 currency crisis, credibility on foreign reserve statistics was critically questioned. The government tried to keep some sensitive statistical information as a secret. When the currency crisis started in Malaysia, Indonesia, and Thailand, the Korean government kept secret the size of its short-term foreign debt and the level of foreign reserves. The bureaucrats even bluffed foreign investors that the central bank had sufficient amounts of foreign reserves. They did it on purpose because they hoped that the foreign investors would naively trust bureaucrats' statements and that they would decide not to pull their money out of Korea.

However, it was their great miscalculation as foreign investors and financial creditors easily learned what was going on in Korea and took advantage of the situation. They immediately pulled out their investments and converted their *won* currency assets into U.S. dollars. Consequently, Korea lost more than 20 billion dollars within a week or so in December 1997.

5. Conclusion

Until its economy was hit by the 1997 currency crisis, Korea had been considered a model country for sustained economic growth for over 30 years. Development economists have pointed out that the main factors of high-speed economic growth were strong political leadership, competent bureaucrats, and a favorable external environment.

In this paper we argue that in addition to the three factors, the government's statistical assistance in planning contributed much to Korea's rapid economic growth. Korea went through seven rounds of 5-year economic plan periods during 1962~96.

To support the argument, we presented a democratic planning model where six organs - - top political leaders, the planning office, the budget office, the statistical office, the mass media, and specialist groups cooperate

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To support the argument, we presented a democratic planning model where six organs - - top political leaders, the planning office, the budget office, the statistical office, the mass media, and specialist groups cooperate

harmoniously.

Sophisticated planning models require the use of large amounts of statistical data. As the planning models become more sophisticated, the database needs to be further expanded.

In this paper we also argue that statistical credibility is critically important in economic development. Without statistical credibility, government policies become ineffective. The sources of official statistics must be clear and correct. The bureaucrats should be honest even with sensitive economic information, otherwise, the economy will suffer even more when an economic crisis occurs.

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Parallel Development of Government Statistical Capability and National Economy: The Case of Korea

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Abstract: Korean economic statistics have developed in tandem with the Korean growth strategy. Despite of insufficient government investment, the official statistical agencies have developed gradually in accordance with socio-economic development of the whole society. The transition of the Korean economy to a more matured and developed level is merely a matter of time. In light of this bright prospect, the government's role in supplying statistics needs to be more emphasized in the years to come.

Keywords: Statistical System, Official Statistics

1. Introduction

In modern society, statistics are the prime measures for the description of social states and natural phenomena. Of course, there are certain limits to conveying the real pictures of complicated and dynamic social and natural states with statistical data, which are classified, compiled, and processed in accordance with uniform standards. In spite of such constraints, statistical information has far greater advantages such as value neutrality, objectivity, and quantification.

These characteristics of statistics are the causes of why statistical information is used as the principal measures in the description, planning and evaluation of various social phenomena. Therefore, statistics serve as

basic information for governments, firms and individuals pursuing rationality and efficiency. Governments can establish rational policies and evaluate them objectively through the use of statistics. Firms not only can grasp incessant changes in business environments through statistics, but also can make use of them as indicators for market analyses, business strategies, and evaluation of corporate performance. Individuals can also use statistics as data for their rational decisions.

In relation to economic development, statistics have three key roles in managing the economy of a country: specifying policy objectives, selecting policy instruments and providing evaluation criteria of policy effects. Specifying a policy objective is the quantification of an economic target to be obtained in the future based on present economic conditions. In order to accomplish such an objective, the government uses various macro- and microeconomic policy instruments. Statistics do not only provide basic data for rational decisions in setting and enforcing policies, but also serve to evaluate whether the objective was accomplished and the selected policy instruments produced the expected results.

The methods of using statistics depend on economic systems or institutional settings of the relationship between the government and the market. In a free competitive market economy, the importance of statistics lies in providing individuals with information so that they may understand the exact market situations. On the other hand, in an economy where the government intervenes heavily in the market, the role of statistics may serve as a proxy of the market mechanism since they directly affect prices as well as the supply of and demand for goods and services. Therefore, the interaction between economic development and statistics are dependent on the institutional settings of the relationship between the government and the market.

Korea has experienced rapid growth induced by a government-led development strategy since 1960, and its successful performance has been positively evaluated internationally. Since Korea's development strategy is unique and unprecedented, it would be meaningful to examine the relationship between the development pattern of the Korean economy and statistics. In this chapter, I will investigate the contributions of statistics to

the development of the Korean economy, and the effects of development strategy on the system of statistics in Korea.

2. Development of Statistics in Korea

2.1 Features of Korean Development Strategy

In order to understand the relationship between economic development and improvement of statistical capacity, it is necessary to examine Korean development strategies. Korea has recorded a fairly high annual growth rate of 7.8% for the last 40 years ever since the government made strong commitment to economic development in the early 1960s, despite several crises such as oil shocks and the recent foreign currency crisis. GNP per capita rose from less than US$100 at the beginning of the 1960s to US$1,600 in the 1980s. It peaked at around US$10,000 U.S. dollars in the middle of the 1990s, though in 1999 it fell down to US$8,581 due to the foreign currency crisis (see Table 1).

In the course of rapid economic growth, the industrial structure of Korea has also been rapidly transformed into that resembling advanced countries. The share of agriculture, forestry and fishery in GDP dropped from 36.8% in 1960 to 5.0% in 1999, while that of the service industry increased from 47.3% to 62.8% and that of the manufacturing industry from 13.8% to 31.8%.

The volume of trade has increased 400 times during the last 40 years. Exports increased from US$33 million in 1960 to US$143.7 billion in 1999, while imports increased from US$344 million to US$119.8 billion. As consequence of such rapid increase in the volume of trade, Korea's share in world trade considerably expanded from 0.1% in 1960 to 2.2% in 1999.

The process of Korea's economic development can be divided into two phases in accordance with the characteristics of development strategies. The first stage covers from the beginning of the 1960s to the early 1980s. During this period, the government set targets for major macro-economic indicators and intervened into the market to achieve those targets. Even

Table 1: Growth of the Korean Economy (1960-1999)

	1960	1970	1980	1990	1999
Annual GDP growth rate (%)		8.5	7.4	8.6	6.8
Per capita GNP ($)	79	249	1,598	5,886	8,581
<Industry Structure>					
Agriculture, forestry and fisheries	36.8	27.1	14.8	8.5	5.0
Mining, quarrying and manufacturing	15.9	22.7	29.7	29.6	32.2
(Manufacturing)	13.8	21.2	28.2	28.8	31.8
Service	47.3	50.2	55.5	61.9	62.8
Trade (million $)					
Exports	33	835	17,505	65,016	143,68
Imports	344	1,984	22,292	69,844	119,75

Source: The Bank of Korea; Korea International Trade Association.

though such a government-led development strategy turned out to be conducive to rapid growth of the economy until the beginning of the 1970s, it entailed severe market distortion. Recognizing the side effects of market intervention, the Korean government began to shift its development strategy in the beginning of the 1980s, placing greater emphasis on free competition, vitality and innovation of the private sector on the basis of a well-functioning market mechanism. For a correct understanding of Korea's economic development process, particular attention needs to be paid to the period from the second half of the 1960s to the first half of the 1970s. During this decade, the pattern of government-led development strategy, which was somewhat loosely defined in the early 1960s, began to be clearly defined and took such a firm root such that it still affects the behavioral pattern of economic agents nowadays.

The period up to the first half of the 1970s is characterized by direct intervention of the government into the private sector's economic activities. Such a role of the government is strikingly different from that of advanced western countries such as the United States and Western Europe, where the

major role of government is to create stable macro-economic conditions rather than to achieve given quantitative targets of economic growth. In those countries, governments have been trying to devise general rules for all economic agents and to simply observe them rather than to directly intervene in the private sector. On the other hand, the Japanese government intervened in the market by providing a long-term vision for the economy as a whole, and played the role of coordinator for the private sector. In comparison with that of Japan and Western countries, the development strategy of Korea has tended to be far more interventionist. The Korean government set a quantitative target to be accomplished within a given period of time. In order to achieve the target, the government distributed resources and provided private firms with direct incentives. Such an interventionist strategy paved the way for the rapid economic growth within a short period by concentrating limited resources on a few strategic fields.

The Korean development strategy, characterized by government intervention in the market, brought about both positive and negative effects. As social resources could be concentrated on key industries, reduced uncertainty encouraged firms to invest more, thus resulting in rapid growth. On the other hand, the negative effects can be summarized by the two following problems. First, heavy intervention of the government in the market led to a serious defect in the market mechanism. Second, a coordination system to ease social conflicts could not be formed. Some point out the defect in the market mechanism and the lack of social coordination system as causes of the 1997 crisis.

Economic policies in advanced countries traditionally were centered on macroeconomic principles. In case of a boom or a recession, the government tried to control the economy by affecting aggregate demand and supply through macroeconomic policy tools such as money supply, interest rates, government spending and taxes. The objective of their economic policies was not to pursue a specific macroeconomic target, but rather to contribute to stabilizing the economy. Microeconomic policy has become the focus of attention since Japan quickly joined the ranks of advanced countries through its industrial policy. In the event of an unbalance between demand and supply in a certain industry, the Japanese government corrected it through

cooperation among private firms. The Ministry of International Trade and Industry (MITI) was at the center of such a mechanism. Apart from the adjustment of conflicting interests, MITI introduced various incentive policies to promote specific industries. Japanese industrial policy, however, did not set a specific target for the economy as a whole.

In contrast, Korea set an economic development plan (e.g., Five-year Economic Development Plan) for a given period and quantitatively specified macroeconomic targets. The government used microeconomic policy instruments to accomplish the specified macroeconomic targets. There are two reasons why the Korean government placed emphasis on microeconomic policy instruments. First, since macroeconomic policy instruments (interest rates, money supply, government spending) affect all industries evenly, it was difficult to concentrate their effects on certain strategic industries that government intended to develop. Second, conditions for a well-functioning market, which are necessary for the satisfactory effects of macroeconomic policies to be realized, were lacking during the early stage of development. For example, raising interest rates should increase savings and decrease investment. However, the change in interest rates could hardly affect the demand and supply of funds in Korea, where there was a chronically insufficient amount of capital.[1]

Microeconomic policy instruments immediately brought about the policy effects intended by the government, which could develop strategic industries in a short period of time through financial support of such policy. The government could control the supply and demand of a specific industry by regulating the entrance and investment of individual firms. To cope with trade imbalance, the government encouraged major firms to export more and to import less. If inflation was at hand, the government controlled the prices of individual goods and services. Such policy interventions, however, tended to disturb the market mechanism. Accordingly, the policy effects could not last long and even a transitory effect could not be expected in the

[1] For example, the raise of interest rate should increase saving and decrease investment. However in Korea where capital was chronically insufficient the raise of interest rate could hardly affect demand and supply of funds.

end. On the other hand, side effects resulting from distortion of the market mechanism were exposed in various fields. Based on reconsideration of such side effects, Korea began to seek a transition from the government-led economy to a market-oriented economy in the 1980s.

Soon the Korean economy appeared to be transformed into a private sector-initiated economy. However, economic agents as well as the government were not free of the past interventionist practices. Even on the road to transition, when economic shocks occurred, the government repeatedly intervened in the market rather than relying on a self-adjustment of the market. Although the intervention of the government in the market gradually diminished and the role of the market expanded, there are still remnants of the past practices.

2.2 Economic Policies and Demand for Statistics

Since economic statistics have been mostly compiled to meet the demand of the state sector, for the identification of the characteristics of the statistics, the characteristics of Korea's economic policies need to be carefully examined. In the course of development, economic policies in Korea can be summarized as follows: mid-term economic policies such as the Five-year Economic Development Plan and short-term economic policies.

Planning and implementing development strategies require comprehensive official statistics. The government first determined basic macroeconomic indices for a particular time period. Then, using macroeconomic models, it set up specific macroeconomic objectives such as inflation, employment, and export/import. For these purposes, models and statistical data were needed. In establishing the first Five-year Economic Development Plan, the input-output table was the main resource due to the shortage of statistics. However, in setting up the second five-year plan in 1966, a macroeconomic model was used. Not only macroeconomic statistics but also supplementary microeconomic statistics, began to be developed.

In addition to official statistics, the Korean government also required statistics for its short-term economic policies. The government, intervening deeply in the market, had to control corporate activities and needed extra

statistics for this purpose. But official statistics had limitations in capturing both actual activities in industries and the effects of the policies. Hence, the official statistics were not very useful resources for policy implementation. Instead, the data gathered by governmental departments (responsible for specific industries) from the individual firms were used as resources for policy implementation. The official statistics were mainly used as data for establishing and evaluating the plans rather than for implementing the policies. Those statistical demands in the short term had adverse effects on the development of official statistics because the reported statistics often lacked rationality of statistical methodology, systematization of classification, and consistency.

Government investment in statistics depends on the level of government demand rather than the social importance of the statistics themselves. These trends are clearly shown by comparing the levels of investment between agricultural and industrial statistics. The economic growth of Korea has been driven mainly by the growth of industrial sectors and the share of agriculture in GDP has decreased in the process of industrialization (27.1% in 1971, 14.8% in 1980, and 5.0% in 1999). Despite these facts, investment in agricultural statistics has dominated that in industrial statistics because the level of government intervention is much stronger in the agricultural sector. The government had a large demand for specific statistics on crop purchases, price maintenance, and stabilization of supply/demand. So, in 1996, 2,095 out of the total statistical manpower (4,801) were included in the agricultural statistics. Considering that the total manpower of the National Statistical Office (NSO) in 1996 was about 1,600, the position of the agricultural sector can be inferred.

Since the government, the largest consumer of official statistics, has given priority to macroeconomic statistics and report statistics, the level of investment in microeconomic statistics has been relatively lowered, which has also lowered the overall level of investment in statistics in Korea. In 2000, Korea has 124 organizations and 4,809 personnel that produce 399 types of statistics, which is not sufficient for the overall size of the Korean economy.

2.3 Role of Statistical Agency

Statistical agencies have played an important role in the development of statistics in Korea. In general, the role of statistical agencies tends to be passive so to react to demands and is conservative to new changes in society. For example, while the progress in information technology (IT) accelerates, the official statistics about the effect of IT remain at the primary level across countries. In contrast to the general trends, the statistical agencies in Korea have played an active role in statistical development.

The NSO is an autonomous body of the Economic Planning Board (presently, the Ministry of Finance and Economy), which has the role of comprehensive planning and adjusting of overall economic policies. Therefore, the NSO has participated in establishing, implementing, and evaluating economic development plans, and can utilize accumulated knowledge for the development of statistics. There is also extensive interchange of personnel between the economic policy and the statistical departments, which has improved the relevance of the statistics to the actual economic policies.

The Bank of Korea (BOK), which has mainly produced macroeconomic statistics such as the national account, played a leading role in strategy formulation during the early stages of Korea's economic development. Until the early 1970s, no special think-tank or government agency with special knowledge for development planning existed. At that time, the BOK was the sole organization possessing excellent manpower and special research capacity. The knowledge and the experience from the participation in formulating economic policies have been the driving force behind the development of macroeconomic statistics. Although, in general, the main role of the central bank is the management of monetary policies, the BOK has played a role in producing statistics as well as planning development policies. Until now, this tradition has continuously contributed to the development of statistics.

Public officials in the economic policy department as well as politicians held a consensus on the importance of statistics, though they did not have a high level of specialized knowledge about statistics. Therefore, they always

requested the development of relevant and realistic statistics, and this has been yet another important factor for the development of statistics. The public officials have also developed several statistics on their fields that the NSO and the BOK could not produce.

The demand for statistics in Korea is neither as great nor as diversified as those of advanced countries. Therefore, the master plan of statistical development, such as categorizing social phenomena and specifying target samples, has been piloted mostly by the statistical agencies, which have developed the statistics, gathered opinions from various sources and utilized the accumulated know-how. In conclusion, these agencies have played a key role in the development of statistics in Korea. Recently, the NSO developed statistics on computer and Internet use, as well as statistics on electronic commerce, all of which are evaluated as advanced statistical fields among those of the OECD countries.

On the other hand, although the statistics in Korea have developed along with economic development, the relative shortage of investment causes the problem of over-workload. Since over-workload may result in lowering the quality of the statistics, a remaining objective for the development of statistics in Korea is to expand both physical and human investment.

3. Present State of Statistics in Korea

3.1 Outlook

As of December 2000, Korea had 124 organizations producing statistics, 45.0% of which are government-led bodies. 4,809 people are employed in those organizations, and about 90% of them are employed by governmental organizations. The majority of this manpower works for the NSO (1,671) and the Ministry of Agriculture and Forestry (1,252); 65.1% are engaged in conducting survey questionnaires. There are 399 types of approved statistics[2] (official statistics) in Korea, 297 of which are produced by

[2] The Approved Statistics mean the statistics which are produced by the Statistical Agencies designated by Statistics Law. The Approved statistics is classified into

Table 2: Categories of Social Statistics in Korea
(as of December 31, 2000)

		Total	Kind		Compiling Method		
			Desi. Sta.	Gene. Sta.	Surv. Sta.	Repo. Sta.	Anal. Sta.
Government Agency	C.A.A.	213	51	162	97	107	9
	(NSO)	50	34	16	42	-	8
	(MAF)	18	5	13	8	9	1
	L.A.A.	84	16	68	29	32	23
	Sub Total	297	67	230	126	139	32
Designated Agencies		102	11	91	72	24	6
Total		399	78	321	198	163	38

Note: Desi. Sta.: Designated Statistics
Gene. Sta.: General Statistics
Surv. Sta.: Survey Statistics
Repo. Sta.: Report Statistics
Anal. Sta.: Analysis Statistics
C. A. A.: Central Administration Agencies
NSO: National Statistical Office
MAF: Ministry of Agriculture and Forestry
L. A. A.: Local Administration Agencies
Source: Survey for Official Statistical Activities, NSO, Jan. 2001

government agencies. The largest portion of the governmental statistics is occupied by report statistics followed by survey statistics. However, the NSO, the central statistics organization in Korea, produces only survey and analysis statistics based on report statistics (see Table 2 and Table 3).

3.2 Macroeconomic Statistics

Macroeconomic statistics are used as the key data in building national development strategies. Macroeconomic models aim to systematically

Designated Statistics and General Statistics; the former is the basic statistics of the nation designated by the Statistics Law and the latter is residual official statistics produced by Statistical Agencies.

Table 3: Statistical Compiling Agencies and Manpower
(as of December 31, 2000)

		No. of Agencies	Manpower				
			Total	Plan.& Anal.	Admin. & Assi.	Data Proc.	Intervi.
Government Agency	C.A.A.	25	3,339	627	336	368	2,008
	(NSO)	1	1,671	279	230	138	1,024
	(MAF)	1	1,252	134	74	130	914
	L.A.A.	32	995	112	26	43	814
	Sub Total	57	4,334	739	362	411	2,822
Designated Agencies		67	475	261	23	125	66
Total		124	4,809	1,000	385	536	2,888

Note: Plan.& Anal.: Manpower for Planning and Analysis
Admin. & Assi.: Administration and Assistant
Data Proc.: Data Processing
Intervi.: Interviewer
Source: Survey for Official Statistical Activities, NSO, Jan. 2001

understand total flows of the national economy and interactions among GDP, inflation, currency, interest rates, exchange rates, and current balance of payment.

Macroeconomic models began to be used in national planning since the second Five-year Economic Development Plan (1967-1971). Real macroeconomic statistics, for example, the national account (time-series data that have been available since 1954) and input-output tables, also began to be used as key resources. Since the late 1960s, the Bank of Korea, the leading organization for macroeconomic statistics in Korea, has developed macroeconomic models that integrate real and financial sectors, and used them in analyzing the effects of various policies. Since then, model building and statistical analysis has developed consistently. Starting with the third Five-year Economic Development Plan (1972-1976), linear planning, which links the input-output model to the macro-model, has been used. Since the Fourth Five-year Economic Development Plan (1977-1981),

the dynamic simulation model, a more developed model, has been used.

The use of macroeconomic models implies that macroeconomic and microeconomic data have been consistently constructed from the long-term perspective at least since the mid-1970s. From the 1980s, the various macroeconomic models have been developed by many organizations and econometric methods have become sophisticated enough to attempt to develop multi-sector models.

The key macroeconomic statistics can be summarized as follows:

1) National Accounts

The system of national accounts provides statistics that show the activities in the national economy and the states of assets/debts in account form during a particular period. The United Nations (UN) recommends that five national economic statistics – National Income Statistics, Input-Output Table, Flow of Funds, Balance of Payments and National Balance Sheet – be produced consistently. The national accounts show the consistent and systematic flow of the national economy, and are used in analyzing economic trends and formulating economic policies. The national accounts are a key tool to evaluate the existing system of economic statistics, propose new directions for improvement, and compare the welfare and economic structures across countries.

According to the UN criteria, Korea has produced national income statistics since 1953, and has produced the national accounts and integrated four out of the five national economic statistics (excluding the national balance sheet). As the UN recommends that the national accounts be based on the new system of national accounts (1993), Korea has already replaced the existing real GNP with the real gross national income; incorporated the social spot (or goods) transfer in estimating disposable income and final consumption expenditure; and reformed the system of categorizing consumption expenditure. Korea aims to completely meet the UN recommendations by 2004. According to evaluation by the UN, Korea, like Japan and France, is reported to have reached the fifth of the six milestones.

Currently, adoption of the SEEA (system of integrated environment and economic accounting), as recommended by the UN, is also affirmatively

considered to analyze the interdependence between economic activities and environment. Besides the seasonal adjusted series, a special classification system and estimation of real GDP based on the chain-weighted method have been developed in taking into account Korea-specific situations.

2) Price Statistics

The price index is the comprehensive level of the price of goods traded in the market averaged with a particular criterion. There are several price indices: producer price index, consumer price index, exports and imports price index, and price index of commodities received and paid by farms. In terms of policy-making and people's lives, the most important among these is the consumer price index, which is the average price of goods and services bought by consumers for consumption. The consumer price index is derived by investigating the price (in terms of 1995 prices) of 509 items used in 12,000 shops across 36 cities nation-wide. The weight of each item changes every 5 years, reflecting adjustments in consumption patterns.'

Despite favorable evaluation by the specialists on its quality, the CPI in Korea does not seem to gain full trust from the general public. This phenomenon stems from the difference between the CPI as an averaged index and the price level one observes individually in the market. This is a common problem in other countries as well. To alleviate such distrust, statistical agencies developed the Index for the Necessities of Life which specifies goods that are most frequently consumed (i.e., the Index for Fresh Food is specified for vegetables, fruits and fish, the prices of which frequently fluctuate depending on the weather; and the Index by Purchasing Frequency that reflects the actual price based on consumption frequency). The statistical agencies plan to develop the weighting system, reflecting changes in supplies of agricultural products,[3] to improve the consumption price statistics, and are considering to design a chain index in which the items and weights are adjusted annually to properly reflect changes in the

[3] As the opening of the agricultural market is expanded and the greenhouse cultivation increased, the seasonality of the supply of the agricultural products reduced.

consumption expenditure structure. The Hedonic Index is also being developed to incorporate the effects from the increase in E-business and the technical progress on items with rapid quality improvement (i.e., personal computers).

3) Labor and Wage Statistics

Labor and wage statistics provide the indices reflecting activities in the real sector. Labor statistics provide the information about employment, unemployment and wage statistics that reflect the level of income. Employment is very important in light of efficient usage of national manpower and the security of people's economic lives. The key statistics include the Economically Active Population Survey, Survey on Establishment Labor Conditions, and Monthly Labor Survey and Survey on Wage Structure. The basic statistics on labor are found in the Economically Active Population Survey, which is based on surveying the population aged above 15-years old across 30,000 households nation-wide. The survey investigates several items such as employment, unemployment and labor in terms of age, sex, education level and industry. The survey has been conducted quarterly since August 1962, based on monthly investigation.

The Korean economy was characterized by low unemployment prior to 1997. After the 1997 crisis, however, the unemployment rate increased from 3% to 7% in 1998. Although the unemployment rate has since declined, the instability of employment remains. Therefore, unemployment is still considered as a major policy issue and interest in the statistics on labor has grown. Although there are some criticisms on labor statistics, partly because of the difference between the unemployment one sees from individual basis and the unemployment rate calculated on the basis of the ILO criteria, the statistical agencies have rectified the problem by introducing unemployment statistics with various criteria as well as a seasonally adjusted unemployment rate. In particular, reflecting new trends in the labor market, the statistical agencies have developed a new method to grasp "irregular employment" and labor stability.

4) Money and Banking Statistics

Money and banking statistics, most of which are produced by the Bank of Korea, focus on the statistics concerning money supply and demand as well as financial transactions. The key statistics include the Monetary Survey based on data gathered from monetary institutions, Money Supply by Sector, Reserve Money Survey, Deposits and Loans Statistics, Reserves of Deposit Money Banks, Financial Survey and Interest Rate Statistics.

The key currency indices are divided in terms of the degree of liquidity into M1, M2, MCT and M3. The money survey categorizes these indices in terms of traders and financial commodities and was a simple summary of balance sheets of various financial institutions when it was initially created in 1958. Adopting the IMF criteria in 1974, the money survey has been carried out monthly using the consolidated balance sheets of monetary institutions, and the financial survey has been performed monthly drawing on the linked balance sheets of monetary and other financial institutions.

Although money and banking statistics in Korea have developed significantly, Korea is forced to reform its existing methods of formulating money and banking statistics because of rapid changes in the world financial market, including emergence of new financial products such as cross-border products from universal banking, E-money, and expanded usage of credit cards. The Korean monetary agencies, the Bank of Korea in particular, are prepared to respond to such changes.

3.3 Microeconomic Statistics

Microeconomic statistics in Korea have been relatively ignored and thus have developed slowly. Except for agricultural statistics, which are closely related to direct policy measures, microeconomic statistics have been considered as a simple tool for building macroeconomic statistics. Regardless of these problems, however, they have been broadened and have become more sophisticated over the years. The great majority of the microeconomic statistics, in a sharp contrast to macroeconomic statistics, are survey statistics. In Korea, considering their manpower and organizational capacity, only the NSO and the Ministry of Agriculture and

Forestry can implement a large-scale statistics survey such as the Census. The key microeconomic statistics are as follows:

1) Agricultural Statistics

Compared to its share of the national economy, agriculture is taken as a special sector in every country, even developed countries. Together with demographic statistics, agricultural statistics have been compiled for the longest time. As shown by the old Korean saying, "Farmers are fundamental of the nation," agriculture in Korea has been important since ancient times. Such social consensus still prevails in Korea because most of the current leaders in various fields come from agricultural areas. In addition to this historical reason, the vulnerability of Korean agriculture required the protection of government. Agricultural statistics have been developed to provide basic references for the government's agricultural policies. This explains the important position of agricultural statistics as well as the existence of various organizations producing agricultural statistics.

Agricultural policy in Korea has taken three basic directions: expansion of the production of agricultural products, maintenance of farmers' income, and stabilization of the supply-demand of agricultural products, particularly that of fruits and vegetables. For the effective implementation of these policies, about 40 survey statistics are produced by the government, including the Agricultural Census, Farm Household Economy Survey, Production Cost Survey of Agriculture and Food Grain Consumption Survey. For the stabilization of crop prices, government purchases have represented a great portion of total crop sales. The Production Cost Survey of Agriculture aims to calculate the government purchasing price. For accurate calculation, government officials are dispatched to all agricultural households.

2) Census of Basic Characteristics of Establishment and Mining and Manufacturing Survey

As sectional statistics by industry, the Mining and Manufacturing Survey has been conducted since 1970. Besides these statistics, overall statistics for individual industries, which cover almost all industrial sectors,

have also been developed. The key statistics for industry and business are the Census of Basic Characteristics of Establishment and the Mining and Manufacturing Survey.

The Census of Basic Characteristics of Establishment covers 2.8 million establishments, all the establishments in Korea except for family business in agriculture, forestry and fishing, military services, private households with employed persons and international/foreign institutes. This survey aims to capture the features of the whole structure of Korean industry and to provide a population for other statistical investigations on industry or business. Given the enormous scale of the survey, it has a limitation in that there are only a few, very simple questions. However, it provides very useful data for policy formulation because it covers all industries and businesses.

The Mining and Manufacturing Survey (including the Industry Census) aims to facilitate policy formulation by providing the structure, distribution and actual conditions of entire industry and by providing basic statistics for other surveys on individual industries. It covers all establishments with five or more workers as classified in Mining and Manufacturing by the Korean Standard Industrial Classification. The survey is conducted annually and includes detailed items on capital/assets, employment, wages, sales, costs, and inventory of each establishment. The Industry Census, surveyed every five years, widens the scope of the survey to include mining, manufacturing, electricity, gas and waterworks industries as defined in the Korean Standard Industrial Classification.

With its wide coverage, specified questionnaires and sophisticated industrial classification system, the Mining and Manufacturing Survey is known as providing the most useful microeconomic statistics for policy formulation and research. There are some criticisms in that the survey reveals only establishment-level statistics and there is a time-gap between conducting the survey and actual announcement. However, in recent years, the National Statistical Office newly developed firm-level statistics and reduced the time-gap to 8 months.

3) Information Technology Statistics

Since the 1990s, the economic and social environments have changed

rapidly as information technology develops and Internet usage gains in popularity. In contrast to these swift changes in social and individual life, only slow progress has been made in related statistics because of the difficulty in classifying and systemizing such a sudden, unprecedented social phenomenon. Statistical agencies in many countries are experiencing difficulty in treating the changes stemming from the so-called "New Economy."

In response to the "New Economy," Korea is implementing the Information and Telecommunications Survey and Electronic Commerce Statistics, while trying to build more proper statistical systems. First implemented in 2000, the Information and Telecommunications Survey aims to comprehensively capture the structural changes and performances in the IT and contents industry by covering the following: information and telecommunication equipment manufacturing, information and telecommunication infrastructure, wholesale and retail trade of information and telecommunication equipment, information and telecommunication services, S/W and computer-related services, and information content business. Electronic Commerce Statistics aim to facilitate government policy creation and enterprise strategy building by providing information on the scale and infrastructure of E-commerce. Beginning in 2000, these statistics have been compiled monthly, covering 1,840 enterprises with B2C cyber shopping malls. seventeen questionnaires are focused on their sales, marketing, performance, managerial costs and so on

Korea is now in an advanced position in terms of statistical development related to the "New Economy," and is striving to make more progress. From 2001, the government plans to construct Digital Divide Statistics and Knowledge-based Economy Statistics to capture the level of informatization of people, and the changes and trends in the knowledge-based industry. In addition, it plans to improve the existing E-business statistics, focusing on B2C and B2B transactions, and to incorporate B2G transactions into its coverage.

4. Prospects for Statistics in Korea

4.1 Changes in Government's Role and Statistics

The government-led development strategy and frequent market intervention has caused many adverse side effects on the Korean economy. The imbalance in supply-demand around 1980 and the crisis in 1997 also stemmed from distortions in the market mechanism due to the government's excessive intervention. The necessity for transition to a true market mechanism has been suggested since the early 1980s and the market mechanism has gradually established by overcoming various barriers.

A genuine market-oriented structure of the Korean economy will take root more firmly as the new domestic economic order established after the 1997 financial crisis. The development of statistics is a prerequisite for the maintenance and improvement of the market-oriented system as well as its efficiency. Welfare improvement in a free market economy largely depends on the rational choices of the actors. Furthermore, statistics, which represent precise information about the market, are a prerequisite to those choices. Since the lack of accurate information about the market will be the biggest threat to proper operation of the market-oriented system, statistics must be considered as one of the key factors to develop a free-market economic system in Korea.

Statistics also contribute to democratization and integration of the society and also to enhancing people's quality of life. In a democratic society, voluntary participation and the resulting public formation of citizens is the prerequisite to national integration. That is why appropriate consensus on social phenomena is very important. Statistics facilitate proper consensus formation and national integration by providing precise information. There are certain policy issues that every country will confront in the near future, such as the problems of aging society, environment and social security. Public consensus about the importance of these problems and the spontaneous acceptance of the costs are critical for proper responses to such problems. Statistics play a key role in providing precise information to induce the required social consensus.

4.2 Prospects for Statistics in Korea

1) Increase in the Demand for Statistics

In the future, the demand for statistics in Korea will increase rapidly. Advancements in industrial structure, diversification of consumption patterns, and rising expectations for the quality of life all elevate the demand for statistics. The more rapid these changes transpire, the more incremental the demand for precise information regarding these changes becomes.

On the other hand, fragmented and primary statistical information is no longer sufficient to capture the main features of the economic phenomena in a complex, specialized and diversified society. Therefore, the need for analysis and manipulated statistics is on the rise. To meet these broadened and sophisticated demands, each statistical agency must reinforce its manpower. More specialists must be recruited from various sectors to provide deeper and more precise analysis and information.

The improvement in living standards diversifies the senses of value and the expectations for a higher quality of life. It is insufficient to estimate the quality of life in terms of the pecuniary index. Hence, there will be a rapid increase in the demand for new statistical methods that can estimate various aspects of society, such as level of leisure, integration of family, protection of privacy, time-saving, better environment and value of community. As globalization develops, the international demands for Korean statistics and the needs for international cooperation in statistical investigation also increase. As a member of various international organizations, such as the UN, WTO, OECD and ILO, there will be a heightened request for carrying out certain duties and for bilateral cooperation in exchanging relevant information.

2) Building an Efficient Supply Mechanism for Statistics

To respond properly to the increasing demands, a new policy agenda for development of statistics can be proposed as shown in Figure 1.

First, improved accuracy and promptness are needed to respond to the rapid changes in society. Second, the reinforcement of statistical organizations and agencies, and the increase in efficiency of statistical

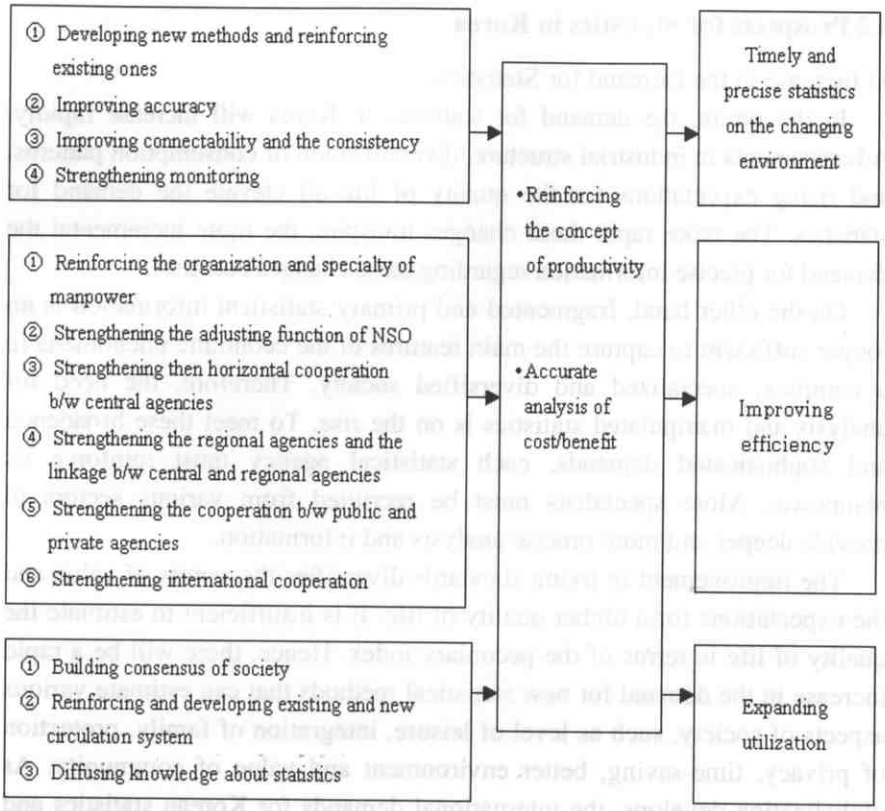

Figure 1. Objectives of National Statistical Development

administration are needed for advancing the production of statistics. Third, the circulation system must be strengthened to improve the availability of the statistics.

To supply timely statistics, new methods of statistical investigation must be developed and the existing system must also be reformed. Particularly, statistics for the environment, social welfare, regional development, corporate sectors, and foreign countries must be reinforced. In addition, the accuracy, connectability and consistency of the statistics must be improved.

The role of government in the production of the statistics will be expanded. As statistics are a kind of public good, statistical investigations

need the authority of the government, the most value-neutral organization.

As described above, there are several organizational problems with Korean statistics. In addition to reinforcement of the individual organizations, the inter-organizational linkages and cooperation must be intensified. For example, the cooperation between central governments, between central and regional governments, and between public and private sectors must be reinforced.

The circulation system of statistics has developed rapidly in recent years. The major statistic agencies in Korea, such as the National Statistical Office and the Bank of Korea, as well as central and regional government agencies, built their own database systems and provided information to the public through the Internet. The NSO is providing unprocessed raw data and processing services as well as to meet special demands. As informatization progresses, the system will become even more diversified and advanced.

The statistical services in Korea will become more and more commercialized. The policy for the beneficiary to share the cost of statistics tends to prevail in many countries. The main object of commercialization in Korea is to expand the demand for the statistics by screening various kinds of demands. Korean statistical agencies adopt the criteria not in terms of the pecuniary cost/benefit, but rather in terms of the social benefit/cost. Since production of statistics shows very low marginal cost while its benefit depends on the level of utilization, the price of the statistical services in Korea has been maintained at the lowest possible level only aim to screen out the actual consumer, and this will be continued in the future.

5. Conclusion

Korean economic statistics have developed in tandem with the Korean growth strategy. For this reason, macroeconomic and unofficial statistics have been considered more important than the microeconomic and official statistics. Despite the resulting insufficiency of government investment, however, the official statistical agencies have developed gradually in accordance with socio-economic development of the whole society.

Statistical administration is also a function of the government, and its development can be expected only if the functional development of the government as a whole is completed.

The transition of the Korean economy to a more matured and developed level is merely a matter of time. In light of this bright prospect, the demand for statistics in the Korean economy is expected to increase rapidly. Moreover, as the main role of Korean government is to shift from a planner and coordinator to an honest broker and fair referee of the economy, government's statistics supplying function needs to be more emphasized in the years to come.

The Korean experience of parallel development of the economy and statistics provides some important implications. It offers a model for developing countries to adopt when searching for the proper statistical system and socio-economic development path. For the developed countries, it can be understood as a new case regarding the relationship between the economic operating system and the national statistical function.

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Contribution of Industrial Statistics for Development of Korean Industry

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Abstract: This paper deals with the contribution of industrial statistics for development of Korean industry. First of all, it describes the model which shows how statistical methods can help industry for its development. Next, the history of QC (quality control) and QM (quality management) is briefly explained to show where the Korean industry stands in terms of QC/QM movements.

The importance of statistics in industry in the information-based knowledge society of the new millennium is explained with figures. Next, a survey result for the use of statistical methods in Korean industry is tabulated and evaluated. Finally, some problems we have encountered so far for the use of statistical methods in industry are revealed, and possible counter-measures for future directions are suggested.

Keywords: Industrial statistics, Quality control, Quality management

1. Introduction

Korean industries, if there were any, were completely destroyed during the Korean War between 1950 and 1953, and the effects of the war lasted for a long time. The birth of Korean QC or QM movements can be said to have begun in 1961 when the Industrial Standardization Act was announced. Over the last 40 years, the firm determination of the Korean people to develop their industry has been successful and, quite remarkably, we have achieved an average of about 8% annual growth in the gross national product. Such development is often called the "Han River Miracle" in the

20th century.

At the present time, however, due to bad effects from the economic crisis controlled by the IMF, due to large increases in the price of raw materials (especially in oil), due to strict protectionism by advanced countries and due to ever-challenging competitiveness by other developing countries, the Korean economy is facing a tough challenge from both the inside and outside. To survive in the international market we have to overcome many difficulties, and need a quality and productivity revolution through the process of total quality management (TQM).

With most of its energies in the past having been largely on the quantitative development of industry, Korea is now at the point of turning its emphasis towards quality in production. Korean people feel that it has become indispensable for enterprises to introduce a higher level of scientific methods of management in order to strengthen their international competitiveness. Recently, this has propelled many Korean companies to adopt TQM, Six Sigma, ISO 9000/14000 series, etc. in their company management.

Scientific management tools should be essentially used for development of industry. However, the basis of all scientific management tools is statistical thinking, statistical methods and/or statistical data base management. In fact, statistical thinking is the beginning of all scientific management tools. Figure 1 shows the rough relationship among these.

The contribution of statistics for the development of Korean industry has been more than remarkable. I believe that, without the help of statistical methods to industry, Korean industry could not have reached the current level of development. This paper first presents the history and the development of QM movements in Korea. Next, it presents how many statistical methods are used in Korean industry. And then, some problems encountered in QM movements in Korea are disclosed and discussed. Finally, some counter-measures to overcome these problems are suggested.

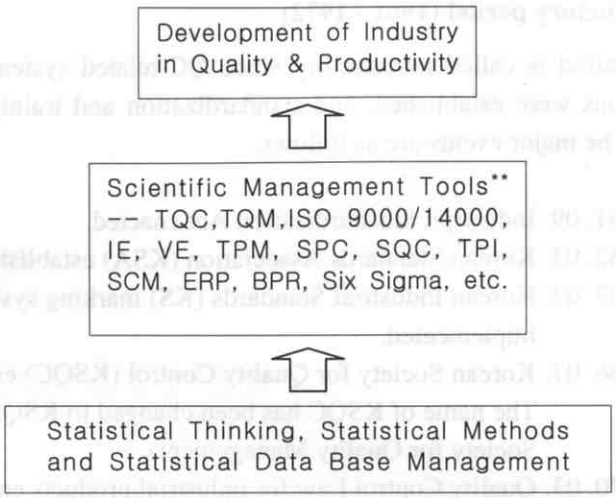

Figure 1: Relationship between scientific management tools, statistical methods and management science tools

** TQC = Total Quality Control TQM = Total Quality Management
ISO = International Organization for Standardization
IE = Industrial Engineering VE = Value Engineering
TPM = Total Productive Maintenance SPC = Statistical Process Control
SQC = Statistical Quality Control TPI = Total Productivity Innovation
SCM = Supply Chain Management ERP = Enterprise Resource Planning
BPR = Business Process Reengineering

2. History and Development of QC/QM Activities

The last 40 years can be divided into 3 periods, i.e. introductory, development and expansion periods. Some explanations about such history can be found in KSA (2000) and Park (1992).

2.1 Introductory period (1961 - 1972)

This period is called introductory since QC-related systems, laws and organizations were established, and standardization and training QC were initiated. The major events are as follows.

1961. 09: Industrial Standardization Act enacted.
1962. 03: Korean Standards Association (KSA) established.
1963. 07: Korean Industrial Standards (KS) marking system implemented.
1966. 07: Korean Society for Quality Control (KSQC) established. The name of KSQC has been changed to KSQM (Korean Society for Quality Management).
1970. 03: Quality Control Law for industrial products enacted.
1971. 03: First national qualification examination for certified QC engineers executed.

2.2 Development period (1973 - 1986)

QC/QM activities began to spread rapidly when the TQC concept was introduced in industries in the early part of the 1970s. At the same time, the Korean economy began to make a drastic conversion from light industry to heavy and chemical industries with emphasis on QC/QM. The foundation of the Industrial Advancement Administration (IAA) in 1973 and the first national contest of QC circles marked a turning point in QC movements in Korea.

1973. 01: The Industrial Advancement Administration (IAA) established under the Ministry of Commerce and Industry.
1975. 10: First national contest for QC circles.
1976. 04: First international convention on QC circles (ICQCC '76 – Seoul) held.
1981. 06: Factory grading system for QC introduced.
1983. 11: QC training center in KSA established.

2.3 Expansion period (1987 - present)

In this period the TQC/TQM concept spread to small and medium-sized industries. TQC/TQM started to be adopted as a management tool and began to be operated as a total systems approach. Also the ISO 9000/14000 series were introduced to Korean industry. In the late 1990s, the concept of Six Sigma was introduced and, recently, many Korean companies have become interested in this quality revolution management concept.

1987. 11: ISO 9000 series introduced.
1992. 12: Amendment of Industrial Standardization Act to include new industrial fields such as services and information processing.
1993. 12: Quality Management Promotion Act promulgated. The KS A/ISO 9000 series adopted as the national standard. Here, KS means Korean Industrial Standards, and A means a serial number in KS.
1996. 12: KS A/ISO 14000 series adopted as the Korean standard.
1997. 01: Six Sigma introduced.
1997. 03: Quality Academy organized.

Quality Academy is an organization in which experts in quality from university - industry - institute study together for development of Korean industry.

3. Use of Statistical Methods in Korean Industry

3.1 Importance of statistics in the new millennium

It is said that the 21st century is the information-based knowledge society. This means that for a company to survive, it should consider the knowledge as the most important asset, and knowledge management should be based on information technology. This fact will be not only true for a company, but also it will be true for any organizations such as university,

government, research institute, and so on.

Figure 2 shows the knowledge triangle. The fact (data source) exists by itself in our society. If we want to obtain some raw data from the fact to understand it, we need some statistical designs such as DOE (design of experiments) or sampling design. Without these statistical designs, we cannot get raw data sets efficiently. From the raw data, in order to obtain useful information, we need to use statistical methods such as data mining tools, regression analysis, multivariate analysis, and so on. To obtain valuable knowledge from information, we need some kind of statistical data base to manage information in an efficient way. At this stage, information technology such as high-speed computers, internet systems, intranet systems, etc. plays an important role.

Note that in Figure 2 that some forms of statistics are involved in each stage from Fact, Data Gathering, Information and Knowledge. This means that statistics is the crucial decision-making science in the so called information-based knowledge society in the new millennium. This also means that statistics will be more studied, used and loved by many people in the new century.

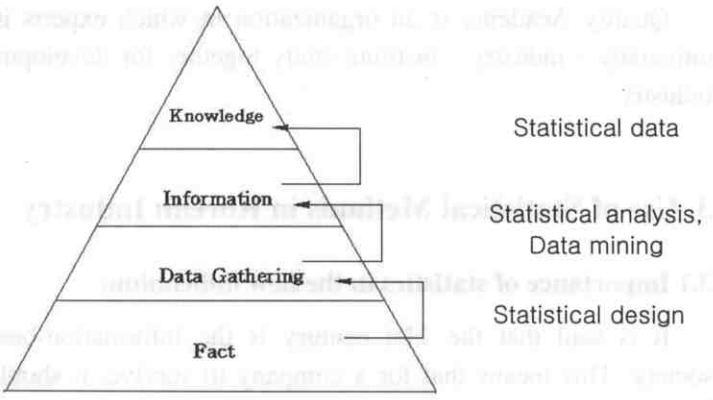

Figure 2: Knowledge triangle

3.2 Major statistical methods used in industry

When we talk about the statistical methods used in industry, the following methods are the major ones.

- Seven basic tools of QC: Histogram, Scatter diagram, Check sheet, Pareto diagram, Statistical graphs, Stratification, Cause-and-effect diagram
- Control charts and sampling inspection
- Correlation and regression analysis
- Hypothesis testing and estimation
- Design of experiments
- Multivariate analysis and reliability theory
- Process capability index
- Gage R&R test
- Taguchi methods and robust design
- SQC/SPC computer statistical system
- Data mining tools

3.3 Survey results for the use of statistical methods in Korean industry

In March 1997, the Quality Academy was organized with quality experts from universities, industries and national institutes. This academy implemented a mail survey in November 1997 to find out the quality competitiveness of Korean companies. For the mail survey, a total of 197 manufacturing companies answered the questions which are related to statistical methods. Some detailed results can be found in KNITQ (1998).

1) Use of Statistical Methods

Table 1 shows that the seven basic tools of QC, control charts & sampling inspection, hypothesis testing and estimation, process capability index and SQC/SPC computer system are fairly well used. However, the correlation and regression analysis, design of experiments and multivariate analysis & reliability theory are not much used. Since the other statistical methods such as Taguchi methods, gage R&R test, and data mining techniques were not involved in the survey, we don't know the degree of use

Table 1: Status of use of statistical methods in Korean industry

Statistical methods	Seven basic tools of QC	Control charts & sampling	Correlation and regression	Hypothesis testing and estimation
Use	189	191	93	117
No-use	6	6	97	75
No-answer	2	0	7	5
Total	197	197	197	197

Statistical methods	Design of experiments	Multivariate analysis & reliability theory	Process capability index	SQC/SPC computer system
Use	78	79	138	134
No-use	111	112	56	61
No-answer	8	6	3	2
Total	197	197	197	197

in Korean industry. However, we can guess that not many of these companies use these advanced statistical methods.

2) Education of statistical methods (SQC/SPC)

In the survey, the number of hours for statistical education in a year related to SQC/SPC was asked. Table 2 shows the average number of education hours per each person per year, which indicates that most companies use less than 20 hours for statistical education. There is no doubt that such education time is not satisfactory.

3) Application effect of statistical methods on SQC/SPC

Table 2: Average hours for statistical education per year

Average hours	Number of companies
less than 10 hours	108
10 - less than 20 hours	59
20 - less than 30 hours	15
30 - less than 40 hours	6
equal to and more than 40 hours	3
no answer	6
Total	197

Table 3: Application effect of statistical methods on SQC/SPC

Degree of application effect of statistical methods	Number of companies
very significant	24
somewhat significant	107
average	36
not much significant	19
not significant	1
no response	10
Total	197

However, Table 3 shows that the application effect of statistical methods on SQC/SPC is generally significant. Therefore, even though the education time is not enough, they judge that the degree of application effect of statistical methods on SQC/SPC is significant.

4) Application area of statistical methods

In the survey the question of "where do you use the statistical methods"

Table 4: Application area of statistical methods

Application area Of statistical methods	Number of companies
quality planning and design (R&D part)	18
process control	80
inspection and test	47
market information for quality and claims	5
no answer	47
Total	197

was asked. The results are listed in Table 4, which indicates that the most applicable area of statistical methods is the process control, and then the next area is the inspection and test. As of 1997, statistical methods were notused in the areas of quality planning and design, and market information. However, I believe that the use of statistical methods in R&D and marketing areas is increasing.

5) Computerization of SQC/SPC

In the survey a question was asked on the degree of computerization of SQC/SPC. It is clear that a good computer system for SQC/SPC is necessary to implement SQC/SPC effectively. Computerized data gathering and automatic computer analysis for key factors and characteristics are essential for a good SQC/SPC system. Table 5 shows how they evaluated their computerization of SQC/SPC system. Table 5 reveals that many companies think that they are more or less in the average level in terms of computerization of SQC/SPC.

6) Degree of contribution of statistical methods for quality/productivity problem solving

Finally, in the survey the question "What is the degree of contribution of statistical methods for quality/productivity problem solving?" was asked.

Table 5: Degree of computerization on SQC/SPC

Degree of computerization on SQC/SPC	Number of companies
very high level	15
relatively high level	36
average level	83
relatively low level	43
very low level	18
no answer	2
Total	197

The result was as in Table 6, which indicates that the companies evaluated that the contribution of statistical methods for quality/productivity problem solving is in relatively the high level.

4. Statistical Process Control

4.1 Meaning and goal of statistical process control

Based on our consulting experiences in Korean industries, the meaning of statistical process control (SPC) may be explained as follows.

S (statistical): By the help of statistical data and statistical analyzing methods,
P (process) : understanding the present process capability and quality specifications,
C (control) : control the quality to meet the specifications with minimum variations.

In every process there are inherent variations in quality. SPC intends to minimize the variations with minimum cost. As shown in Figure 3 there are

Table 6 : Degree of contribution of statistical methods for quality/productivity problem solving

Degree of contribution of statistical methods for quality/productivity problem solving	Number of companies
very high level	15
high level	47
medium level	79
low level	31
very low level	6
no answer	19
Total	197

four major factors that are most important for successful continuous improvement efforts in SPC activities. The four major factors are as follows.

1. Education and training: education of statistical thinking, quality control (QC) tools, SPC methods and other scientific management methods such as total productive maintenance (TPM), just-in-time (JIT), value engineering (VE) and industrial engineering (IE).
2. Total participation and standardization: 100% participation of all employees, self-motivation atmosphere, suggestion system, and full participation in making and observing standards.
3. Quality improvement teamwork: small group activities such as quality circle, quality improvement team, task-force-team and cross-functional team.
4. Using statistical methods: proper use of statistical tools such as control charts, process capability index, reliability, correlation and regression methods, design of experiments, etc.

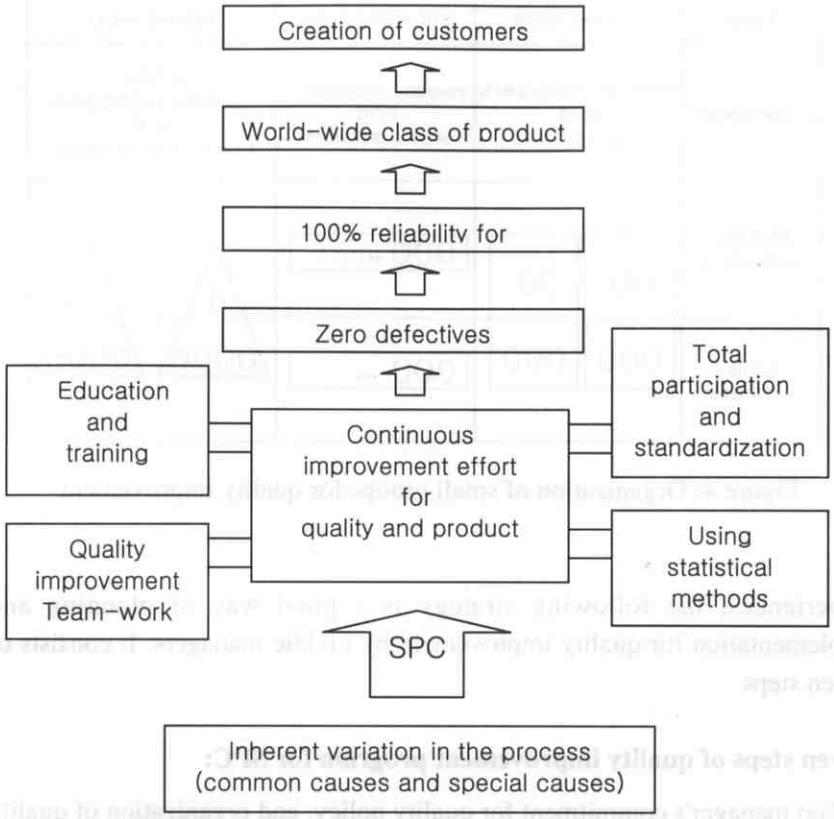

Figure 3: The goal and key factors of SPC

4.2 Team effort for quality improvement in SPC

There are basically two types of teams for quality improvement in SPC. One is the well known QC circle whose members are mainly line workers. Another is the team organized by middle managers such as engineers and researchers. Sometimes a mixed type is desirable depending on the situations encountered. Figure 4 shows three types of small group organizations for quality problem solving.

The author has been involved in education and consultation for quality programs of many companies for the last several years. From our

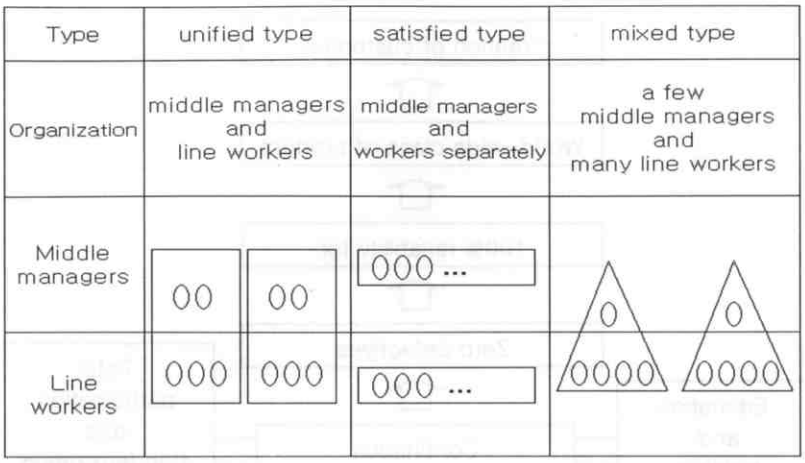

Figure 4: Organization of small groups for quality improvement

experiences, the following strategy is a good way of planning and implementation for quality improvement by middle managers. It consists of seven steps

Seven steps of quality improvement program for SPC:

1. Top manager's commitment for quality policy, and organization of quality improvement team which will achieve quality target.
2. Quality evaluation and selection of projects.
3. Setting up goals for the team to achieve.
4. Detecting trouble sources and determination of possible counter - measures.
5. Implementation of counter-measures and preparation of team reports.
6. Holding a report session in a place where all managers participate and recognition of team efforts for quality improvement results.
7. Evaluation of the gains, standardization of the results and planning for the next team efforts.

It is of interest to study the general procedure of quality problem

solving. Constant watch of quality variations is necessary in SPC. Such constant watch can be done by statistical tools such as control charts, graphs, and process capability indices. If a quality problem occurs, in general, the following procedure is applied to solve the occurred quality problem. This procedure is explained in Figure 5. When a quality problem is detected, the present situation and the causes of trouble are investigated through data collection and analysis. For data analysis, statistical computation using statistical software is needed, since we should ordinarily handle large sets of past data which are related to the trouble sources.

Based on the findings of trouble sources with quality, some counter-measures to solve the problem are considered and implemented. If the problem is solved by these counter-measures, the flow goes to the usual checking process for the mean and variation of quality. If the problem is not solved, some type of experimental designs should be adopted to find either the optimum operating conditions or another way of handling the situation. Taguchi's robust design is a powerful tool for this stage. After such activity, one should check again whether the quality problem has been solved or not. If not, quite different counter-measures such as change of manufacturing engineering or facility replacement should be studied.

4.3 Computerization of SPC and its difficulties

In order to maintain a good SPC system, we need to have an integrated computerized system for process control, in which several types of statistical computation are necessary. Figure 6 shows a rough sketch of the system.

In Figure 6, there are 5 systems in which some types of statistical computerization are needed. They are quality design, quality tracking, operating condition monitoring, quality evaluation and quality analysis. If a company wants to have a good system of process control, it must have good statistical software which is built in its process control facility.

Many Korean companies do not have a good integrated computerized SPC system, which may be the case in many other countries as well. The reasons why there are some difficulties in having a good SPC system are

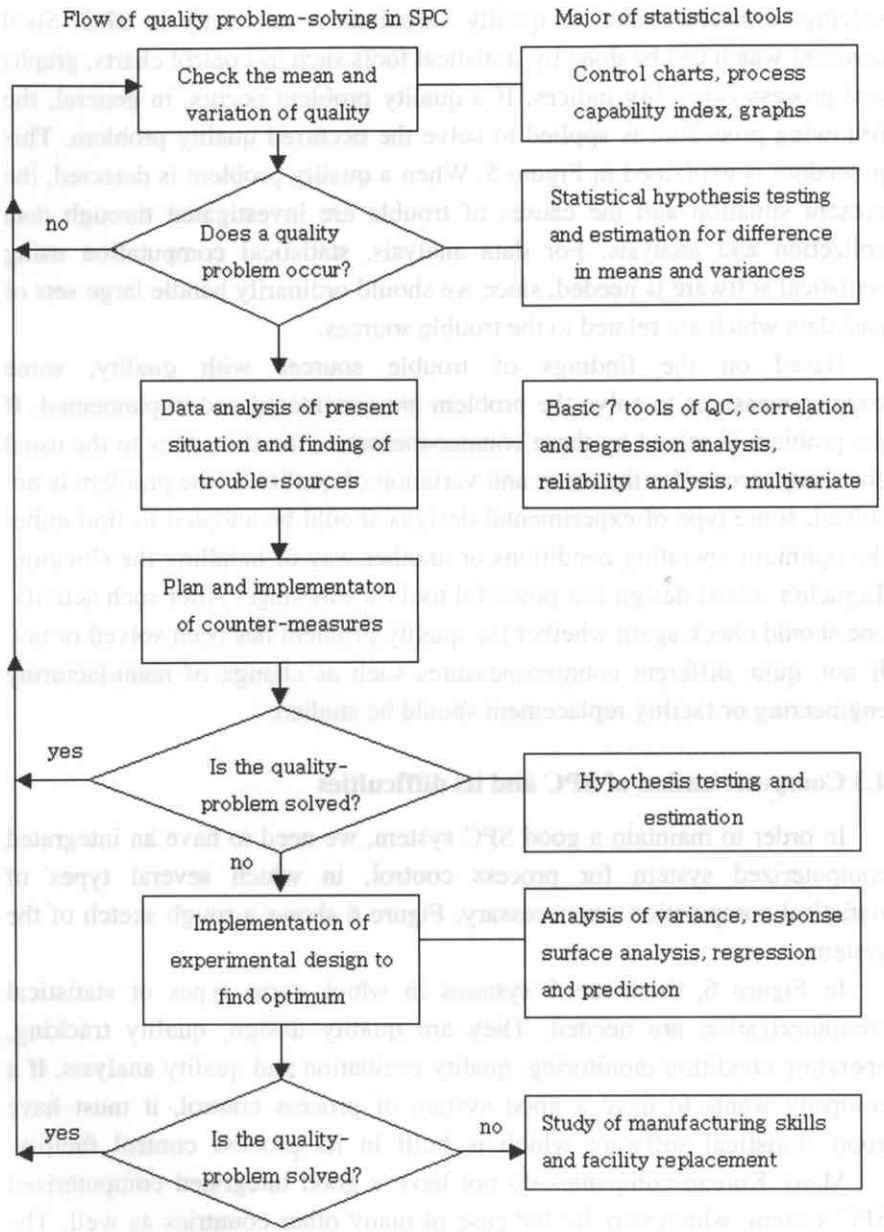

Figure 5: Flow-chart of quality problem solving in SPC

as follows.

1. The company does not have good statistical software written in their own language, which can be conveniently used for engineers and workers in factories.
2. Engineers and workers do not understand statistical tools, so they are afraid of using statistical methods.
3. Managers are not eager to invest in computerization, and to train engineers and workers to use statistical tools.
4. SPC related departments in universities such as statistics, industrial engineering and management science do not educate their students well to cope with statistical computation and quality problems. Therefore, when they face problems in companies, they are not capable of handling the problems well.

However, recently a number of companies are trying to maintain a good SPC system which is a positive sign. In the view that the coming century is the century of quality and productivity, we believe that, to be a competitive company in the international market, the company should have a good SPC system. Park (1993, 1996, 1999), Park and Sun (1993) and Park et al. (1997) presented some insights about SPC and related matters.

5. Current Problems and Future Desirable Directions of Industrial Statistics

The previous sections have given a brief outline of QC/QM activities in Korea, and some survey results on the use of statistical methods in industry.

Even though Korea has enjoyed, generally speaking, a fast development in economy and in the use of statistical methods in industry, we have encountered several problems and difficulties in promoting statistical methods as discussed below.

It may be noted that similar cases often exist in other countries, and we want to share our experiences and opinions with other relevant persons. When the

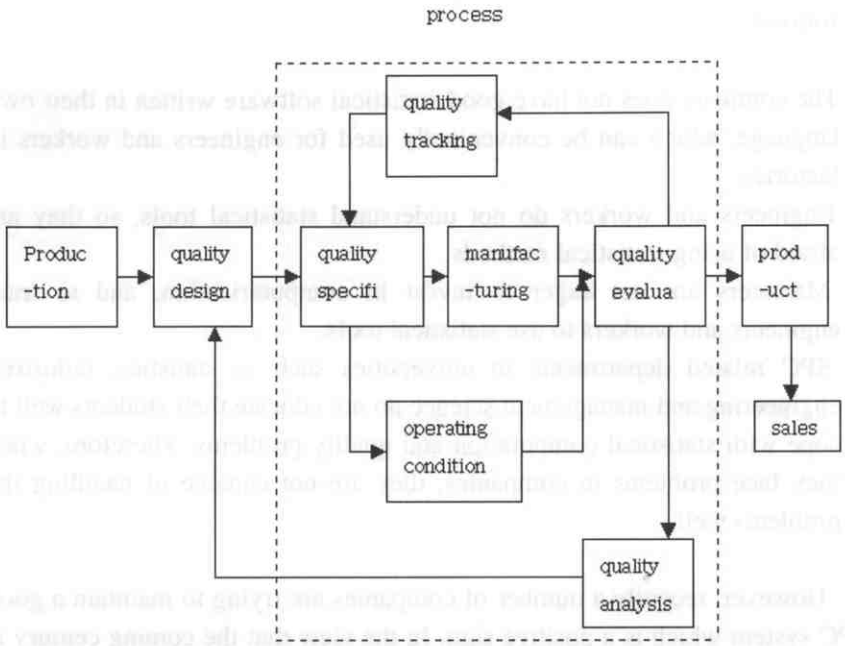

Figure 6 : SPC integrated system

problems are revealed, desirable future directions to solve the problems can be suggested. Below we want to first point out some problems and difficulties, and to raise possible counter measures to solve those problems.

1) Statistical education for engineers and scientists

In order to use statistical methods for QC/QM activities in industry, the engineers/scientists in industry should understand the pertinent statistical methods. However, in general, they did not receive proper education in statistics during their university days.

For instance, statistical courses are only optional for engineering students, and they usually do not take the statistical courses. They just think that statistics is difficult to understand. Generally speaking, companies do not educate engineers in statistical methodology, hence the engineers are not

really capable in using statistical methods for quality/productivity problem solving.

The workers/operators in industry have not had enough opportunities for education in statistics. Table 2 shows that the average hours for a worker to receive statistical education a year is less than 20 hours. This is just not enough.

I believe that two courses should be compulsory for all engineering students. One course is the introductory statistics course, and another one is the empirical model building and experimental design course. For workers in industry, I believe that at least 40 hours a year should be allocated for statistical education.

2) Statistical software in the Korean language

For ordinary Korean workers to use statistical methods and statistical computing, there should be easily used statistical software written in the Korean language. We do not have good Korean software such as SAS, SPSS, Minitab, S and so on. This is the responsibility of Korean statisticians, including the author.

For quality/productivity problem solving, small-sized statistical software for personal computers can be usefully used. A few groups of Korean statisticians have been interested in developing statistical software, but it may take a long time to develop as good a statistical software as SAS or SPSS. However, we understand that we should start working for this, and the sooner the better. Fortunately, there are some small-sized statistical software programs emerging recently such as ISP(Information Statistical Processor), Spectrum, Sigma Prism and so on which are written in the Korean language.

3) Use of scientific QC/QM methods

Many managers and engineers in industry are not well aware of the power and usefulness of scientific QC/QM methods such as SPC (Statistical Process Control), DOE (Design of Experiments), reliability analysis, TPM (Total Productive Maintenance), IE (Industrial Engineering) and so on. Even though there are many certified QC engineers in Korean industries, it

seems that they are not very active in using some of the scientific QC/QM tools. Since they do not use scientific tools much, consequently, they often do not use industrial statistics.

In order to advance the current status of industrial statistics to a further level, more scientific QC/QM tools should be actively used, and some related statistical software should be provided with proper education. Perhaps the best way to activate the use of industrial statistics is to organize project teams, and let them use the statistical tools for their problem solving.

Fortunately, as Six Sigma is introduced in Korea, many companies which adopt Six Sigma, start to form many project teams and use statistical methods. We are in fact quite encouraged by Six Sigma management in Korean industry.

4) Reliable data gathering, and use of information technology

Since the industrial situation becomes more complex and a lot of variables are involved, we need to obtain large data sets for the complex industrial systems. Therefore, in order to visualize the complex industrial systems, reliable data gathering is necessary. However, modern technology is still not quite capable of handling large data sets with good reliability. Moreover, most top managers from the old generation do not understand the current changing society with fast information technology.

We need to prepare and quickly go ahead to cope with complex industrial systems by using modern information technology and good statistical tools such as data mining and large-scale data analysis tools.

5) Application mind in statistical academic circles

At the end of 1999, the number of universities which have a statistical education program is over 70, which is about half of all universities in Korea. And, every year more than 2000 college graduates majored in statistics enter society. However, they do not satisfactorily play their roles in society including industry, because, in my opinion, they do not have proper education for statistical application which is really needed in society. One major reason for this problem is that many statistical professors are theoretically interested in statistics, and they do not know how to teach

statistical application to their students.

I believe that statistical academic circles should be more interested in applied statistics including industrial statistics. Then students could get more application oriented education in statistics.

6. Concluding Remarks

Now is the right time in industrial and academic circles in Korea to reflect upon whether industrial statistics has been playing the right role for development of Korean industry. For this point of view, we reviewed the historical development of QC/QM activities, and a survey result with regard to statistical methods.

Several problems and difficulties we have in using statistical methods in industry have been disclosed and possible counter-measures were suggested. We hope that eventually industrial statistics can be strengthened in Korea, and that it contributes to the development of the Korean economy.

Acknowledgements

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PART II

Reconstructing Population Trends in the Chosun Kingdom[1]

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Abstract: This paper tries to establish the population trends of the Chosun Kingdom utilizing household and population registry data reported in various historical documents. For this, the completeness of reported populations is examined and the pattern of under-enumeration is determined for the earlier period and the later period separately. Adjustment factors for each yearly data are derived based on those observations, and populations are reconstructed by applying those factors. Finally, the quality of the reconstructed population trends is evaluated indirectly by their association with Malthusian population checks.

Keywords: Population History of Korea, Population Reconstruction for Chosun Kingdom, *Hogu* Data, Evaluation of Data Quality, Malthusian Checks.

1. Introduction

In Korea, the first modern census was undertaken in 1925, but a system of household and population registration, called *hogujosa*, is known to have existed more than one thousand years. Population and household counting through *hogujosa* persisted throughout the Chosun era that lasted 518 years from 1392 to 1910, and most of the figures available were reported in

[1] The major part of this paper is drafted based on the author's previous work, "On population estimates of the Yi dynasty Korea, 1392-1910, Donga Munwha 14, 1977, written in Korean.

Chosun Wangjo Sillog (the Official Royal Record of the Chosun Kingdom). Books of *hogujosa* (or *hogu* registries), which contain information on the age, sex, occupational role, and family background of both father's and mother's side of each family member, are available, too, for some selected areas and years. The information provided is so extensive that it could warrant any modern demographic analysis without difficulty if the registration is complete and the provided information is correct. But, the coverage is known to be very poor and to differ greatly in terms of age, place of residence and role status. In addition to the official registry data, kinship genealogy books were compiled among elite (*yangban*) families since the mid Chosun era. Theoretically, these can be an important source of population and family studies, but the books have rarely been used for demographic analysis due to the lack of reliability of the information provided and few analytical skills to overcome data problems of its kind.

According to the population totals enumerated in *hogujosa*, the population of Chosun Korea had grown from 3,745,000 in 1519 to 6,748,000 in 1861, revealing an annual growth of less than 0.2% on average. The growth rate is apparently reasonable under any traditional socioeconomic setting, but cannot be taken as a warrant for a high quality of *hogu* data. Judging from the 1925 census population, which is renowned for its completeness, the *hogu* population for 1861 is undoubtedly too small. Being calculated from these two figures, the annual growth rate rises to 1.6%. Also, unlikely pictures emerge if age structures are assembled from the registry records. The proportion of child population is very small and a diamond shape of age composition is noticed (Kim D-S, 1990: 10; Lee H-T, 1990: 24; Ehn K-S, 1987: 60-62). In a word, the quality of data should be determined to construct population phenomena for the Chosun Kingdom based on *hogu* data.

The coverage of a reported population is usually examined in two ways: (1) the comparison with figures from other sources with known coverage, and (2) the evaluation of its demographic and social characteristics. The first type of data used in our evaluation consists of the 1925 census population and *ad hoc* population counts conducted for emergent grain distribution in famine or disease affected areas. For the second type of evaluation, age

structure compiled from scattered original *hogu* registries and household sizes available from reported *hogu* populations are used. The type of information for evaluation, however, differs between the earlier part and the later part of the kingdom, and the evaluation of *hogu* population is separated in terms of period of examination. If the quality of data is examined properly, the next job would be the reconstruction of population figures and trends.

2. Data Evaluation

Population data for the early Chosun era are highly limited. Only a few population and household totals are available for the pre 16th century period. In addition, the quality of these figures is extremely poor. There are, however, additional population and household counts for certain years in the mid 15th century in famine stricken provinces to release relief grain. These were proved to be of crucial importance in determining the quality of *hogu* population at that time (Han Y-W, 1977).

Population and household enumeration based on the *hogu* system was conducted every three years, with some exceptions, during the 222 years between 1639 and 1861. The figures are reported mostly in *Chosun Wangjo Sillog,* and *Takjiji* carries some (these were compiled in Government General of Korea, 1927, Seoul National University Press, 1971, and Han Y-W, 1977). But the quality of *hogu* data for the 1630s and 1640s is grossly questioned even from a cursory look. The quality appears to have been improved greatly in the thirty years between 1639 and 1669 due probably to the reworking of the *hogu* registration system which was destroyed by the invasions of Japanese and Mongols in 1592 and 1636 respectively. For the next 192 years between 1669 and 1861, no drastic changes are noticed in the quality of the data. Besides, some supplementary data are available in some selected regions and years, for example, original *hogu* registries on which *hogu* counts were made. The latter have proved to be an important source of information to enable us to determine the quality of *hogu* population.

The completeness of the *hogu* population for the later years of the Chosun Kingdom can be approximated by a backward projection based on

the 1592 population census. Two assumptions are required for this projection; that is, the coverage of the 1925 census population is complete and the population had been stable for at least the last sixty years. These two assumptions are known to be highly reasonable. The 1925 census reporting is evaluated as good as any Western or Japanese census (Kwon T-H, 1977: 11-15). Also, the 1925 age composition reveals the very structure of a traditional stable population, although the Korean population entered the first stage of demographic transition in the late 1910s or in the early 1920s (Chang Y, 1966: 165-210). Reading the age structure, the annual rate of population can be determined as 0.2% with crude birth and death rates of 3.7% and 3.5%, respectively. Considering this and other population situations between 1910 and 1925, the population at the closing of the Kingdom was estimated to be 17,427,000 (Kwon T-H & others, 1975: 1-5), and an extended population projection back to 1861 shows the 1861 *hogu* population achieved a completeness of only 43%. From this observation, we can easily surmise that the population enumerated through *hogu* registry covered less than 50% throughout the entire period of the Kingdom.

But the completeness of the *hogu* population is known to differ greatly among regions. Several population figures are available for Seoul during the period 1640-1799. According to the figures, the population of Seoul changed little, having fluctuated around 200,000, during 1727-1799. On the other hand, the 1925 census reported it as 247,404 showing an annual growth rate of 0.019% during 1799-1925. Considering various population situations of the time, the *hogu* populations are judged to have more than 90% completeness during the 18th century in Seoul (Kwon T-H, Jun K-H & Ehn K-S, 1997: 77-87). Furthermore, it is apparent that the quality of population enumeration in the Chosun Kingdom was poorer in more remote provinces, particularly during the earlier period, when the data are compared with the 1925 census population distribution, though the regional *hogu* data are available only for a few selected years. These observations clearly suggest that the government power of control over the regions was detrimental to the quality of population enumeration in the Kingdom.

3. Reconstruction for 1392-1637

The population reconstruction based on population reports can easily be conducted if there is a series of population reports and the completeness of the reported populations is known or determined. As mentioned above, however, there are only a handful of reports on population available for the first half of the Chosun Kingdom. In addition, the quality of those data differs greatly between the periods in question. For example, the average number of household members obtained from *hogu* data is 2.05 for 1406, 3.43 for 1440, and 4.97 for 1519.[2] This observation indicates that there were serious omissions in population counts among reported households, at least in 1406 and 1440. It is also reasonable to assume that a serious omission of population count in the reported households accompanies a considerable underreporting of households and that the two types of errors are interrelated. This means that the coverage of *hogu* population can be determined if the reported household size is reasonably evaluated.

Concerning the *hogu* populations for the early period, Han Y-W (1977) attempted to evaluate the completeness of the reports based on the comparison of two sets of data with different sources for Hwanghae and Kangwon Province. For Hwanghae, *hogu* data of household and population are available for 1447, and the corresponding data from an *ad hoc* household and population enumeration, which was conducted in 1447 to plan distribution of relief grain to those affected by famine. The *hogu* report reveals that the province housed 25,511 households and 71,897 persons, while the *ad hoc* survey shows 62,637 households and 462,662 persons. If we assume that there was no change in population and the number of households in the two year period and that the *ad hoc* survey was complete in its coverage, the completeness of the *hogu* counts will be 41.4% for household and 15.5% for population. (If the same evaluation is applied to Haeju, the provincial center, the coverage of *hogu* population turns out to be 11.94%. If we assume that the *ad hoc* survey was more complete in Haeju

[2] It is apparent that there was a change in the concept of household from the composed household to the natural household between 1406 and 1440.

than the other part of the province, the coverage of *hogu* population can be regarded to have been less than 12%.)

A similar evaluation can be made for Kangwon. The population of the province was reported in the *hogu* registry as 29,009 in 1432. On the other hand, a special investigator who was in charge of population check for supplying relief grains in famine affected areas reported it as 121,499 in 1446. Provided that the latter is complete and that there was no change of population between the two years involved, the coverage of the former would be about 24%. But, the investigator's report appears to have been grossly underreported in view of the reported *hogu* populations for Kangwon in later years. Taking this into account, the 1432 *hogu* population for Kangwon would be less than 15% complete. In a word, the evaluation for Hwanghae is viewed as more acceptable.

An additional consideration is needed in order to apply the evaluation for Hwanghae to the whole country. It would be necessary to consider differences in the coverage of *hogu* population enumeration between provinces. In traditional societies where migration is very limited, there is little difference in population growth between regions. Taking this to be the case of Korea in the 15th through 17th century, we can consider the regional differences in population growth to indicate the different coverage of population enumeration for the regions in question. If we assume that the degree of population enumeration in the later year is the same between regions, the different rate of population growth would suggest the regional gap in the coverage for the earlier year. In Korea, it can be easily manifested that the relative coverage of *hogu* population differs only marginally in the later part of the Chosun Kingdom and that the regional gap was greater during the earlier period. In Hwanghae, the growth rates for 1440-1640 and for 1440-1717 are higher than the national rates by about 27%. Based on these observations, the completeness of the 1440 *hogu* popultion for the nation is determined as 12.25% and the actual population as 6,724,000.

The quality of *hogu* registration was improved substantially during the first half of the 16th century. The average household size was reported to be 4.97 both in 1519 and 1543, indicating sharp reductions in the omission of household members among registered households. With this limited

information, we have to determine the quality of *hogu* populations in the first half of the 16th century. For this, the reported average household size is adopted as an indicator for the coverage of *hogu* population. Then, it is assumed the relationship of the logarithm of the completeness (log y) of population enumeration with the reported average household size (x) is linear, as expressed below.

$$\log y_e = \log y_1 - (\log y_1 - \log y_2)\ \{(x_1 - x_2) / (x_1 - x_e)\}$$

where y_e stands for the completeness of the *hogu* population in question, y_1 and y_2 for the estimated completeness of the *hogu* populations 1 and 2, and x_1 and x_2 for the average household sizes of the populations 1 and 2. Here two sets of data are selected to determine the completeness of *hogu* populations for 1519 and 1543. The first set consists of the Hwanghae case discussed above. The average household size of 3.06 is taken to indicate the completeness of 15.54% in *hogu* population registration and the size of 7.39 the full enumeration coverage. The second set is arranged from the 1440 *hogu* data for the nation and the 1426 *hogu* data for Seoul. The average household sizes calculated from those data are 3.7 and 6.1, and these are accepted to represent the 12.25% and 100% completeness of *hogu* population enumeration. Applying these figures to the above formula, both the *hogu* populations for 1519 and 1543 are estimated to be 34.48% complete from the first set of assumptions and 37.17% complete from the second set. Then, the mean of 35.83% is taken as the final estimated coverage, and the population is reconstructed as 10,469,000 for 1519, 11.083,000 for 1531, and 11,633,000 for 1543.

When calculating from these estimates, the annual rate of population growth during 1440-1519 becomes 0.56% and the rate for 1519-1543 is 0.44%. Clearly, these rates are considerably higher than the average growth rate for the entire period of the Chosun Kingdom. But these are still regarded as reasonable in view of the fact that this period is known to have been economically prosperous and politically stable.

The next step is to make population projections for the years prior to 1440 and after 1543 until Japan invaded Korea in 1592 based on the above estimates. For this, a uniform rate of yearly population growth of 0.4% is

adopted for both cases, in view of less stability of the country in the earlier years and the deteriorating socioeconomic conditions in the later period. In this way, the population at the beginning of the Kingdom (1392) is estimated as 5,549,000, and that for 1591, just before the devastating invasion of Japan, as 14,095,000.

During the forty years between 1592 and 1637, Korea was invaded twice, once by Japan and the other by Mongolia, and the country was totally destroyed. After the Japanese invasion, there were a series of epidemics, famines and insurrections throughout the country for a prolonged period. Taking these situational factors into account, population is assumed here to have changed at the same tempo during the war years on the one hand and during the years between the two wars on the other.[3] For the latter, the experience of such troubled years in the later half of the Chosun Kingdom is borrowed, and it is assumed that population declined by 0.2% annually during 1598-1636. Then, the rate of population growth during the war years is simultaneously computed as –2.58%.

4. Reconstruction for 1638-1910

As mentioned earlier, the *hogu* data on population and household are available for the 222 years between 1639 and 1861 in an interval of three years in most cases. For the years after 1669, the reported household size is fairly stable indicating that a certain relationship can reasonably be assumed between the completeness of *hogu* population and the reported average household size of the population. But the same assumption is difficult to invasion. The omission in *hogu* counts appears to have been very extensive in these post war years, due primarily to the destruction of *hogu* records in many areas and voluminous flows of refugee movement during the war

[3] During the first 30 years of the 17th century, various disasters affecting population took place, such as an extremely poor harvest in Hamkyung province in 1601, the prevalence of epidemic diseases throughout the country in 1620, and a sequence of insurrections between 1624 and 1630.

years. According to the *hogu* reports, the number of households doubled during 1639-1669, whereas it increased during the next thirty years only by 18%. This clearly indicates a need for an adjustment in the number of reported households for the period 1639-1669 to obtain comparable coverage with that for the post 1669 years. Considering the possibility of family formation having been facilitated after the war, it is postulated that the actual number of households increased by 25% during 1639-1669. The adjusted number of households for this period is then calculated with an additional assumption of linear change, and the reported populations are inflated accordingly to obtain adjusted populations. These adjusted figures, instead of the reported *hogu* data, are used for the years between 1639 and 1669 to reconstruct the population trend. For the remaining period in the second half of the kingdom, population reconstruction is conducted based on the reported *hogu* data.

Now, the task confronting us is to establish the relationship of the average household size from *hogu* reports with the completeness of *hogu* population in the second half of the Kingdom. For this, we have examined two types of data. Firstly, a set of adjacent populations showing a considerable or unusual increase or decrease is selected, and the pattern of change in the average family size is examined in terms of population change. Secondly, age composition was obtained from the 1720 *hogu* register of Daehyun Myun, Ulsan to have an idea on the age pattern of omission and, through this, to obtain a set of data on the completeness of *hogu* population and the average household size.

It is observed from *hogu* data that unrealistic population changes accompany significant changes in the reported household size. For instance, population is reported to have increased by 7.2% annually during 1675-1678, and there occurred a change in the average household size from 3.78 to 4.41. On the contrary, a substantive population decline is reported for 1693-1699 (3.3% per year and 19% in the six year period), and it is accompanied by the reduction of household size from 4.55 to 4.33. Similar observations can be made in the 18th century and the early 19th century, though the range of change is much narrower. These observations confirm that the change of reported household size is greater than the accompanied change of *hogu*

population and support the assumption that the coverage of household enumeration affects positively the coverage of population count.

A very unlikely picture is noticed in the age structure derived from the 1720 Ulsan *hogu* register. Compared with that from the 1925 census, which is characterized as typically traditional, it shows a greatly higher proportion of the aged population and a lower proportion of the young population. The proportions of population at ages 40-59 and 60 or more in the Ulsan register are 31.2% and 19.2% respectively, whereas those from the 1925 census are 15.9% and 6.4%. This is known to be a general age pattern of *hogu* population, and the pattern is interpreted to indicate that the *hogu* population count was much more complete in older ages. If we assume that the enumeration of the aged 60 or more is complete in the 1720 Ulsan register, coverage of the whole reported population would be 32.82% with the average household size of 3.35. If we further consider that about 45% of households are evaluated to have been omitted in the register in this case, the actual coverage of the reported population would go down to 18%. It is also noticed that the enumeration of *hogu* population was nearly complete in Seoul with the household size of 6.0 in the early 18th century.

Based on the information mentioned above, an attempt is made to derive a series of correction factors for each reported *hogu* population. An exponential curve with the following equation is found to fit the data.

$$y = e^{1.830038 - 0.2105x}$$

where y stands for the correction factor (1/y for the completeness of a given *hogu* population) and x for the average size of registered households. By applying it to the adjusted populations for the period 1639 through 1666 and to the reported *hogu* populations for 1669-1861, a new set of preliminary population estimates is obtained. Then the estimates are smoothed as follows.

$$P'_x = (P_{x-3} + 2P_x + P_{x+3}) / 4$$

where P' stands for the smoothed population, P for the estimated population, and x for the year involoved. When the estimates for x-3 or x+3 are not available, interpolation is used to obtain P'. The populations for 1900 and

1910 are projected backward from the 1925 census. The result are presented in Table 1.

5. Discussion of the Results

In order to explore the sound socioeconomic explanations of various historical events in the Chosun Kingdom, the need for population reconstruction is pressing. But such an endeavor was often discouraged because of the paucity of reliable population statistics or indirect materials that enable us to make sound judgement on the general population trends. In other words, the reconstruction of population phenomena involves wild guesses based on a handful of scattered materials with very poor quality, and, accordingly, is vulnerable to defenseless criticisms. For this very reason, discussion on population for Chosun Korea is very limited. This study is no exception. Still, it may be of some value to reveal the major characteristics of our estimates in the hope that it would help the readers make their own evaluation.

One simple way to get a rough idea on the reliability of a given set of population projection is to compare it with other projections. But even such an opportunity is very limited for our estimates. Han Y-W (1977) estimated the national population in the Chosun Kingdom for the period prior to 1600. The work is, however, limited only for a few selected years, and our projection for those years relies on his evaluation of data quality. The only difference between the two is that we have considered an additional factor, regional differential in the coverage of *hogu* population, in the earlier period. In any event, Han estimated the population at the beginning of the kingdom as 4,450,000, about 20% less than the current one. For the 16th century years, the gap increases up to 32%.

For the later Chosun period, there is no other comprehensive effort to reconstruct the population trends based on the evaluation of *hogu* data. Kim D-S (1990) estimated the total population for 1789 in an effort to examine the patterns of urbanization at that time. He reached a conclusion that the national population for 1789 would be 17,977,000 if the quality of *hogu*

Table 1: *Hogu* data, estimated populations and growth rates, and attendance of traditional factors in population change

Year	*Hogu* Household	*Hogu* Population	Average H-Hold size	Note (a)	Population Estimate In 1000	Annual Growth rate (%)	Note (b)
1392					5,549		
1393		301,300		(1)			
1404	153,404	322,786	2.10	(2)			
1406	180,246	370,365	2.05	(3)			
1423	196,975						
1426	16,921	103,328	6.11	(4)			
1440	201,853	692,475	3.43	(5)	6,724	0.40	
1445	217,000			(6)			
1519	754,146	3,745,481	4.97		10,469	0.56	
1531		3,965,253			11,083	0.47	
1543	836,669	4,162,021	4.97		11,633	0.40	
1591					14,095	0.40	
1598					11,769	-2.58	C
1636					10,908	-0.20	
1637					10.603	-2.58	C
1639	441,827	1,521,165	3.44		10,665	0.29	
1642	481,660	1,649,012	3.42		10.764	0.31	
1645	505,911	1,738,888	3.44		10,836	0.22	
1648	533,720	1,793,701	3.36		10,860	0.07	
1651	580,539	1,860,484	3.20		10,904	0.13	
1654	628,603	2,047,261	3.26		11,037	0.40	
1657	668,737	2,201,098	3.29		11,226	0.57	
1660	758,714	2,479,658	3.27		11,488	0.77	E
1663	809,365	2,851,192	3.52		12,017	1.50	BE
1666	1,108,351	4,107,156	3.71		12,830	2.18	E
1669	1,313,652	5,018,744	3.82		13,192	0.93	B

(Table 1 continued.)

Year	*Hogu* Household	*Hogu* Population	Average H-Hold size	Note (a)	Population Estimate In 1000	Annual Growth rate (%)	Note (b)
1750	1,783,044	7,328,867	4.11		18,657	0.20	B
1753	1,772,749	7,288,627	4.11		18,656	-0.00	B
1756	1,771,350	7,318,359	4.13		18,413	.-0.44	D
1759	1,690,715	6,968,856	4.12		17,897	-0.95	
1762	1,691,040,	6,981,598	4.13		17,741	-0.29	A
1765	1,675,267	6,974,642	4.16		17,682	-0.11	
1768	1,679,865	7,006,248	4.17		17,693	0.02	
1771	1,689,046.	7,016,370	4.15		17,789	0.18	B
1774	1,703,030	7,098,441	4.17		17,927	0.26	
1777	1,715,371	7,238,523	4.22		18,041	0.21	
1780	1,714,550	7,228,076	4.22		18,126	0.16	
1783	1,733,757	7,316,924	4.22		18,242	0.21	
1786	1,740,592	7,330,965	4.21		18,361	0.22	
1789	1,752,837	7,403,606	4.22		18,296	-0.11	
1792	1,689,596	7,438,185	4.40		18,083	-0.39	
1799	1,741,184	7,412,686	4.25		18,389	0.24	A
1801	1,757,973,	7,513,792	4.27		18,497	0.29	
1807	1,764,801	7,561,403	4.28		18,619	0.11	D
1811	1,761,887	7,583,046	4.30		18,305	-0.43	AC
1814	1,637,108	7,003,167	4.28		17,321	-1.84	ACD
1816	1,555,998	6,595,368	4.24		16,728	-1.74	AC
1820	1,533,515	6,512,349	4.25		16,217	-0.78	D
1823	1,534,238	6,470,570	4.27		16,216	-0.00	ABD
1826	1,549,653	6,558,784	4.23		16,337	0.25	D
1829	1,563,216	6,644,482	4.25		16,456	0.24	D
1832	1,565,060	6,610,878	4.22		16,516	0.12	D
1835	1,572,454	6,615,407	4.21		16.489	-0.05	B
1837	1,551,951	6,708,572	4.32		16,479	-0.03	BD
1840	1,560,774	6,617,997	4.24		16,503	0.05	AD

(Table 1 continued.)

Year	*Hogu* Household	*Hogu* Population	Average H-Hold size	Note (a)	Population Estimate In 1000	Annual Growth rate (%)	Note (b)
1669	1,313,652	5,018,744	3.82		13,192	0.93	B
1672	1,205,866	4,720,815	3.91		12,935	-0.66	A
1675	1,250,298	4,725,704	3.78		13,145	0.54	A
1678	1,332,446	5,872,217	4.41		13,937	1.95	E
1681	1,376,842	6,218,342	4.52		14,651	1.68	
1684	1,444,377	6,573,107	4.55		15,201	1.23	
1687	1,468,537	6,769,723	4.61		15,633	0.94	
1690	1,514,000	6,952,907	4.59		16,026	0.83	
1693	1,547,237	7,045,115	4.55		16,030	0.01	
1696	1,296,569	5,626,968	4.34	(7)			
1699	1,333,330	5,774,739	4.33		14,411	-1.77	AB
1702	1,342,486	5,922,510	4.41		14,255	-0.36	
1705	1,370,313	6,062,953	4.42		14,528	0.63	
1708	1,406,610	6,206,554	4.41		14,948	0.95	B
1711	1,466,245	6,394.028	4.36		15,457	1.12	
1714	1,504,483	6,662,175	4.43		15,961	1.07	
1717	1,557,709	6,839,771	4.39		16,347	0.80	
1721	1,559,488	6,799,097	4.36		16,534	0.38	
1723	1,575,966	6,865,404	4.36		16,722	0.57	
1726	1,614,598	6,955,400	4.31		17,089	0.72	
1729	1,663,245	7,131,553	4.29		17,567	0.92	
1732	1,713,849	7,273,446	4.24		17,698	0.25	
1735	1,618,172	6,979,798	4.31		17,465	-0.44	A
1738	1,672,184	7,096,565	4.24		17,535	0.13	A
1741	1,685,884	7,192,848	4.27		17,904	0.69	E
1744	1,749,612	7,209,213	4.12		18,275	0.68	B
1747	1,759,692	7,340,318	4.17		18,544	0.49	

(Table 1 continued.)

1843	1,582,313	6,719,648	4.23		16,632	0.26	B
1846	1,581,594	6,746,862	4.26		16,549	-0.17	D
1850	1,529,356	6,470,730	4.23		16,476	-0.11	D
1852	1,588,875	6,810,206	4.29		16,549	0.22	A
1856	1,597,343	6,828,907	4.29		16,856	0.46	AD
1859	1,600,434	6,869,102	4.29		16,839	-0.03	
1861	1,589,038	6,748,138	4.25		16,762	-0.23	B
1900					17082	0.05	
1910		13,129,000		(8)	17,427	0.20	

Note (a): (1) Two northern provinces bounded with China excluded.
(2) Seoul and Kyunggi Province omitted.
(3) Seoul omitted.
(4) For Seoul only.
(5) Seoul and Kaesung omitted.
(6) Seoul omitted.
(7) Pyungan and Hamkyung provinces omitted.
(8) First Registration figure by the colonial government of Japan.

Note (b): Traditional factors known to affect population are listed for the period 1636-1861.
A refers to famine, B to epidemics, C to war or insurrection,
D to miscellaneous miseries, and E to institutional improvement.

Sources: Han Y-W, 1977; Chun K-W, 1961: Chronological Table; Jindan Hakhae, 1973: Chronological Table.

population is checked based on the age structure of Seoul and 17,202,000 when data for Taegu city are used. The method and data used for deriving correction factors differ from ours, but the results are very close to each other. Our current estimate is two to six percent greater than Kim's. This may be taken to indicate that the quality of population estimates is more questionable for the earlier period than the later years for which population related information including *hogu* data is much more abundant.

According to our estimation, the coverage of *hogu* population had been in a range between 40% to 50% between 1669 through 1861.This should not be taken to suggest that the actual population trends during this period are difficult, if not impossible, to be approximated by any means. It is, however, still possible to assemble a reasonable picture of population change either from our estimates or from the original *hogu* reports, if errors involved in various *hogu* reports are systematic. It was discussed that the pattern of omissions in *hogu* reporting had been consistent and the average household size from *hogu* data is fairly stable throughout the period. This is interpreted to indicate that both the original *hogu* populations and our current estimates can be used to have a sensible idea on the population situation during the later half of the kingdom, although the *hogu* populations do not reflect real population situations.

Traditional populations are known to be sensitive to Malthusian checks such as famine, epidemics, warfare, and various kinds of social instability. If this idea is accepted, we may evaluate the overall quality of our estimates by looking at how the population trends respond to those Malthusian factors. Attendance of these factors in a given period is listed in the last column of Table 1, and the relationship between these factors and the projected population growth is examined through a multiple regression analysis as shown in Table 3. Table 2 presents simple correlation coefficients between the variables adopted for multiple regression.

It is apparent from Table 2 and Table 3 that among four types of factors, that is, famine, epidemics, wars and insurrections, and others, three factors other than epidemics correspond closely to population change. Their relationships are negative. On the other hand no significant association is found between the Malthusian factors. The four factors explain about 50% of the variations in reconstructed population change. The lack of relationship between epidemics and population change can be explained by the fact that most children, highly vulnerable to epidemics, were omitted in *hogu* population count.[4] In other words, the effect of epidemics would have

[4] According to various population compilations for selected small areas from the *hogu* register, the proportion of *hogu* population at ages 0-4 is about 3-4% only, while that from the 1925 cnesus is 16%. (Ehn K-S, 1987; Lee H-T, 1990)

Table 2: Simple correlation coefficients between the rate of population growth, famine, epidemics, warfare and other factors during 1636-1861

	Famine	Epidemics	Warfare	Others
Pop. Growth	-.476	-.081	-.427	-.434
Famine		.101	.179	.131
Epidemics			-.103	-.042
Warfare				.041

Table 3: Multiple regression of the rate of population growth, 936-1861

Variable	B	Beta	T	Sig T
Famine	-.527100	-.352134	-3.885	.0002
Epidemics	-.149786	-.098332	-1.105	.2732
Warfare	-.842510	-.358413	-3.988	.0002
Others	-.552409	-.376884	-4.252	.0001
(Constant)	.504257		6.618	.0000
Multiple R	.70139			
R Squared	.46195			
Adjusted R Squared	.46116	F =	15.97729	
Standard Error	.53176	Sig F =	.0000	

been delayed for a long period before becoming evident in *hogu* reporting. The analysis clearly confirms that the population of traditional Korea had been subject to Malthusian effects. This may be taken, in turn, as partial evidence that our population estimates for the later Chosun period would be accepted as highly reasonable.

The importance of a Malthusian dilemma in explaining the population trends in Chosun Korea can be suggested still another way. According to

Malthus, population increases for a prolonged period result in instability and miseries to the society. The idea is confirmed by our current estimates, too. For example, population increase continued during most of the 15th and the 16th century owing to social stability and technological improvement. But in the late 16th century when population pressure was built up to a saturation point in consideration of technology, environment and organizational capacity, various types of miseries and social unrest began to take place. Famines and severe food shortages were reported very often. It is also interesting to note that Japan and Mongolia invaded the Chosun Kingdom after the population reached the first peak. A similar picture is seen in the later half of the kingdom. The population of the kingdom was reduced significantly during the war period 1590-1640. Following that, a sustained growth had been revealed until the population reached the second peak in mid 18th century. The population was estimated as 18,656,000 for 1750, which is larger by 4,500,000 than that at the first peak, owing to greatly enhanced technological and organizational capacity for food production and disease control. During the next fifty years, population declined by about 5% and returned near the peak point in 1807. Then, an overall trend of population decline is noticed during 1807-1861, which witnessed a series of starvation due to flood, famine, epidemics, and insurrections. The social unrest having prevailed in the 19th century resulted in the Donghak Peasant Revolution in 1894 and finally the takeover of the country by Japan in 1910. These observations are enough, though cursory, to suggest that the Malthusian process dominated the population phenomena in traditional Korea.

6. Concluding Remarks

In this paper, we have attempted to introduce a set of population estimates for the entire period of Chosun Korea and to discuss their demographic and social implications. The basic data utilized for this work are a series of *hogu* reports on population and household compiled from various historical documents. The prime task for this population

reconstruction was to determine the quality of those data. But a uniform data evaluation is not plausible because the amount of data available and the concept of *hogu* differ greatly between the earlier period and the later years. So, separate quality evaluations were conducted depending upon the types and availability of data used. Various assumptions should be involved in data evaluation, and accordingly the reliability of population estimates depends on the validity of the assumptions.

In this study, assumptions were made based on intuitions rather than grounded materials. It is an irony that we have to use the final outcome to validate the assumptions adopted to obtain the result. More extensive data evaluations and better assumptions will certainly be possible with the accumulation of research on the historical demography or population history of Korea. One important task in this regard would be a thorough analysis of the original *hogu* records available. This would be possible only after tremendous time, energy and money are invested to transfer the records into a computer data base. Genealogy books of various kin groups are abound in Korea and often cited as an important, but unexplored, source of data for the historical demography and family studies in the 18th through 19th centuries. But the use of these data should encounter the same kind of data transformation problem. It is not surprising to note that there is no single demographic or family study based on genealogy records in Korea.

Most historical studies in Korea have neglected population in explaining societal conditions of a given time. But this study clearly reveals that population change is a crucial ingredient of historical process. This, in turn, suggests that extensive knowledge on societal conditions would contribute greatly to understanding population change at that time. Anyway, the more reasonable population reconstruction is very likely with some additional work. This current study may be valued as a grounding work for such endeavors in the future.

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The Instrumental Precipitation Records During the Last 220 Years in Seoul, Korea

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Abstract: Statistical characteristics of precipitation in Seoul have been examined by using long-term observational data. Precipitation records from modern rain gauges were used for 1908-1999, together with the traditional Korean rain gauge (Chugugi) precipitations for 1777-1907.

Keywords: ARIMA Model, Intervention Model, Precipitation Records, Rain Gauge, Time Series, Trend Analysis, Wavelet Analysis.

1. Chugugi

The Korean government has been measuring quantitative precipitation for a long period of time. In fact King Sejong, who was the fourth king of the Chosun Dynasty (1392-1910), invented *Chugugi*, the first rain gauge in the world in 1441 (Annals of King Sejong). The Korean people have relied

heavily on agriculture, and crop yields depended on precipitation amount received during the growing season. Such an impact of precipitation amount on agriculture might have been much more serious due to the improper irrigation system. The social environment at the beginning period of the Chosun Dynasty may have been related to the invention of the scientific rain gauge. *Chugugi*, made of iron and stone, remarkably resembles modern rain gauges in shape and size (Kim, 1988) as shown in Figure 1. The height, diameter, and thickness of Chugugi are 30cm, 14-15cm, and 0.25cm, respectively. It is known that there was no change in shape (cylinder) and

Figure 1. Chugugi

size over the years of 1770-1907. During the Chosun Dynasty, a network of Chugugi had been maintained in 8-9 places (including Daegu and Seoul) and the records were kept in the King's diary (Kim, 1988). The diary has been located in the King's palace in Seoul. The rank of the officers (Figure 2) who were responsible for measuring and recording precipitation was third in the Ministry. Only the records in Seoul are found from currently available books. Korea has been keeping one of the world's longest time series of quantitative precipitation amounts measured by scientific rain gauges dating back to 1770.

Figure 2. The officers measuring precipitation in Chugugi

In Korea, modern rain gauges were introduced in 1907. Since then, the modern gauges have been used for measuring the amount of precipitation. Recent analysis (Lim and Jung, 1992; Cho et al., 1996; Jung et al., 2001) suggested that there is a clearly discernable sudden increase of precipitation days around the year 1907, which resulted from the change of measuring unit from the traditional Korean rain gauge to modern ones (see Figure 9 in Section 2.3). In contrast to the change in the number of precipitation days, it seems that there is no significant change in the annual precipitation amount (see Figure 3). The impact on the precipitation amount by the change of instrument and measuring unit will be studied in the following sections.

We constructed datasets of pseudo-hourly and annual precipitation amounts based on the precipitation records recovered by both of Cho and. Na (1979) for 1777-1800 and Lim et al. (1996) for 1801-1907. The precipitation records by the traditional Korean rain gauge in Seoul were recovered for the time intervals of a few hours or a half-day. The term

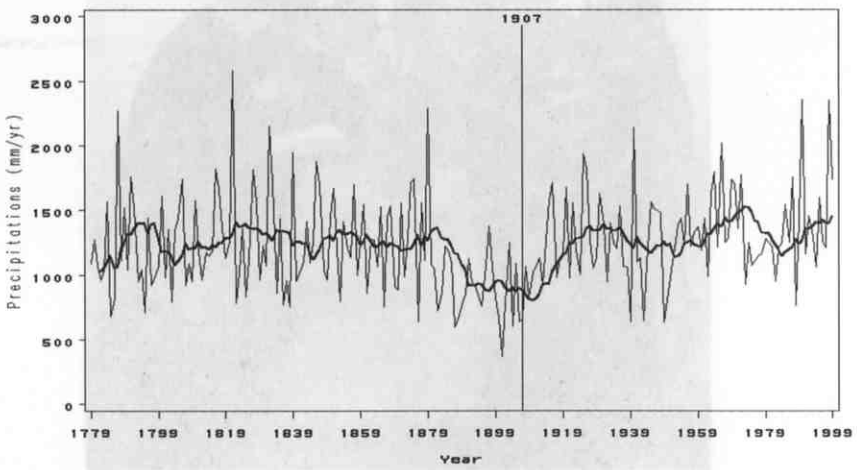

Figure 3. Time series plot of annual precipitation at Seoul from 1777 to 1999 with 11-year moving averages

pseudo-hourly amount means that the traditional Korean rain gauge measured precipitation amounts not every hour, but measured the total accumulated amount for individual precipitation events together with the starting and ending times of days (i.e., duration), if precipitation events occurred. A lunar calendar with 2-hour increments in which zodiac symbols are used to note the time of a day was used in the Chosun Dynasty (1392-1910). Therefore, we calculated the pseudo-hourly precipitation amount assuming that rainfall intensity is uniform during the corresponding event. We did not modify or correct the Chugugi data except for unit conversions.

The precipitation amount by the traditional Korean rain gauge was recorded with the Korean foot-rule such as *Pun, Chi* and *Cha*, which approximately correspond to 2 mm, 20 mm and 200 mm, respectively. For example, 1 *Pun* or more of precipitation was measured with the minimum resolution of *Pun* and the event with precipitation amount less than 2 mm was not measured. This sounds more like a "truncation" problem. To compare the characteristics of the diurnal cycle during the later part of the Chosun Dynasty with those of modern characteristics, therefore, we converted the original traditional Korean rain gauge records to those of modern ones with accuracy to one hundredth of a millimeter. No matter how many digits we keep in the conversion, the accuracy still remains at one *Pun*. The events like snowfall and hail are not measured.

The earlier part of the data for 131 years (1777-1907) in this study were derived from the pseudo-hourly precipitation record in the *Seungjungwon-ilgee* (Figure 4) which is the official diary of the Chosun Dynasty. Unfortunately, observations before 1770 are not recorded in any of the currently available books. Part of a record is also found in the *Ilsong-rok*, but the record is very similar to that of the *Seungjungwon-ilgee*. The later part of the record for 92 years (1908-1999) was obtained from the Korea Meteorological Administration. Missing values during the Korean War (1950-52) were not included. Missing values were interpolated where necessary. A time series plot of these data (annual precipitation) is given in Figure 3.

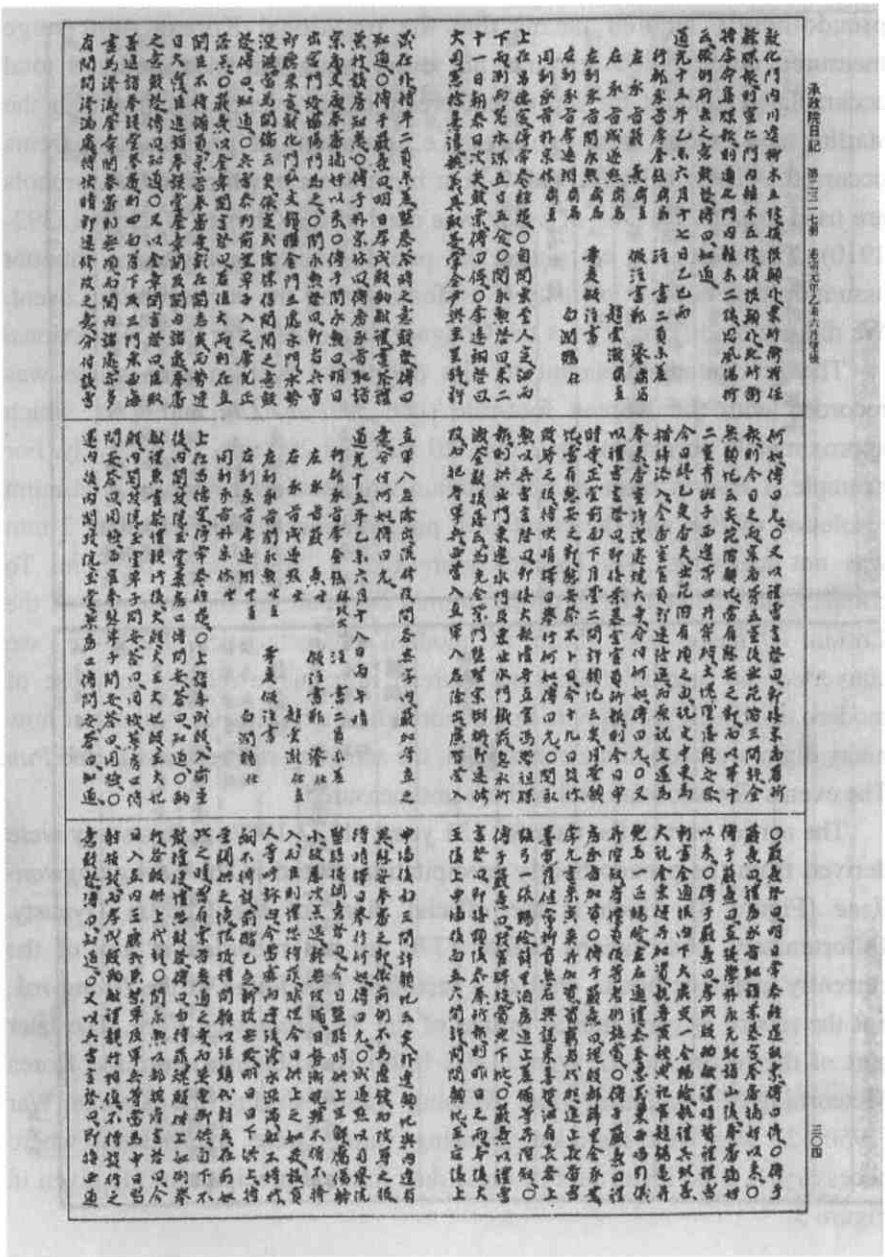

Figure 4. A sample page of Seungjungwon-ilgee

In 1917, Wada, a Japanese meteorologist who had worked as a directr of the Incheon meteorological observation station during the early 1900's, published monthly precipitation data of Chugugi. He converted Chugugi records to millimeters based on several historic books including *Seungjungwon-ilgee* and *Ilsong-rok* (some of the books he had used are not available today). In addition to the unit conversions, he corrected the Chugugi data by comparing precipitation amounts of the years which were measured simultaneously by both of Chugugi and the modern gauge. He published yearly precipitation amounts based on his correction. However he did not describe the correction method precisely. Recent analysis (Lim and Jung, 1992; Cho et al., 1996) suggests that Wada's correction is inconsistent (see Section 2.3).

2. Statistical Analysis

2.1 Trend analysis for Chugugi time series

Recent concern about the possibility of climatic change has focused attention on climatic time series such as temperature and precipitation. A key question raised by these data is whether the temperature (or precipitation) rise is the start of a systematic change or simply an effect of natural variability. Here some statistical methods for detecting climate change, or any trend over years are applied to Chugugi time series. Actually, testing a hypothesis about a correlation coefficient, a regression method for testing the deterministic trend, and Brillinger's nonparametric method are used.

For this purpose, time series of two months moving averages are constructed from 1771 to 1999. However, since snowfall was not measured by Chugugi, only the eight time series of two months (MA, AM, MJ, ..., SO, ON) are used for trend analysis. We applied the above methods to each of eight time series, respectively.

Now, the above methods are briefly reviewed here. First consider the following linear model:

$$Y_t = a + bt + E_t \tag{2.1}$$

where Y_t is the observation at time t, and E_t stands for the unexplained part by the linear model which is assumed to be a stationary process with mean zero. When the null hypothesis $H_0: b = 0$ is rejected, we can say that there is a deterministic trend in the time series $\{Y_t\}$. Here t stands for the year of observation.

For testing the trend in the model (2.1), the test statistic

$$T = \hat{b} / SE(\hat{b}) \tag{2.2}$$

is usually used. This test statistic varies according to the methods of obtaining $\hat{b}$ and $SE(\hat{b})$. If E_t is independent with respect to t, then (2.2) is the statistic for testing a regression coefficient in a simple linear regression model. If E_t is dependent (e.g., AR(p) process), then the appropriate estimate of $SE(\hat{b})$ should be used (Bloomfield and Nychka, 1992). Actually the Chugugi data (all 8 time series) turn out to be independent series by the generalized Durbin-Watson(DW) test. We used the Autoreg procedure of SAS/ETS for the DW test.

Based upon independence, the null hypothesis $H_0: \rho = 0$ was tested for existence of a trend using Spearman's correlation coefficient between time t and observation Y_t.

Brillinger (1989) proposed a nonparametric procedure for testing the monotonocity of the mean value μ_t. Brillinger's test statistic is

$$T_{Br} = \sum_{t=1}^{n} c_t Y_t \Big/ \left[\sum_{t=1}^{n} c_t^2 \, Var(Y_t) \right]^{1/2}$$

which has asymptotically a standard normal distribution under the null hypothesis $H_0: \mu_t = \mu$, where c_t is the Abelson and Tukey's (1963) coefficient

$$c_t = [(t-1)(1-\frac{t-1}{n})]^{1/2} - [t(1-\frac{t}{n})]^{1/2}.$$

When a trend is detected for data, the increment is to be estimated by using the moving average

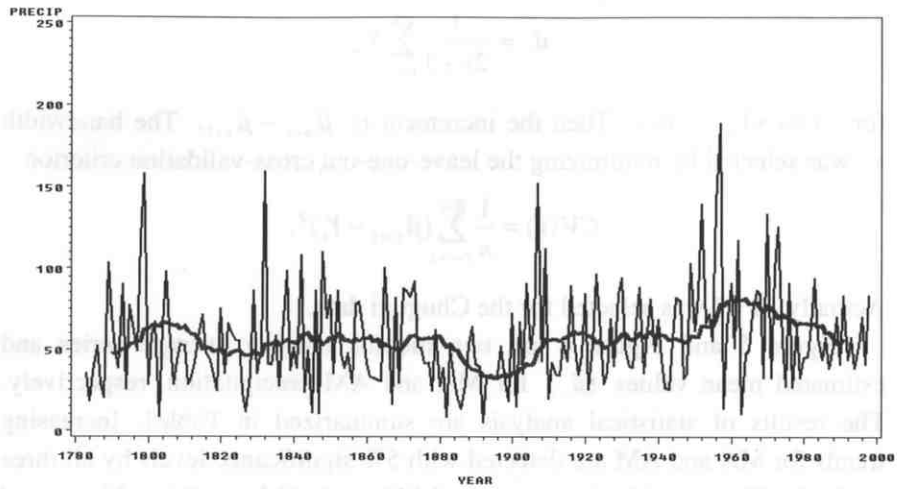

Figure 5. Two months moving average series and estimated mean value $(\hat{\mu}_t)$ for March and April precipitation.

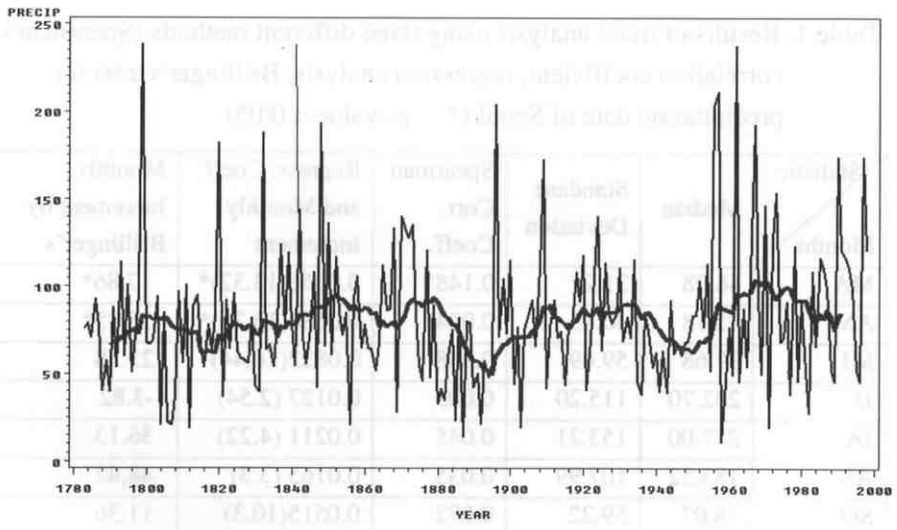

Figure 6. Same as Figure 5, but for April and May.

$$\hat{\mu}_t = \frac{1}{2v+1}\sum_{s=-v}^{v} Y_{t+s}$$

for $t=v+1, \ldots, n-v$. Then the increment is $\hat{\mu}_{n-v} - \hat{\mu}_{v+1}$. The bandwidth v was selected by minimizing the leave-one-out cross-validation criterion

$$CV(v) = \frac{1}{n}\sum_{t=v+1}^{n-v} (\hat{\mu}_{(-t)} - Y_t)^2.$$

Actually, $v=7$ was selected for the Chugugi data.

Figure 5 and Figure 6 are two months moving average series and estimated mean values $(\hat{\mu}_t)$ for MA and AM precipitation, respectively. The results of statistical analysis are summarized in Table1. Increasing trends for MA and AM are detected with 5% significance levels by all three methods. The monthly increments of MA and AM are 8mm-13mm and 14mm-16mm, respectively. However we do not claim these increments over 220 years are climatologically significant.

Table 1. Results of trend analysis using three different methods (Spearman's correlation coefficient, regression analysis, Brillinger's test) for precipitation data of Seoul (* : p -value < 0.05).

Statistic / Months	Median	Standard Deviation	Spearman Corr. Coeff.	Regress. Coeff. and Monthly Increment	Monthly Increment by Brillinger's
MA	48.98	31.21	0.148*	0.0666(13.32)*	7.86*
AM	72.18	40.45	0.094*	0.0688(13.76)*	15.85*
MJ	97.68	59.49	0.068	0.0822(16.44)	23.38
JJ	232.70	115.20	0.005	0.0127 (2.54)	-3.82
JA	277.00	153.21	0.045	0.0211 (4.22)	36.13
AS	183.52	107.99	0.035	0.0165 (3.3)	48.42
SO	78.07	59.22	0.072	0.0515(10.3)	11.36
ON	39.94	25.49	0.410	0.0278(5.56)	10.34

2.2 Wavelet analysis for Chugugi time series

Recently, a wavelet transformation method with statistical analysis has been used in many fields of applications including signal processing, image analysis, and data compression. It has been also applied to data analysis in the atmospheric sciences (Baliunas, et.al., 1997; Torrence and Compo, 1998). A wavelet transform is a common and powerful tool for analyzing the localized variations of power within a time series. By decomposing a time series into time-frequency space, one is able to determine both the dominant modes of variability and how those modes vary in time. In this section we give characteristics of precipitation in Seoul using wavelet analysis.

Wavelet analysis is based on the convolution of $f(t)$ with a set of elementary functions $\Psi_{b,a}(t)$ called 'daughter wavelets' or 'wavelets', derived from the translations and dilations of a mother wavelet $\Psi(t)$

$$\Psi_{b,a}(t) = \frac{1}{\sqrt{a}}\Psi\left(\frac{t-b}{a}\right) \quad , \tag{2.3}$$

where a (>0, real) is a scale parameter and b (real) is a location parameter. An energy normalization factor $1/\sqrt{a}$ in (2.3) keeps the energy of daughter wavelets the same as the energy of the mother wavelet (Weng and Lau, 1994).

To be a mother wavelet both formally and practically, $\Psi(t)$ must have the following properties: i) It must be a function centered at zero and in the limit as $|t| \to \infty$, $\Psi(t) \to 0$ rapidly, and ii) It must have finite energy and a zero mean (Meyers et al., 1993). The wavelet transform of a real signal $f(t)$ with respect to mother wavelet $\Psi(t)$ may be defined as

$$W(b,a) = \frac{1}{\sqrt{a}}\int \Psi^*\left(\frac{t-b}{a}\right) f(t)dt \quad .$$

A wavelet transform analysis was performed for Chugugi data to figure out the multiple timescale variability of precipitation. One of the most widely used continuous wavelets in geophysics is the complex Morlet wavelet, which consists of a plane wave modified by a Gaussian envelope. The Morlet wavelet we use in this study has the form

$$\Psi(t) = e^{-i2\pi t} \exp\left[-\left(\frac{2\pi}{K_\varphi}\right)^2 |t|^2 / 2\right] , \qquad (2.4)$$

where K_φ is a constant that defines the width of the Gaussian envelope of the mother wavelet. The Morlet wavelet is admissible only for values of $|K_\varphi|$ that approximately are equal to or larger than 6 (Farge, 1992).

Figure 7 shows the scalogram (Ogden, 1997) of wavelet transformation for precipitation amount in Seoul using (2.4). This scalogram is a useful plot for indicating how the frequency content of the function is changing over time. See Ogden (1997, Sec. 5.1) for details of plotting and interpretation. Our results (Figure 7) are obtained using the algorithm and Fortran program of Gu and Philander (1995), and using GrADS (Grid Analysis and Display System; available at http://grads.iges.org/grads/).

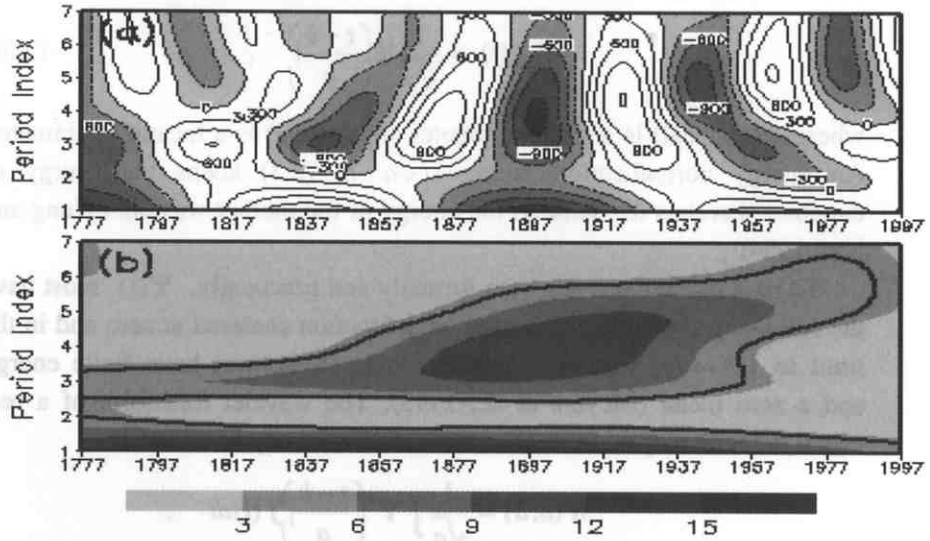

Figure 7. Scalogram of wavelet transformation of Chugugi data using Morlet wavelet. (a) The real part of Morlet wavelet transform, and (b) normalized local wavelet spectrum. The periodicity index 1, 2,$\cdots$, 7 refers to periodicities equal to 120yr, 60yr, 48yr, 34yr, 30yr, respectively.

The results of wavelet transform of precipitation amount indicate the dominant 50-60 year oscillation during the dry period. In the case of the inter-decadal variations with periodicities longer than 20 years, the energy power maximum region shifts toward the shorter periodicities after the mid-1770s in the time and frequency analyses. The 20-30 day oscillation has a notable spectral peak. It seems to suggest the pass of typhoon and intensive cyclones (Figures not shown). Also the spectral peaks with periodicities from 3 to 8 days mostly resulting from the synoptic-scale transients are dominant when 20-30 day oscillation is strong (Figures not shown, see Jung (1999) for details).

2.3 Analysis using the intervention model

To determine whether it is necessary to recover the time series of annual precipitation amounts of Korean rain gauge, we analyzed the Chugugi data and Wada's converted data using the intervention model.

One of the issues related to the precipitation amounts is the discontinuity in the time series around 1907 when the modern rain gauge was first used in Korea. To solve this discontinuity problem Wada (1917) reproduced the Chugugi data but many authors questioned the validity of Wada's method. In this section we analyze the annual precipitation amounts in Seoul from 1777-1999 using the intervention model and show that Wada's method results in the overestimation of the annual precipitation amounts. Also we show whether there exist any discontinuities in the precipitation amounts due to the change in the measurement gauges and the methods.

For the analysis we use four time series. The four time series are the annual precipitation data observed by Chugugi at King's palaces in Seoul (1777-1907), the annual number of rainy days (1777-1907), the Wada data, and the annual precipitation data and the annual number of rainy days observed by the modern rain gauge (1908-1999).

The time series of the annual amounts of precipitation (1777-1907) of Chugugi and Wada together with the times series of the modern gauge (1908-1999) are displayed in Figure 8, in which the missing data in 1822, 1833, 1880 and 1950-1952 are estimated by a linear interpolation method.

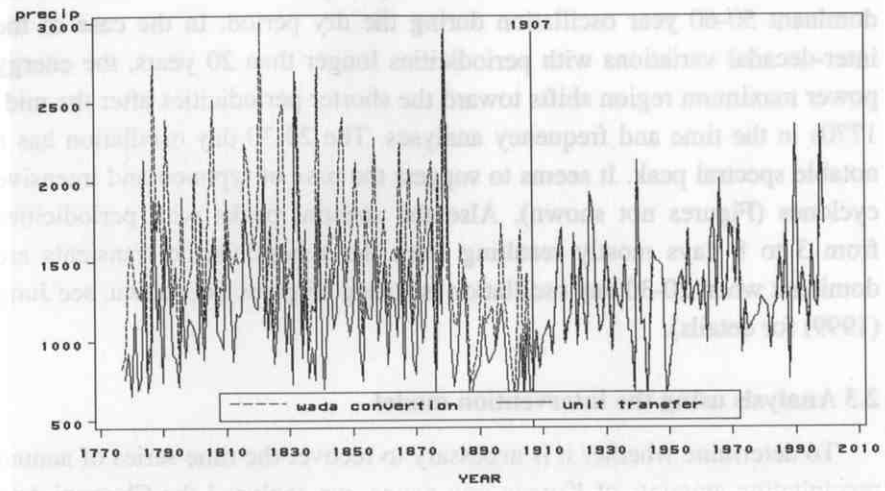

Figure 8. Time series plot of the annual precipitation data

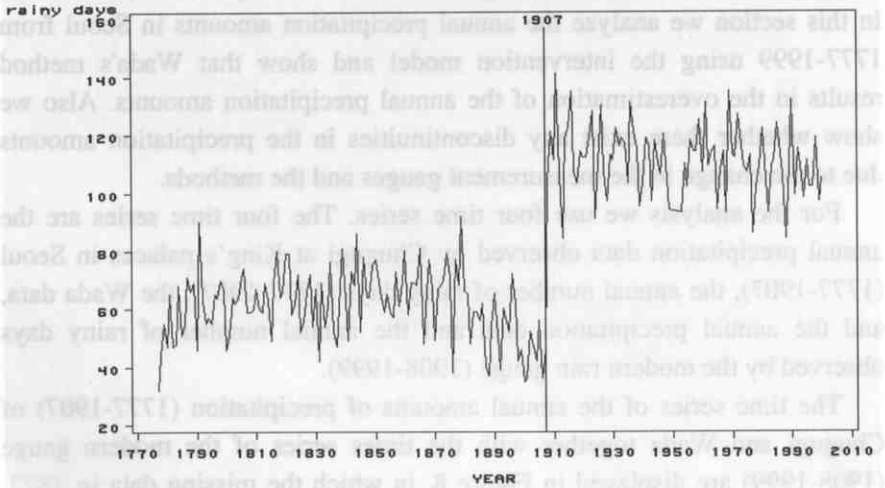

Figure 9. Time series plot of the annual rainy days.

As we can see from Figure 8 the Wada data exceed the Chugugi data for the period 1777-1907. Also from Table 2 we observe that the annual average precipitation for the period 1908-1999 when the modern rain gauge is used is larger than that of the Chugugi data by 173.8mm while that of the Wada data is larger by 208.1mm. This may indicate a possibility of the discontinuity.

Figure 9, which displays the annual rainy day time series, clearly shows the discontinuity. For the time series observed by the modern rain gauge, the day when the recorded precipitation is 0.0mm is excluded. We can see that the annual rainy days for the Chugugi period (1777-1907) are much less than those for the modern gauge period (1908-1999) by almost 50 days, see Table 3. These differences between two periods arise since the snowfall and hail are not measured for the Chugugi period.

In Table 2 we summarize the ARIMA models together with the mean and the standard deviations for each period. Unconverted and converted data are Chugugi and Wada data appended by the modern gauge data, respectively.

To identify if there is any discontinuity in the precipitation time series we fit the ARIMA model to Chugugi data (model 1), Wada data (model 2), and the modern gauge data (model 3) separately. As we can see from Table 2, model 3 is different from models 1 and 2, while model 1 and 2 differ from each other only at the levels. This implies that there is a discontinuity problem due to the change of measurement gauge and method. The fact that the level of model 2 is about 381.9mm higher than that of model 1 implies that Wada's correction overestimates the annual precipitation data. When we fit the ARIMA model to the combined data (model 4 and 5) we cannot see the differences in the ARIMA order of the model except the parameter estimates. In particular, the parameter estimates of each model are not much different from each other except the level. The difference in the level between models 4 and 5, 219.4mm, is much smaller than the difference between models 1 and 2, 381.9mm. These observations imply that there might be a discontinuity problem between the Chugugi data and the modern gauge data due to the change in the measuring method and gauge. Therefore, we have to be careful in using the combined precipitation data without any

Table 2. ARIMA model and statistics for each period

Period	Model	Mean	Standard Deviation
Chugugi data (1777-1907)	Model 1 $(1-0.3421B^{11})(Z_t-1135.2)=a_t$	1135.2	419.38
Wada data (1777-1907)	Model 2 $(1-0.2571B^{11})(Z_t-1517.1)=a_t$	1517.1	476.46
Modern Gauge data (1908-1999)	Model 3 $Z_t-1309.0=a_t$	1309.0	341.36
Unconverted data (1777-1999)	Model 4 $(1-0.2103B^5-0.1638B^6)(1-0.2395B^{11})$ $\times(Z_t-1219.9)=a_t$	1219.9	380.73
Converted data (1777-1999)	Model 5 $(1-0.1723B^5-0.1356B^6)(1-0.2343B^{11})$ $\times(Z_t-1439.3)=a_t$	1439.3	421.57

correction. This is one of the reasons why Wada made correction using his own method, but recent studies show that his method is inconsistent (Lim and Jung, 1992; Cho et al., 1996). We need further study in this direction.

Table 3 displays the ARIMA model of the rainy days for the Chugugi period and modern gauge period, respectively. We can clearly see that there is a big difference between two models (model 6 and 7) for two periods not only in the means but in the models also, since the snowfall and hail are not measured for the Chugugi period.

To measure the effect of the change in the measuring method and gauge we fit the intervention model to the precipitation data using the change of the measurement method as an intervention. We use the following indicator function

Table 3. Model of the rainy days for each period

Rainy days	Model	Mean	Standard Deviation
Chugugi period (1777-1907)	Model 6 $(1-0.9874B^{11})(Z_t-52.64)=(1-0.8447B)a_t$	52.64	11.21
Modern gauge (1908-1999)	Model 7 $Z_t-110.42=a_t$	110.42	11.77

$$I(t)=\begin{cases}1, & 1777\sim1907\\ 0, & 1908\sim1999\end{cases}. \tag{2.5}$$

and consider two separate models.

The intervention model fitted to the converted data by Wada (1777-1999) is

$$\underset{(55.978)}{Z_t=1327.0}+\underset{(72.306)}{194.58}\times I(t)+\frac{1}{1-\underset{(0.0685)}{0.2308}B^{11}}a_t,\quad \hat{\sigma}=425.06 \tag{2.6}$$

and the intervention model fitted to the unconverted data (1777-1999) is

$$\underset{(54.900)}{Z_t=1332.1}-\underset{(70.493)}{188.93}\times I(t)+\frac{1}{1-\underset{(0.0678)}{0.2925}B^{11}}a_t,\quad \hat{\sigma}=388.98. \tag{2.7}$$

In model (2.6), 194.58 is the intervention effect which means that the Wada data records 194.58mm more than the modern rain gauge data on average. Standard errors of the estimates are given in parentheses. On the other hand the intervention effect of model (2.7), -188.93, implies that the Chugugi data records 188.93mm lower than the modern rain gauge data on average. The intervention effect in model (2.7) might be explained by firstly, the Chugugi data does not record the precipitation amount less than the minimum unit of 1 pun (≈2mm), and secondly, the snowfall and hail are not

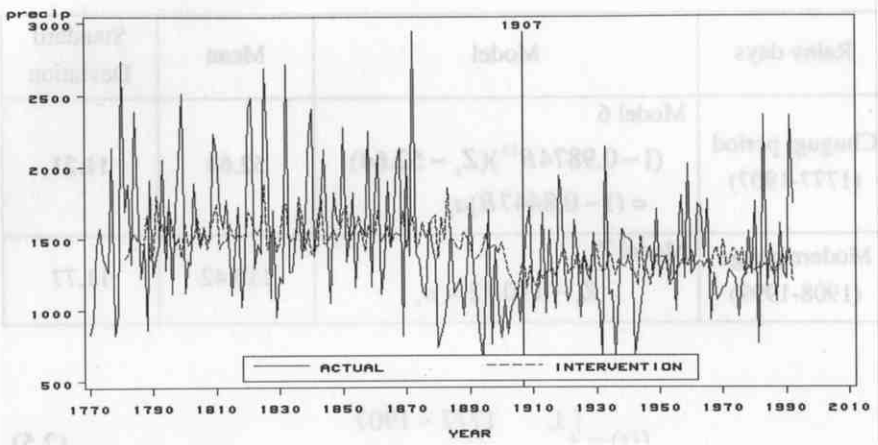

Figure 10. Time series plots of the Wada data and the forecast of the intervention model (2.6)

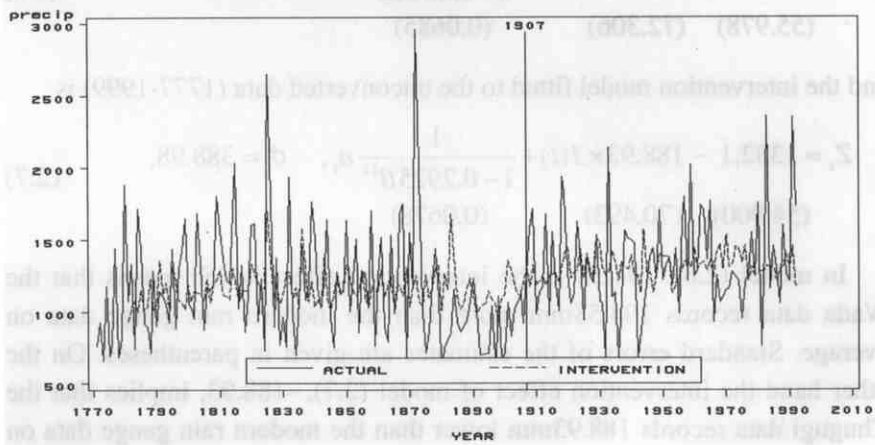

Figure 11. Time series plots of the Chugugi data and the forecast of the intervention model (2.7)

measured for the Chugugi period. On the other hand the difference in the Wada data and the modern rain gauge data cannot be explained by natural variation. Jung (1993) also showed that the time series plot of the rainy days data for the period 1943-1991 with less than 2mm excluded is similar to the time series plot of the Chugugi data.

Figure 10 is the time series plot of the Wada data and the forecast using the intervention model (2.6), and Figure 11 is the time series plot of the Chugugi data and the forecast using the intervention model (2.7). From Figure10 and Figure 11 we can see that the Chugugi data explains the precipitation data better than Wada's converted data.

3. Summary and Discussion

The history of Chugugi and reconstruction of Chugugi data are introduced and described in detail. The precipitation record is one of the longest in the world. Some statistical analyses are done for precipitation records during the last 220 years in Seoul including the Chugugi data. In the trend analysis, increasing trends for MA and AM are detected with a 5% significance level with monthly increments of 8mm-13mm and 14mm-16mm, respectively. However we do not claim these increments over 220 years are climatologically significant. The results of a wavelet transform of precipitation amount indicate the dominant 50-60 year oscillation during the period.

In order to check the existence of discontinuity in the time series around 1907 when the modern rain gauge was first used in Korea, we analyzed the Chugugi data, modern gauge data, and Wada's converted data using the ARIMA model and the intervention model. Our conclusion is that there might be a discontinuity problem between the Chugugi data and the modern gauge data due to the change in the measuring method and gauge. In addition, we found that Wada's correction method results in the overestimation of annual precipitation amounts.

Based on this study, we showed the precipitation record measured by Chugugi is not less reliable than that measured by the modern rain gauge.

The study by Jung et al. (2001) also showed that the Chugugi data are sound enough to establish a climatology of diurnal variation for various Korean precipitation regimes, which could be used to investigate the characteristics of each precipitation category (e.g., dry period and wet period). They conclude that while there are large inter-decadal variations (e.g., dry conditions from 1884-1910), the 220 years record is fairly homogeneous. A measurement problem of Chugugi is, nevertheless, that snowfall amount was not measured. Thus the precipitation during winter must be under-recorded. Another problem is that the precipitation less 2mm, which appears over a broad period during the daytime based on modern records, was not recorded. This caused a sudden increase of the number of annual rainy days around the year 1907. We do not think the difference of true precipitation and the recorded amount is much. However we need to estimate them (snowfall amount, precipitation less than 2mm, number of rainy days with less than 2mm or with snowfall) in the future for more precise research. In any event, in Section 2.3 we have taken account of these measurement problems.

Acknowledgements

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A Statistical Study of Ancient Korean Astronomical and Meteorological Data

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Abstract: We examined various forms of ancient Korean astronomical documents as they were recorded over a span of 4333 years. Their value as historical material was exceptional especially in terms of their accuracy. By accuracy we mean they are valid and reliable. In addition we examined the relationship between astronomical and meteorological materials and financial statistical materials in the late Joseon (Chosun) Period.

Keywords: Quantitative history, Accuracy, Validity, Reliability

1. Introduction

To introduce Korean history to the world, researchers in the past would try to approach the statistical data of Korea as a historical record of data.

According to A. N. Whitehead, the founder of symbolic logic (who had a thorough knowledge of philosophy, mathematics and natural science), we know the reason why a statistician has some interest in history. He defines history as 'the record to express feelings possessed by only human beings'. That means that we can extract information as data from not only documents that were created and intended to be official documents, but also other kinds of documents which human beings have recorded in other various forms. Presently, all sorts of data, including archaeological remains, relics and ancient astronomical data (like astronomical charts) fall into this category, and can be utilized to research history.

In terms of the broad analysis of history, it is necessary to approach history through both cultural social sciences such as archaeology, anthropology, comparative linguistics, political economics, and natural sciences such as astronomy. Furthermore, in the 19th century, it was believed that history was connected with statistics and quantitative history, or serial history. In fact, it was already established as an independent school by the time the magazine *Anales* was published in 1929. Since the connection between history and statistics began when it was realized there were some aspects that they shared, we tried to propose new statistical hypotheses by concentrating on the ancient astronomical data both historians and statisticians are commonly interested in. Doing this will begin a new era which will open 'the Window of Time'.

Korean historical documents are considered valuable for the cultural heritage of the world and are important data for scientific research because they were accurately recorded. There are a lot of statistical data about Korea and there is a valuable cultural heritage that Koreans have recorded and preserved for a long time. In this paper, the author's goal is to grasp real aspects of ancient times by searching the significant rules, patterns and features of each period that we call 'the Window of Time'.

In Section 2, we will deal with the accuracy of the data, the rationality and consistency of recording methods centered on solar eclipses, 'Taebaek-juhyeon' (太白晝見, the appearance of Venus in the daytime), and sunspots. Then, in Section 3, we will explore the relationships among meteorological data such as precipitation, population data known as 'the number of

households' (戶數), 'tax-relief due to disaster damage' (災結), and financial data such as 'the year-end holding amount' (年末時在額), 'payment of money per gyeol' (結當上納額), and 'the taxable land' (實結), where gyeol is the unit corresponding to 10,000m^2. The time frame for this study is the latter period of the Joseon dynasty. In addition, we intend to examine the influence of meteorological variables on the change of systems, and socio-economical and political patterns. Section 4 covers a summary and the conclusion of this study.

2. Accuracy of the Ancient Astronomical Data in Korean History

The human experience of time goes back to ancient time when man started to observe astronomy. Man estimated the accurate azimuth by observing the sun, the moon and the stars. Furthermore, he estimated time with the sundial around 6000 years ago, and kept using the sundial until the early 20th century. In addition, he manufactured the clepsydra and created the hourglass to make up for the sundial on cloudy days and in the evening time, and made the calendar to describe time. That is, humans have felt and experienced time by astronomical observation in every historical period. Today we also continue to spend a lot of time and effort to make accurate astronomical observations.

A migratory bird goes on a long journey without getting lost. His sense of direction is based on the location of the sun in the daytime and the constellations at night. Some birds can even perceive the magnetic field of the earth for a long journey. If we compare the spread and movement of culture in human history to a sea voyage, the routes of time would be classified with nomadic cultures, agricultural cultures and oceanic cultures. In various cultures, astronomical observation was considered very important to estimate and describe 'the 24 solar periods' (節氣) and direction as well as time and distance. Because of astronomical observation, the creation of these diverse cultures was filled with seasonal order and vitality. The way of human (called 'the small cosmos') life changed as man has explored a new

sea route in each period of time, but man can only meet 'the broad cosmos' by astronomical observation. Moreover, he came to realize that the earth where he now lives is a unique and valuable planet for him in the universe even though it is not so big.

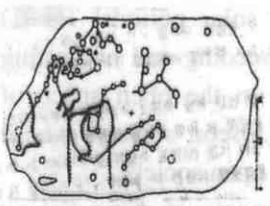
2.1 Astronomical Observations in Dangun Joseon Period (2333 B.C.~108 B.C.)

Let's look at the record about the foundation of Dangun Joseon. Dangun (壇君), a wise king, who accomplished social and cultural integration as 'Descendants of Heaven' (天孫) established Joseon (朝鮮, Bright Morning), the ancient kingdom in 'Asaddar' (the Morning Land). The ancient kingdom in Asaddar was covered with pine trees, which became the symbol of Korea. Pursuing 'Hongik-ingan' (弘益人間, the humanitarian ideal) based on divinely inspired active and dynamic universalism, Dangun governed human society with the help of Pung-bak (風伯), Un-sa (雲師) and U-sa (雨師). They can be considered a meteorologist and reporter of wind, cloud and rain. There remain historical documents about this period.

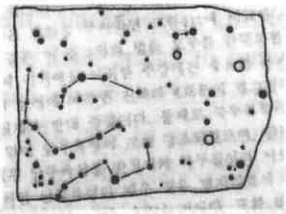
The national slogan of Old Joseon (古朝鮮) was 'Hongik-ingan' (弘益人間, humanitarianism). It was simple and humble but it indicated an open and future-oriented world-view based on *Kairos* (perceived), a view of time to include the universal ideal of human beings. As the culture of Old Joseon played a role in the integration of society as the festival of a community, it contained remarkable characteristics in even the ceremony of praying for heaven. That is, 'Worship of Heaven and Loving One's Neighbors' (敬天愛人) was considered the basic social order and virtue of the time. Dungun is the great ruler of Old Joseon who possessed a castle for defense and had economic power as well as a proper-sized population. The king who founded a nation with this motto ('Hongik-ingan') governed the kingdom wisely and rationally. He considered 'the 24 solar periods' (節氣) in planning the future with information and knowledge obtained by observing astronomy and analyzing the data necessary for scientific skills. We can confirm the above historical facts from Chinese documents as well as Korean historical documents.

1) The Constellation Figures of the Bronze Age

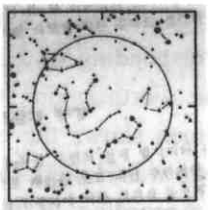
Dolmens, a part of Bronze culture that ancient people preserved for a long time to trace their life, were scattered in Jilrin (吉林) castle, seashores like the Ryaoning (遼寧) castle, Sandung (山東) castle, and Jeojang (浙江) castle, Kyushu (九州) in Japan, India, Indonesia, Palestine, areas around the Black Sea, Italy, Spain, areas around the Mediterranean Sea, France, the Netherlands, the Scandinavian peninsula, and England etc. In Korea, 40~50% of the 55,000 dolmens of the world were widely distributed. And 'Dolman-group in Gangwha (江華), Whasun (和順), and Gochang (高敞)' were registered with the UNESCO World Cultural heritage in 2000.



Dolmen of Jiseok-ri (1500 B.C.)
(Ursa Major, Draco, Ursa Minor, part of Cepheus)

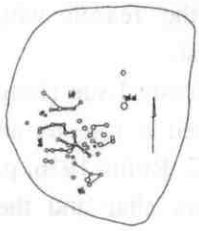


Stone plate of Adeugi dolmen in Cheongwon (500 B.C.)
(Ursa Major, Draco, Ursa Minor)

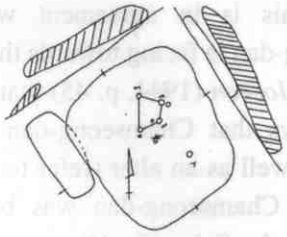


Simulated star chart near the North Celestial Pole at 500 B.C.

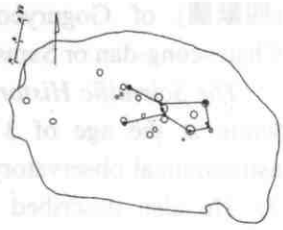
Source : Park, Changbeom, "A Stone Star Chart Found from a Dolmen at Ahdeugi in Cheongwon," *Journal of the Korean Astronomical Society* (2000).



Dolman of Euncheon Maehwa No. 9
(The Polar star, Crv, Cra, Hya)



Dolman of Euncheon No. 0-2-15
(Crv)



Dolman of Anak No. 11-2
(Ori)

Source : Lee, Hyeonggoo, *Dangun and Old Joseon*, (Seoul, Sal-lim-teo, 1999) p.551, p.553.

Recently, new scientific data were found on dolmen. Some dolmen contained records of people from Old Joseon who managed power in the East Asia area. We are now able to trace the daily life of people in that period on the cover stones of dolmen in Pyeongannam-do, Hwanghae-do, Hamkyeong-do, Gyeongki-do, Chungcheongbuk-do, and Gyeongsangnam-do etc. There have been various analyses about the signs (holes) carved on the cover of dolmen that were symbolic open spaces. But, according to recent new research, they turned out to be 'the constellation figure of the Bronze Age' (about the 15th or 16th century B.C.). That is, they indicate their *Kairos* view of time (perceived time) and their viewpoint of universe and the scientific world. They are interpreted as a composite art to express the constellation symbolizing a particular 'the 24 solar periods' (節氣) corresponding to the rhythm of nature such as the seeding and harvesting time. Furthermore, the constellation figure carved on the open space of dolmen shows the characteristics of the wise Old Joseon society, whose motto was Hongik-ingan (弘益人間), to strive for an open society.

According to *the Real Records of Joseon Dynasty at King Sejong (世宗實錄地理志)*, King Dangun prayed for heaven on 'Chamseong-dan' or 'Samseong-dan' (塹星壇 or 參星壇, stone altar) piled by stones (10-cheok height, 4 sides with 6-cheok & 6-chon, and 15-cheok stone below) at the top of the mountain. Here Samsung (參星) is located in the west of 'the 28 Zodiacal constellation' (28星宿). It was also expressed as the figure of 'Baekho' (白虎, the White Tiger of the West) in 'the picture of 4 Animals' (四獸圖) of Goguryeo. This is in agreement with the reason why Chamseong-dan or Samseong-dan is facing towards the west.

The Scientific History of Joseon (1944, p. 45) that professor I-sup Hong wrote at the age of 31 says that Chamseong-dan played a role as an astronomical observatory as well as an alter (refer to W. C. Rufus 1936, p. 7). He also described that Chamseong-dan was both an altar and the astronomical observatory in *the Scientific History of Joseon* as he could confirm the fact that officials of 'the Royal Astronomical Observatory' (書雲觀) had been detached there and they observed astronomy from *'Seongbyeon-Cheukhu-Danja' (星變測候單子, Rapid Reports on the Observation of Celestial Event,* daily records of changes in the heavens*).*

2) The Feature of the Astronomical Observations in Old Joseon Era

Astronomical phenomena and natural disasters were recorded in the Bible, related to significant historical events. Some representative events are as follows: Noah's flood and the appearance of new pastoral and agricultural culture, the great population migration and the transfer of culture into other civilizations after the destruction of the Tower of Babel, and the 10 disasters in Egypt and the historical Exodus of the people of Israel in *the Old Testament*. Furthermore, *the New Testament* dramatically describes an event in which three scholars from the East were observing the stars and went to Bethlehem to worship Jesus Christ. Koreans also thought that natural disasters like earthquakes and violent volcanic eruptions might cause Balhae (渤海) to be destroyed.

As in the research of astronomical phenomena, millions of years is considered as just a few short moments, it is therefore necessary to have data from accurate long-term astronomical observation. But, even in world history, we cannot find any example of data as highly valid and reliable as the records by long-term astronomical observation for over 2000 years in their various forms in the historical periods of Korea, China, and Japan of the Far East Culture.

And W.C. Rufus (1936, p.8) describes as follow, "*Bisa(秘詞, an Atronomical Ativity)* was written in 2247 B.C. by Sinji (神誌, who might be styled the first astronomer of Dangun Joseon)." Therefore, we guess that national systems and organizations were established to collect the information and astronomical observation data in ancient kingdoms and the research was highly advanced. They observed astronomy based on these institutions, organizations and knowledge in that era.

i) 'Oseong-chwi' (五星聚, the Regimentation of Five Stars) in 1733 B.C.

The people of Old Joseon left unique daggers called 'Bipahyeong-dongkeom' (琵琶形銅劍, the mandolin-style bronze dagger) and 'Sehyeong-dongkeom' (細形銅劍, the Korean-style narrow bronze dagger). They were found all over Korea. And they also left elaborate 'Danyu-semun-gyeong' (多紐細文鏡, the bronze mirror multi-knobbed with subtle geometric designs, Korean National Tresury No. 141) that has 100 circles

and 1,3000 lines. These mirrors contained narrow lines that cannot be easily imitated even in present times. 'The bronze implement with eight bells' (八頭鈴) describes the 24 directional points delicately, and the Constellation figure of the Dolmen cover describes features of 'the 24 solar periods'. Nevertheless, there are only a few literal documents as they were lost due to many wars and disasters along with their outflow to Japan and other countries. This prevents Koreans from totally observing the era by limiting their space of history. So, we need to approach the historical documents of China and Japan and examine new methods through various other historical data as well as literal records. In this condition, the ancient astronomical records written in a few secondary and tertiary literal documents are still regarded as valuable proof that makes it possible to guess the circumstances and culture of that period.

It is necessary to criticize and review the reliability of this data. On this point, recently scholars who study ancient astronomy proved the validity and reliability of the data that records 'the regimentation of five stars' in 1733 B.C. and 5 solar eclipses in 765 B.C., 579 B.C., 525 B.C., 423 B.C., and 248 B.C. Especially, Professor Changbeom Park of the Dept. of Astronomy in Seoul National University confirmed the record of 'Oseong-chwi' (五星聚), the phenomenon that the five planets (Venus, Mercury, Jupiter, Mars and Saturn) were in alignment. He proved it was very reliable and credible data.

ii) Validity of Rational Record (Legitimacy) and Reliability of Consistent Style (Tradition)

The validity of the rational astronomical observation data deserves special attention because it had been recorded for a long time (from 2333 B.C. to 108 B.C.) by the people of Old Joseon (古朝鮮). As we can find a consistent pattern of data and content from the following Korean historical documents, they have valuable reliability. In this paper, we would like to approach the data focusing on the historical legitimacy (the validity of the rational record) and tradition (reliability of consistent style).

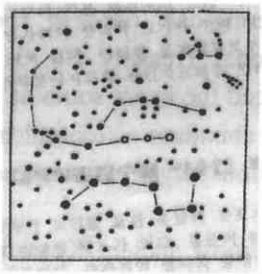
The characteristics of Korean historical documents were revealed clearly by the legitimacy of rational records based on the *Kairos* view of time, and

the traditions remained for 4300 years from the Old Joseon (古朝鮮) period (2333 B.C.～108 B.C.) to the Joseon (朝鮮) era (1392～1910). In addition, the recurrency of the historical tradition is seen in the name of kingdoms like Goryeo (高麗, 918～1392), Joseon (朝鮮, 1392～1910), and Korea(韓國).

Korea already holds the *Joseon-wangjo-silok (朝鮮王朝實錄, the Real Records of Joseon Dynasty*, Memory of the World 1997), the World Cultural Heritage of Records registered in UNESCO, and *Seungjeongwon-ilgi (承政院日記, the Diary of the Royal Secretary*), was also designated as a candidate of that is the UNESCO World Cultural Heritage of Records. And the Diary of the Royal Secretary of the early Joseon era which included the king's orders, the king's daily life and commands, departments' reports and data to appeal to the king vanished in the 'Japanese invasion of Korea' (壬辰倭亂, 1592～1598). These data contained all the significant records for 288 years from King Injo (1623) to the latter period of Joseon.

2.2 Astronomical Charts, the Records of 'Taebaek-juhyeon' and Solar Eclipse of the Three Kingdoms & Latter Period of Silla (57B.C.～917 A.D.)

People who lived in the Three Kingdoms made more efforts than those of Old Joseon, and left brilliant literal documents and astronomical charts as part of the murals of old tombs.



(Ceiling of Jinpa-ri Mounds)

People of Goguryeo directly succeeded in Old Joseon in establishing a large ancient empire. They had a population of 3.8 million and they played a key role in East Asia. The people of Goguryeo already manufactured 'Cheonsang-Yeolcha-Bunya-Ji-Do' (天象列次分野之圖, CYBD) in the first century B.C. Goguryeo culture was regarded as 'typical for a Far East civilization' at that time. As a result, they left a magnificent legacy of integrating science and art. They successfully searched for their own 'Korean-oriented culture' by completing an

astronomical direction system like 'Sasu-do' (四獸圖, the Four Mythological Animals of the Four Seasons). Sasu-do is painted on the old tombs and it abstracts the constellation into 4 directions.

And Baekje developed an open ancient kingdom with a population of 3,500,000. They declared they were 'Descendants of Heaven' represented as the historical spirit of Old Joseon. They already constructed a large-scaled palace the same size as 'Poongnap mud rampart' (風納土城) and they observed the solar eclipse accurately in the 6th year of King Onjo (13 B.C.). And they left unique records of 'Taebaek-juhyeon' (the appearance of Venus during the daytime) in the 11th year of King Kusu (224). This shows that they were accomplished in science and astronomy at a level much higher than those of other countries. In October of the 3rd year of King Mu (November, 602), Gwan-nuk (觀勒), a scholar of Baekje transferred books of astronomy and geography, calendars, and medicine to Japan. In this way, Baekje deserved to be regarded as a developed country of science and culture.

Meanwhile, the Silla dynasty was proud that they were 'Descendants of Heaven'. They established an ancient kingdom system comparable with Goguryeo and Baekje. King Park Hyeokeose, also called 'Balgeun-Hae' (Bright Sun), let them observe the solar eclipse on his 4th year of rule (54 B.C.). In addition, there were accurate records of 'Taebaek-juhyeon' in the 5th year of King Nahae(200). These records show that they developed to a similar level as Goguryeo and Baekje. Additionally, in the 16th year of Queen Seondeok (647), they constructed 'Cheomseong-dae' (瞻星臺, the oldest observatory in the world, and Korean National Treasury No. 31) which was made of 365 stones. This observatory faced the exact south at a height of 9.108m. Using it, they came to maintain abundant astronomical records with almost 4 times as much data as in previous days. It was due to their earnest astronomical observation.

Since 2333 B.C., the common spirit shared by most ancient Koreans came from the notion that they were 'the Descendants of Heaven'. That is the reason why the Three Kingdoms pay such great attention to astronomy already in the first century B.C., and in particular to the sun.

1) Cheonsang-Yeolcha-Bunya-Ji-Do (天象列次分野之圖, CYBD) and Sasu-do (四獸圖, The Four Mythological Animals of the Four Seasons)

The CYBD (天象列次分野之圖, Korean National Treasury No. 228), the core of Korean recording culture was based on the *kairos* view of time. This shows the cultural spirit of Koreans who would like to express an orderly universe. The Three Kingdoms shared the common historical and spatial sense that their predecessors had in the Old Joseon (古朝鮮) period. Like them, they believed they were 'Descendants of Heaven'. The living historical sense of 'Hongik-ingan' (弘益人間, humanitarianism) integrates agricultural and marine societies and culture. The integration was based on nomadic culture, astronomical data and information accumulated for a long time since the Old Joseon era. These things were inherited in the particular form of the CYBD of the Three Kingdoms. The brilliant results succeeded in Joseon since Silla through Goryeo. Therefore, the CYBD was considered as an overall art form that incorporated the accurate scientific work of astronomy, the Korean spirit and historical sense with the *kairos* view of time, as well as the historical data.

'Sasu-do' (四獸圖, Four Mythological Animal), considered an important clue to the old tombs of the Three Kingdoms, was the abstract 'Four Seasons and the Cardinal Direction System' that expressed the scientific and cosmic viewpoint along with an ancient astronomical and natural view of the world. It furthermore occupied 'the typical style of the Far East' at that time.

2) The Original Records of Solar Eclipses during the Three Kingdoms Period

Contained within *Samguk-sagi (三國史記), Samguk-yusa (三國遺事), Zeungbo-munhun-bigo (增補文獻備考),* and *Dongkuk-tongkam (東國通鑑),* there are a total of 67 records of solar eclipses: 11 records came from Goguryeo, 26 came from Baekje, and 30 originated from Silla. Two cases of these were observed in Goguryeo and Silla at the same time.

In this way, the pattern of astronomical observation records in the Three Kingdoms period was similar to that of the Old Joseon. It was natural for Koreans to have knowledge of the principles of heaven through astronomy

as they had declared themselves the Descendants of Heaven since Old Joseon.

3) Accurate Observation Records of 'Taebaek-juhyeon' (太白晝見, Venus Appearing during the Daytime) in the Three Kingdoms Period

There are 8 records of 'Taebaek-juhyeon' (the appearance of Venus during the daytime) in total. It is very hard to find an example of 'Taebaek-juhyeon' even in Eastern country where they had abundant astronomical observation materials except in China. Unlike a solar eclipse that is easily observable with only predictable knowledge, it is not easy to observe Venus during the daytime. In spite of today's development of theoretical astronomy and modern observation instruments, we can find Venus during the daytime only when we calculate its place and lightness in celestial mechanics. Moreover, we can only observe it during the best conditions for astronomical observations.

In the 200's, Korean scientists with high technology about astronomical observations handed down scientific and ancient astronomical materials by predicting and observing the 'Taebaek-juhyeon' phenomena accurately. These important records were written in *Baekje-bonki* (百濟本紀), *Goguryeo-bonki* (高句麗本紀), and *Silla-bonki* (新羅本紀).

4) Record of Halo in the Three Kingdoms Period; 'Tincture of Red' (赤氣), 'Tincture of Black' (黑氣), Sunspots (黑點), Dark Halo (黑暈)

Nine observations of halo recorded in *Samguk-sagi (三國史記)* informs us of the following important facts.

First, the records of 'Tincture of Black' (黑氣) in the 4th year of King Adalla (157) in Silla, 'Tincture of Red' (赤氣) in the 24th year of King Biryu (327) in Baekje, 'Sunspots' in the 23rd year of King Yeongryu (640) in Goguryeo, and 'Dark halo' in the 7th year of King Heondeok (822) in Silla show a more developed observation mode.

Second, the observation record of 'Ticture of Red' (327) in Baekje is very significant astronomically. This will be discussed later when we discuss the observation record of sunspots in Goryeo.

Third, the 'Red Crow' (赤烏), which was acknowledged as a mysterious

spiritual being to ancient Koreans, appears in 'Ticture of Red' observation records in Baekje.

Fourth, the modes of observation records ('Ticture of Red', 'Tincture of Black', Sunspots) are also maintained in observational records in Goryeo and Joseon Period.

2.3 Records of Solar Eclipses and Sunspots in Goryeo Period (918-1392)

Goryeo people had more than 3000 years of experiences at a high level with astronomical observations and they passed on their historical traditions. These people built the Astronomical Observatory of Cheomseong-dai (瞻星臺) to the west of Manwol-dae (滿月臺) in Gaeseong and showed a great improvement with more developed information, knowledge, and theory of astronomical observations. There are detailed records of astronomical phenomena like 137 solar eclipses, 211 lunar eclipses, 76 comets, 547 meteors, 168 stars appearing during the daytime (mainly 'Taebaek-juhyeon'), and 34 sunspots in *Astronomical Records* (天文志) of *the History of Goryeo* (高麗史).

1) Records of Solar Eclipses in Goryeo Period (918-1392)

There are 31 records of solar eclipses, which were unobservable in the capital of Gaeseong, out of 137 solar eclipses in *Astronomical Records* of *History of Goryeo.* The following conclusions can be inferred:

First, Goryeo people were devoted to solar eclipse observation and they were equipped with the correct materials, information, knowledge, and theory of calendar calculation and movements of the sun and the moon for predicting solar eclipses. That is, Goryeo had well-equipped institutes for correct astronomical observations and produced men of ability.

Second, the average observation ratio is 0.29 although there is no early record. It is higher than that of Old Joseon, 0.0033 or that of the Three Kingdoms Period, 0.0687. This reflects that a great improvement in astronomical theory was made in Goryeo.

Third, according to the throne period, the observation ratios in the Hyeonjong Period (1010-1031) and the King Gongmin Period (1352-1374)

are 0.5 and 0.52 respectively and higher than any other time.

Therefore, we can find that when a nation or a society is administered in an orderly fashion, it makes economical, political, socio-cultural and scientific developments autonomously.

2) Records of Sunspots in the Goryeo Period

The Koreans, who had observed sun-related phenomena like solar eclipses and halo carefully from Old Joseon, recorded the observations of 'Tincture of Red' (赤氣), 'Tincture of Black' (黑氣), and sunspots as well as those of solar eclipses and halo in the Three Kingdoms Period. They began to observe sunspots in a more developed mode in the Goryeo Period. Considering those observations of sunspots, we can find very interesting facts.

First, they used standard equipment for observations.

Second, they left detailed records of sunspots using a standard method through evaluating the observational results systematically.

Third, they classified the tinctures or colors of sunspots with a lower level as 'Tincture of Red' (赤氣) or 'Tincture of Black' (黑氣) .

Fourth, they classified the size of sunspots in 5 levels. For example, there were sunspots described as 'Sunspots', 'Plums', 'Eggs', 'Peaches', and 'Pears'.

Fifth, Koreans started full-scale observation of sunspots from March 31, 1151 in the Goryeo Period while Westerners started to observe it systematically at the beginning of the 18th century. Korean observation records preceded those of the Westerners by 6 centuries, although they did not index the results.

Sixth, the observations of sunspots that is started from the 12th century lasted in a consistent way up to the 5th～7th levels until April 15, 1387. Therefore this lasted for 237 years.

Seventh, observational materials of sunspots show 11-year short-term cycles and 97- year long-term cycles.

Eighth, this pattern is similar to modern sunspot cycles.

Ninth, the mode to record the size of sunspots correctly up to the 5th～7th levels by using an interval scale continued until the Joseon Period.

This explains the original rational Korean legitimacy and tradition, or the cultural consistency of the view of the universe, world and nature noted above based on the *Kairos* view of time (perceived time).

2.4 Records of Precipitation, Supernova Observations, and Astronomical Phenomena during the Joseon Period (1392-1910)

It is appropriate to refer to 'the Great King Sejong' (世宗大王, 1387-1450) before we examine astronomy-related records. The name of 'the Great King Sejong' is Ido, but people love to call him 'the Great King Sejong'. He suffered from shingles and neuralgia and had difficulty in working because of physical pain from overwork. 'The Great King Sejong', however, carried out a series of consistent scientific and cultural policies synthetically with open-mindedness for the improvements of people's lives.

As a result, he made an unprecedented contribution to world historical culture; he made 'Hangul' (the Korean alphabet) to communicate and hold information in common. This was his important contribution to linguistic history. He installed a synthetic system for astronomical observations and he developed science through improving observational instruments. He also improved typography to record scientific and cultural works in a book. Furthermore, he invented 'the Cheugu-gi' (測雨器, the rain gauge). He was the first in the world to measure standardized precipitation. This was indispensable for the rational and scientific development of agriculture. He is the king of kings to contribute to world history in science. Furthermore, it cannot be overstated for him to be called 'the Great King Sejong'. His own writing, *Goowhang-byukgok-bang (Plan of Relieving Famine)* shows his humanity.

The invention of 'Cheugu-gi' remains an epoch-making achievement in meteorology for agriculture in world history.

1) Establishment of Synthetic System for Astronomical Observations by 'the Great King Sejong' in Early 15th Century

They say that world scientific history is absent before Copernicus in 1543. On the contrary, in 1434 one century earlier than Copernicus,

Great King Sejong, a great scientist and ruler in the Joseon dynasty, established the perfect and synthetic system for astronomical observations with a center of Gyeonghoe-ru (慶會樓) in Gyeongbok-palace (景福宮) in the capital of Seoul. His records and study of astronomical observations are considered as a form of Korean pride in world history as well as in Korean history.

The Great King Sejong made an exceptional appointment. It was Jang Yeongsil. He was a slave in the government employed at Dongrai-hyeon. As a technocrat in Byeoljwa he manufactured 'Jagyeok-nu' (自擊漏, the automatic striking clepsydra). This was first used in June 1434. Finally, he used it officially on the 1st of July and let people know the standard time with the sound of a drum every hour and that of a gong every minute. The Great King Sejong knew the importance of measuring time and tried to improve the clepsydra as a correct machine clock. In 1434, there appeared 'Anbu Il-gui' (仰釜日晷, the scapho-sundial). The scapho-sundial is made of bronze and is almost beautifully, geometrically perfect. 'Anbu Il-gui' is supported with 4 pillars that were stuck in a crosspiece. There was a groove in a crosspiece to balance the clock. The characteristics of 'Anbu Il-gui' are as follows: First, 'Anbu Il-gui' informs the exact 24 solar periods and time with the lines of longitude and latitude because it measures the 24 solar periods from 'the Winter Solstice' (冬至) to 'the Summer Solstice' (夏至) with a parallel line and it measured time with a vertical line. Second, it was used as 'the public clock'. That is, 'Anbu Il-gui' was installed not only in the royal palace, but also at the corner of Hyejeong-bridge and the street of Jongmyo (宗廟) in Seoul. This shows Great King Sejong's open-mindedness towards the people. Third, he considered people's convenience and encouraged people to make and use them. As a result, many people manufactured 'Anbu Il-gui' with various materials. Now, there are many kinds of big and small 'Anbu Il-guis' on display in Korean museums. It also shows the open-minded historical sense of the Great King Sejong. There were not only clepsydras and sundials, but also machines for observing astronomical phenomena with scientific value. They were produced in Gyeongbok-palace in the 15th century. The astronomical observatory of 'Ganui-dae' (簡儀臺, the simplified armillary platform) was built in the

north of Gyeonghoe-ru in 1433. In 'Ganui-dae' (the simplified armillary platform), there was 'the Ganui' (簡儀, the simplified armillary sphere) observation machine that was made of bronze. It was made by simplifying five ton's of the observation machine of 'Honcheonui' (渾天儀). And there was 'Jungbang-an' (正方案, the direction-determining square board) in order to determine the exact direction. Therefore, government officials could observe the stars with the Ganui every night and measure the exact time. Furthermore, they could determine the Jung-seong (中星, the meridian stars of dark and dawn during the 24 solar periods) visible to the right south when the sun rises and sets.

The base of the Great King Sejong's science and culture became stagnant during the 7 years of Imjinwaeran (Japanese Invasion, 1592-1598). This was temporary and his scientific sense was revived in the King Yeongjo and King Jeongjo Periods and continued to the end of the Joseon Period. It became a motive to bring back many works.

2) Records of Solar Eclipses in Joseon Period

If we examine the observation ratio of solar eclipses in the Joseon Period according to time, it is as follows:

First, the observation ratio of the Joseon Period is recorded as 0.35 and it is much higher than 0.0033, 0.0687, and 0.29 of the Old Joseon Period, the Three Kingdoms Period, and the Goryeo Period, respectively.

Second, there is a record in the early in Joseon Period unlike in the Goryeo Period.

Third, the ratio was relatively even during the whole period of the Joseon Period.

Fourth, the ratio is relatively so low that it was 0.12 in the King Seongjong period, 0.14 in the King Taejo period, 0.15 in the King Jungjong period and 0.17 in the King Taejong period. However, it rose after King Myeongjong (1546).

Fifth, considering the observation ratio, the King Sejong period in the early Joseon dynasty and the King Seonjo period through the King Yeongjo and King Jeongjo periods in the late Joseon dynasty saw the developments of cultural arts and scientific technology at the same time.

3) Records of Precipitation Observations by 'Cheugu-gi' (測雨器, the Rain Gauge) in 'the Great King Sejong Period'

The precipitation had been measured at 'Seoun-Gwan' (書雲觀, 'the Royal Astronomical Observatory Board') since the Goryeo Period, and so it had been in the Joseon Period. By the recommendation of the Ministry of Finance in the 23rd year, 8th month and 18th day of King Sejong (August 29, 1441), the standard precipitation gauge of Cheugu-gi was made in the 24th year of King Sejong (1442). Seoun-gwan instituted a method for measuring precipitation and its reporting mode. It regularly reported the precipitation of Seoul, each province (Do) and counties and prefectures (Gunhyeon). Cheugu-gi was used at 'Seoun-gwan' in the center and at Gamyeong in each local province (Do). It is the first standard scientific instrument for measuring precipitation. It was made of porcelain or china and it was used nation-wide until the end of Joseon dynasty.

The Great King Sejong re-edited *the History of Goryeo (高麗史)* in order to make it more accurate with an open-minded sense of history. He ordered civil ministers of the State to work in 'the Hall of Assembled Sages' (集賢殿) to revise it many times until the last period of his enthronement. He was a sage king to initiate the restoration of science and culture. He devoted himself to establish statistics and a system for ruling with order and left the longest record of precipitation in meteorological history with the invention of the Cheugu-gi.

The Cheugu-gi, created in 1442, was a modern instrument used for meteorological observations. It was a landmark invention 198 years ahead of its time, and it signified the transition period from 'naked eye observations' to 'instrumental observations'.

Starting from Sejong's period, precipitation measurement was documented consistently for the longest period of time in the world. And the observation mode is regulated in details; the unit of precipitation was recorded up to pun (about 2mm). At that time, they recorded the time of each precipitation and they also had 8 categories of rain-type from a fine rain to a heavy rain.

4) Records of Supernova Observations (1604-1605) in King Seonjo

One hundred thirty one records of observing supernova, known as 'Kepler's supernova' from October 13, 1604 to April 23, 1605, were written in *Joseon-wangjo-silok(the Real records of Joseon Dynasty)*. Those records compare the lightness of the supernova with those of Jupiter, Venus, Mars, and Scorpio α (心大星). Moreover, they described the colors and the location of the supernova.

3. Change of Pattern of Financial Management According to Meteorological Phenomena in the Late Joseon Period (1779-1881)

In this study, we propose a new hypothesis that meteorological phenomena brought a change in the patterns of financial management, political society, and institutes in the late Joseon Period. We would like to point out the various changes through examining the financial and meteorological documents of *Joseon-wangjo-silok (朝鮮王朝實錄, the Real Records of Joseon Dynasty,* the Korean National Treasury No. 151*)* and *Ilseonglok (日省錄, the Daily Diary of Royal Secretary*, the Korean National Treasury No. 303*)*.

To begin with, we approach the hypothesis suggested in this study after getting 'payment of money per gyeol'(結當上納額) and 'surplus and deficit' (財政黑赤字額), by using 'tax relief due to disaster damage' (災結), 'payment of money' (實上納), 'taxable land' (實結), and the 11 main 'the year-end holding amount'(年末時在額) statistical materials. We will also examine the relationships between them.

3.1 'Jea-gyeol' (災結, 'Tax Relief Due to Disaster Damage') and the Change of Financial Management

'Tax relief due to disaster damage' (Jae-gyel) is an important statistical material as an index to indicate the degree of damage. Furthermore, it is related to financial materials and others. In *Joseon-wangjo-silok (朝鮮王朝實錄)* there are records of the number of total 'Jaegyeol' every

year, where 1 gyeol means 10 thousand square meters. When the number of total 'Jae-gyeol' is over 60 thousand gyeol, the number of 'Jae-gyeol' in each province (Do) is recorded in details. We can find the following from the statistical materials of Jae-gyeol:

First, in the years when the number of 'Jae-gyeol' was more than 100 thousand gyeol, there was the possibility that a natural calamity happened. It might have happened in 1784, 1787, 1793, 1795, 1799, 1810, 1813, 1815, 1829, and 1877.

Second, deficits in 1784, 1787, 1795, 1810, and 1815 were up to 900 thousand ryang (兩, unit of money) where there was a possibility of natural disaster. In particular the number of 'Jae-gyeol' (tax relief due to disaster damage) in 1810 is about 190 thousand gyeol, the highest record in the late Joseon Period. Also, it is equal to about 25% of the average taxable land, around 800 thousand gyeol. And 'payment of money' (實上納額) in 1810 is around 880 thousand ryang.

Third, financial status in 1793 (surplus 33 thousand ryang) and in 1799 (deficit 68 thousand ryang) before 1810 shows relatively sound financial management compared with that in 1813 (deficit 470 thousand ryang), in 1829 (deficit 680 thousand ryang), and in 1877 (deficit 630 thousand ryang).

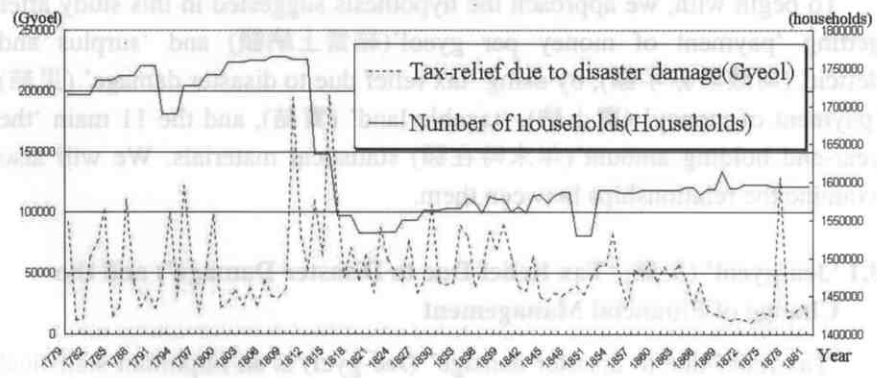


Fig-1 Tax-relief from damage and No. of households in census (1779 -1881)

Therefore, 'Jae-gyeol' in 1810 were 190 thousand gyeol, and this was the highest record. It means that about 25% of average 'taxable land' (about 800 thousand gyeol) was damaged. And 'payment of money' was around 800 thousand ryang at that time. This shows that there was the worst natural calamity in meteorological history and that new patterns of financial management in 'the Power Ruling Period' (勢道政治時代) appeared unlike that of the King Jeongjo period.

3.2 'Payment of Money Per Gyeol' (結當上納額) and Change of Financial Management

'Taxable land' (實結) and 'payment of money' (實上納額) related to financial income out of records in Joseon show a relatively similar aspect. Considering the ratio of 'payment of money' to 'taxable land' that is, 'payment of money per gyeol', we can find the following:

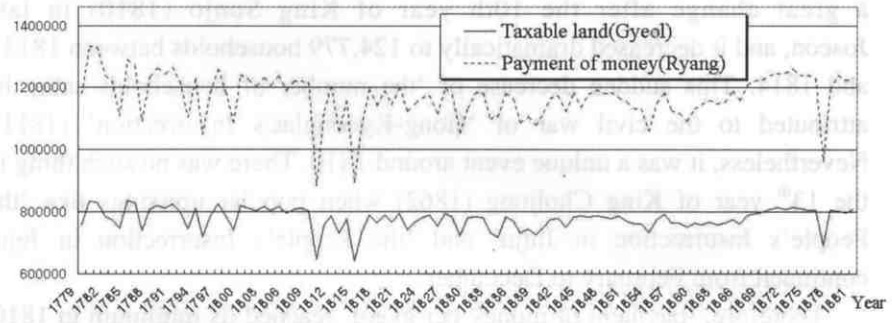


Fig-2 Taxable land & payment of money (1779-1881)

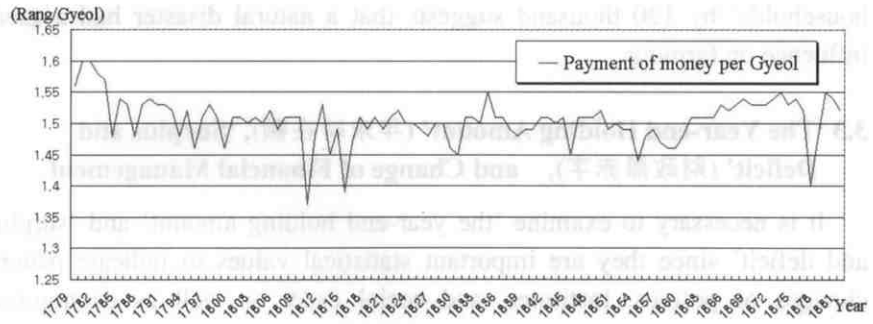


Fig-3 Payment of money per gyeol (1779-1881).

First, 'taxable land' and 'payment of money' show a very similar pattern. So does 'payment of money per gyeol'. Therefore, 'payment of money per gyeol' is an important index to indicate the general financial state as well as financial income in the late Joseon.

Second, 'payment of money per gyeol' is expressed as a value between 1.60 and 1.36. In 1810 when the maximum Jae-gyeol was 190 thousand gyeol, 'payment of money per gyeol' was a minimum of 1.36 and 'payment for money' was a minimum of 883,462 ryang.

Third, we can find similar characteristics in 'the number of households' (戶數). 'The census system' (戶口制度), which was managed by creating a new census every 3 years, was established, and its records had appeared since "the Three kingdoms Period. It was composed of national statistical materials for conscription and tax policy. Thus the total number of households was an important basic statistic to manage a nation. It underwent a great change after the 10th year of King Sunjo (1810) in late Joseon, and it decreased dramatically to 124,779 households between 1813 and 1814. This sudden decrease of 'the number of households' may be attributed to the civil war of 'Hong-Kyeonglae's Insurrection' (1811). Nevertheless, it was a unique event around 1810. There was no such thing in the 13th year of King Choljong (1862) when popular uprisings like 'the People's Insurrection in Jinju' and 'the People's Insurrection in Jeju' continued from February to December.

Therefore, 'payment of money per gyeol' reached its minimum in 1810. And the historical event like the rapid decrease of 'the number of households' by 120 thousand suggests that a natural disaster had a great influence on farming.

3.3 'The Year-end Holding Amount' (年末時在額), 'Surplus and Deficit' (財政黑赤字), and Change of Financial Management

It is necessary to examine 'the year-end holding amount' and 'surplus and deficit' since they are important statistical values to indicate pattern changes of politics, institutes, and social order as well as economical conditions.

1) 'The Year-end Holding Amount' (年末時在額)

'Public account' (會計簿) from the statistical documents written in *Joseon-wangjo-silok (the Real Records of of Joseon Dynasty)* and *Ilsunglok (the Daily Diary of Royal Secretary)* in late Joseon is the year-end financial record of 11 kinds of things, such as gold, silver, money, hemp (布), cotton cloth (木), silks (綿紬), ramic cloth (苧布), rice, hulled millet, soybean, and miscellaneous cereals. 'The year-end holding amount' is the amount of total money converted by 11 kinds of things in 'public account' into constant market price in 1807. There was a long-term series of data from the 3rd year of King Jeongjo (1779) to the 18th year of King Gojong (1881). This data was also an important document to study financial history in the late Joseon. Considering 'the year-end holding amount', we can find the following:

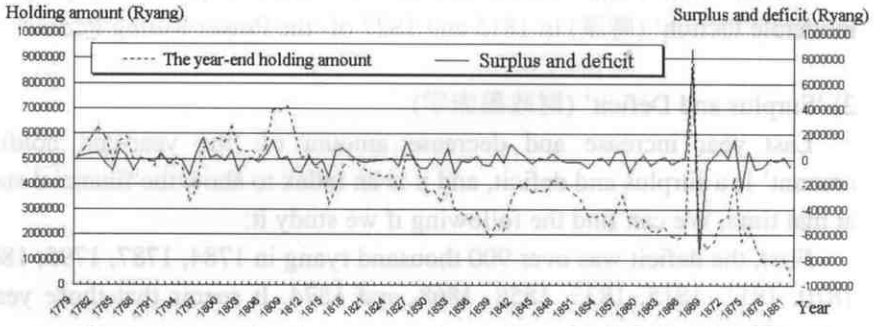


Fig-4 Year-end holding amount & surplus and deficit (1779-1881)

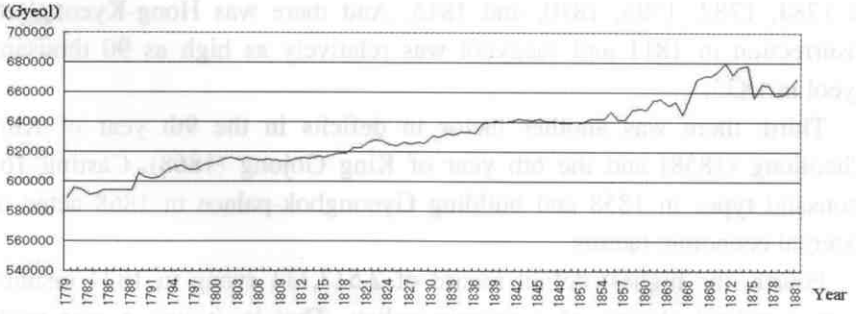


Fig-5 Tax-relief (1779-1881)

First, 'the year-end holding amount' had a decreasing tendency in the long run. In the 'appeal of Sangkyu Sim' (*Sunjo-silok*, volume 25, the 22nd year of King Sunjo), a scholar and Minister of Finance who wrote *Mangi-yoram (萬機要覽, a guidebook in national administration)* a statistical year book in the 8th year of King Sunjo (1808) on the basis of *Takji-ji (度支志, a guidebook in national administration)* in the 20th year of King Jeongjo (1776), the exact cause and the counterplan about this tendency were described. It was closely related to a long-term increase in 'tax-relief gyeol' (免稅結) value.

Second, 'the year-end holding amount' had a 20～27 year long-term changing cycles.

Third, at the lower point of this changing cycle was the persecution of Catholics in 1795, 1815, 1827, and 1866.

We can notice that Joseon was in the vortex of politics to purge 'a moderate faction' (時派) in 1815 and 1827 of 'the Power Ruling Period'.

2) 'Surplus and Deficit' (財政黑赤字)

Last year increase and decrease amount of 'the year-end holding amount' is a surplus and deficit, and it is an index to show the financial state at that time. We can find the following if we study it:

First, the deficit was over 900 thousand ryang in 1784, 1787, 1795, 1802, 1810, 1811, 1815, 1833, 1858, 1868, and 1874. It seems that those years were related to historical events.

Second, as we examined above, Jaegyeol was over 100 thousand gyeol in 1784, 1787, 1795, 1810, and 1815. And there was Hong-Kyeonglae's insurrection in 1811 and Jaegyeol was relatively as high as 90 thousand gyeol in 1833.

Third, there was another factor in deficits in the 9th year of King Cheoljong (1858) and the 6th year of King Gojong (1868). Casting 160 thousand types in 1858 and building Gyeongbok-palace in 1868 acted as external economic factors.

Fourth, the highest deficit record of 2,517,111 ryang in 1874 resulted from a radical change of economic policy. That is, it was a man-made disaster, phenomena that occurs from the absence of economic policy. It

happened because they forbade the use of Chinese currency (小錢, 淸錢).

Fifth, we cannot find the special cause in the deficit of 957,455 ryang in 1802 except that it was the starting point of 'the Power Ruling Period'.

Therefore, we illuminated that the main deconstructing phenomena in late Joseon were both natural disaster and a man-made disaster resulting from 'the Power Ruling Period'.

3.4 Change of Financial Management in the Light of Precipitation Data

If we examine the years (1785, 1795, 1803, 1822, 1838, 1853, 1866 and 1876) with a precipitation record of below 800mm, we can verify that the climate had various influences on the changes of economics, politics, and social institutes. That is, considering the financial state of 1803 (continued from a large deficit finance since 1802), 1822 (continued from a deficit finance since 1819), 1838 (continued from a deficit finance since 1837), 1853 (continued from a deficit finance since 1848), and 1876, we can discover that the accumulated deficit finances became serious. That is, it was not unrelated to the fact that society entered a destructive period in the late Joseon. This period resulted from accumulated deficit finances. And in spite of surplus finances of around 150 thousand ryang, there was the persecution of Catholics in 1866.

It is noteworthy that there were no special events and a surplus finance of 783,404 ryang was recorded in the 9th year of King Jeongjo (1785). This

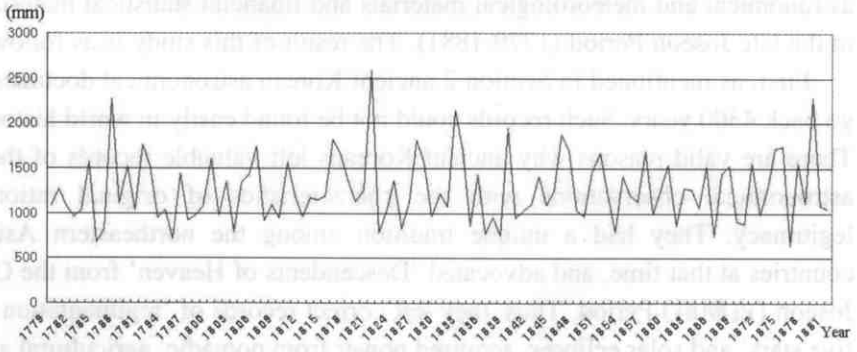


Fig-6 Precipitation records by Cheuku-gi (the rain gauge) (1779-1881)

was an exceptional phenomenon, and it makes us estimate that sound financial management was done in the King Jeongjo period. This is called 'the Jinkyeong period' (眞景時代, the Tranquil and Serene Period) as well as a restoration period to effuse dynamic energy.

We made the outstanding characteristics of 'the Tranqil and Serene period' clear through comparing 'jae-gyeol' (tax-relief due to disaster damage), 'surplus and deficit', and the precipitation according to the period. The King Jeongjo period was greatly different from the later 'the Power Ruling Period' in its periodical order, characteristics and pattern. That is, the sound financial management of 'Yang-ip Wi-chul' (量入爲出), which means a basic principle of Joseon to control annual revenues and expenditures economically, was applied to the King Jeongjo period. This is what we call 'the Tranquil and Serene Period'. Great differences from careless and confused accumulated deficit finances in 'the Power Ruling Period'.

4. Conclusion

We examined various forms of ancient Korean astronomical documents as they were recorded over a span of 4333 years. Their values as historical materials were exceptional in their accuracy, which we define as their validity and reliability. And we examined the relationship between astronomical and meteorological materials and financial statistical materials in the late Joseon Period (1779-1881). The result of this study is as follows:

First, as mentioned in Section 2 ancient Korean astronomical documents go back 4300 years. Such records could not be found easily in world history. There are valid reasons why ancient Koreans left valuable records of their astronomical observations with the characteristics of original rational legitimacy. They had a unique tradition among the northeastern Asian countries at that time, and advocated 'Descendents of Heaven' from the Old Joseon (古朝鮮) Period. Thus, they left correct records of 'regimentation of five stars' and solar eclipses, acquired power from nomadic, agricultural and oceanic culture through astronomical observations, and they embodied the

foundational idea of 'Hongik-ingan' (弘益人間, humanitarianism) wisely and practically by measuring the correct solar periods and directions. To rule the country in accord with the season and to accumulate documents and information about agricultural, fishing and sailing periods, the ancient Koreans had left many records of astronomical observations in the space of history. They endeavored to find out information and knowledge from astronomical materials that were indispensable for sailors, and it met the needs of the times.

As we examined above, Koreans tried to unify social cultures in order to progress as a maritime country. They did so on the basis of uniting nomadic and agricultural cultures and they accumulated astronomical materials, information, and knowledge of the exact 24 solar periods and direction. They did it systematically 4300 years ago. We studied Korean cultural characteristics to rule the country and society wisely and orderly in the light of its historical legitimacy and tradition.

Second, the records of ancient astronomical observations preserved in Korean historical documents are very important in that they maintain the scientific accuracy and consistency of observational methods. We can clarify this point by examining the records of 'Oseong-chwi' (the regimentation of five stars) in the Joseon Period and those of solar eclipses and 'Taebak-juheon' (the appearance of Venus in the daytime) in the Three Kingdoms Period, and those of long-term sunspots in the Goryeo Period. There was also the establishment of synthetic observational systems and the longest records of precipitation in the world by using Cheugu-gi (the rain gauge) in 'the Great King Sejong Period' during the early 15th century of the Joseon Period, and the first continuous records of supernova in the world for 7 months in the King Seonjo Period.

The reasons why Koreans produced continuous and unique achievements in the world are a necessity of information about the exact 24 solar periods for the cultural development of agricultural society at that time. Their interests in astronomical extraordinariness and natural disasters are due to their native *Kairos* view of time that human society is closely related to the natural change of time in agricultural society adapting to nature. Koreans had wisdom, that is, *Kairos* thought, to acknowledge and practice

the principle of Heaven. This *Kairos* view of time is based on the traditional legitimacy of 'Hongik-ingan' (humanitarianism). The proof of this is due to the fact that Koreans left many documents on astronomical phenomena and natural disasters. Their coverage of such significant events in the space of history last a long time.

It is a scientific and cultural masterpiece to uniquely express the Korean *Kairos* view of time (perceived time). It was found in 'the Three Kingdoms Period CYBD'. This was a crystal of vast astronomical materials, information and knowledge from the year 100 B.C. It contained methods to express astronomical observation materials. It has kept its historical legitimacy and tradition and succeeded to a United Silla and Goryeo. In addition, vast astronomical documents of 282 constellations and 1465 stars were expressed as the Joseon dynasty CYBD (天象列次分野之圖, the Korean National Treasury No. 228)).

Third, we examined that there occurred a change of climate and a natural disaster in a specific time. We also examined and pointed out that these conditions had a great influence on the financial and sociopolitical changes. We found this through analyzing the materials of ancient climate change and the financial history of the late Joseon period (1779-1881).

Fourth, from the statistics of the greatest Jae-gyeol (tax relief due to disaster damage) of about 190 thousand gyeol, we pointed out that grave natural disasters happened just before and after 1810. These disasters were followed by continuous civil war and the radical decrease of the number of households to 120 thousand households.

Fifth, if we consider that the record of precipitation was below 800mm (in 1785, 1795, 1803, 1822, 1838, 1853, 1866, and 1876), we can reconfirm that the climate had an indirect influence on the changes of finances, society, and institutes. That is, the financial status in 1803, 1822, 1838, 1853 and 1876 came to intensify an aspect of the accumulated deficit. Thus, we can discover that in the late Joseon period, society entered a deconstruction period because of the financial crisis that resulted from the accumulated deficit.

A remarkable historical fact is that during the 9th year of King Jeongjo (1785) the finances were in a surplus of 783,404 ryang. This is a very

exceptional case, and we can conjecture that was a result of sound financial management in King Jeongjo's period. This was called a restoration period and 'the Tranquil and Serene Period' (眞景時代) with effusing dynamic energy. In section 3 of this study, we noted the outstanding characteristics of 'the Tranquil and Serene Period' while we were comparing the Jae-gyeol, surplus and deficit, and the precipitation records through that time.

Sixth, the King Jeongjo period is very different from 'the Powering Ruling Period' in its order, characteristics, and pattern of times. King Jeongjo, a wise king in 'the Tranquil and Serene Period', had kept his diary through his life since he was appointed as the heir apparent (Son of Crown Prince) at the age of 9. He revived 'the Hall of Assembled Sages' (集賢殿) in the Great King Sejong period by establishing 'the Royal Research Institute' (奎章閣) a half a year after his accession, in 1776. He also institutionalized the writing down of historical events as well as all of the king's words and deeds in *Ilseonglok (日省錄, the Daily Diary of Royal Secretary*, the Korean National Treasury No. 153*)*. Furthermore, as one of the sage kings in the 18th century, he laid the foundation to open a new period of recording culture in the space of history.

In conclusion, we examined that there was a historical sense and a spirit of time based on the *Kairos* view of time, which were flowing in every era, country and society in the space of history, and they were expressed as a unique Korean pattern, with an exact rational legitimacy and consistent tradition. This was done through analyzing the documents of ancient astronomical observations extending from the 22nd century B.C. till the 19th century and those of financial history in the late Joseon period. Upon pondering the living historical sense, its characteristics, pattern and meaning in the Great King Sejong's golden period—a blossoming period of the foundational idea of 'Hongik-ingan' (弘益人間, humanitarianism)—in the 15th century and in the King Jeongjo period—called 'the Tranquil and Serene Period' (眞景時代)—in the 18th century, we would like to conclude the study as follows: "at a time when future-oriented historical consciousness and a open-minded spirit of time flow endlessly like a river, society's cultural arts will breathe since rationality and equality is maintained. As this spirit of Hongik-ingan(弘益人間) will be realized and

various scientific technological breakthroughs will blossom, we can feel the true breath of history. Therefore, only in such times, true statistical order and the energy to generate a new vitality can be created in human history."

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PART III

Change in Korean Society and Its Impact on Statistical Developments

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Abstract: Korean society is experiencing dramatic changes in socio-economic sphere and the changes have raised a few statistical issues. We attempt to show the trend of changes, impact of the changes on the field of statistics, and discuss countermeasure schemes to deal with the issues for statistical developments.

Keywords: countermeasure schemes, official statistics, statistical developments, statistical issues, trend of changes

1. Current System of Official Statistics in Korea

1.1 Current Practice in Statistical Compilation

Official statistics in Korea are classified into two types according to Statistics Law: designated statistics and general statistics. Governmental

and public institutions as authorized by the Commissioner of The National Statistical Office (NSO) compile both designated and general statistics. If a survey or census qualifies as designated statistics, the general public is obliged to provide information to the authority. Penal regulations are provided for non-observance of this obligation. However, there is no legal obligation to report information to the authority under the general statistics classification (see KNSO, 1999).

As shown in Table 1, a total of 407 kinds of official statistics were compiled as of 1 Feb. 2001. Among them, 79 kinds (19.4%) of statistics were classified as designated statistics. This means that the remaining 328 kinds (80.6%) of statistics are classified as general statistics. The 407 kinds of official statistics cover all sectors of Korean economy and society including demographic, social, economic, natural resources and environmental statistics. Examination of Table 1 by producers of statistics reveals that there are 130 producers designated as statistical agencies in Korea.

NSO itself is also one of such statistical agencies, playing a key role in the Korean statistical system. It has the responsibility of integrating and coordinating national statistical services as well as compiling fundamental statistics and disseminating integrated statistical information. As an

Table 1: Number of Agencies and Statistics (as of 1 Feb. 2001)

	No. of agencies	No. of statistics	By type		By method		
			Designated[1)]	General	Survey	Administ.	Process
KNSO	1	53	34	19	45	-	8
Central Gov't	26	167	17	150	59	106	2
Local Gov't	36	89	16	73	32	32	25
Public	67	98	12	86	70	22	6
Total	130	407	79	328	206	160	41

Note: 1) They refer to large-scale surveys covering the whole country. The general public is subject to supply information for compiling statistics.

independent central government authority, NSO is under the supervision of The Ministry of Finance and Economy, but as far as technical matters are concerned, it responds directly to the appropriate ministries.

Table 1 also shows the number of statistics by methods of compilation. In Korea, 50.6% of the official statistics are compiled on the basis of conducting surveys or censuses. On the other hand, 39.3% of the total are compiled for utilization of administrative records. The use of such administrative records requires much attention in order to produce official statistics in the future.

1.2 Statistical Personnel

Table 2 shows the number of statistical personnel working for central and local governments in Korea. As of 1 July 2000, the total number of

Table 2: Statistical Personnel in Korea

	1 Feb. 1990	1 July 2000
Total	5,148	4,809
Central Gov't	3,714	3,339
· NSO	1,286	1,671[1)]
· Agriculture	2,056	1,252
· Others	372	416
Local Gov't	731	995[2)]
· Provinces	148	104
· Counties	583	840
Public Institutions	703	475
· Bank of Korea	261	208
· Others	442	267

Source: KNSO, Results of Statistical Activities' Status Survey

Note: 1) The figure includes 500 persons transferred to NSO from Ministry of Agriculture on July 1998.

2) The figure includes 51 persons working for Provincial Offices for School Affairs.

persons is shown to be 4,809. Of them, 1,671 persons are in NSO, 1,252 persons are in The Ministry of Agriculture & Forestry, and 208 persons are in The Bank of Korea. Apart from the above three agencies, the statistical activities of other central governments are found to play a minor role, having a very small number of statistical personnel. In the case of local governments, it is found that each province has 6.5 persons and each county has 3.3 persons working for statistical areas on average. Compared to that of Japan, the size of statistical personnel in Korean local governments is found to be much smaller (each prefecture in Japan has 51.4 persons on average). Nevertheless, the size of statistical personnel in central governments and in public institutions decreased by 10.1% and 32.4%, respectively, over the last 10 years as indicated by KNSO (2000).

2. A Few Important Changes in Korean Society

The statistical measurement of the events that describe our society is now going through dramatic changes. Several factors are known to have contributed to these changes.

In the economic sphere, as Franchet (1995) discussed, globalization of activities at regional and world levels is accelerating, and is accompanied by strong deregulation, resulting in the loss of traditional statistical sources. Korea is no exception in this globalization trend, especially after becoming one of the OECD member countries since the end of 1996. A big share of trade volume among world trade is another incentive for Korea's alignment with the globalization trend (Korean trade volume ranks 12th with 2% of world trade volume).

In the social sector, our societies are becoming more complex and traditional core values of the 20th century are changing, which is a reflection of the changing world. Attitudes vis-a-vis employment, mobility, life-styles and family structure continue to change. There are abundant examples of change: the post of permanent job is substituted by part-time job, the nuclear family is commonly having less than two children, divorce is increasing, people give a high priority to leisure activities, foreign labor

migrants who have a different cultural background are increasing, and so on. Assessing the effectiveness and efficiency of social policies becomes a growing concern for policy makers.

Since local autonomy was introduced in 1995, demand for regional statistics has been more conspicuous than ever. Policies in several fields, including agriculture, fishery, tourism, transport, environment and others, have to take account of regional and local consequences, and not be in contradiction with regional policies or with town and county planning. New technology (Geographical Information Systems) provides the tool to handle data with detailed spatial reference, thus helping official statisticians, and at the same time stimulating a demand from local administrations and market operators for geographically detailed data.

The information society is progressing. The global economy is steering away from the industrial age towards a digital economy. The development of information technology and a rapid expansion of the internet are altering traditional social and economic paradigms. As the digital economy proceeds further, spatial and temporal distance is meaningless, which was emphasized in the past industrial society for the acquisition and utilization of core production elements such as land, labor and capital. Higher priority is placed on access to information and knowledge that advance the efficiency of the utilization of those production elements, rather than on the

Table 3: Trends and Impact on Statistical Fields

< Changes >		< Emerging Issues >
· Globalization · Complexity in Society · Information Society · Localization	↔ Increase in Demands ↔	· New Information · Privacy · Role of Private Sector · Integrity · Information Technology · Uncertainty Increase · Internet Use Increase

acquisition of them. That is to say, as the digitization of the economy progresses further, we will move into a knowledge-based economy where knowledge and information are more highly valued, as mentioned by KNSO Commissioner Yoon (2000).

At this juncture, policy makers and researchers demand that statisticians measure and explain these socio-economic changes. All of these changes and emerging issues can be summarized as in Table 3.

3. New Emerging Issues

The changes in Korean society have undoubtedly influenced many fields and raised new emerging issues in the area of official statistics. Firstly, one of the most important phenomena arising from the changes is the enormous increase in the demand for new information. Furthermore, the new information is required to be more accurate, extensive and timely available. Several factors as mentioned in Section 2 contribute to the big increase in the demand for new information. These factors include trends of globalization, increasing complexity in society, localization and rapid advancement in information technologies. The rationale between the increase in demand for new statistics and the changes in society is as follows. First of all, there is a growing consciousness of the decision makers at the national, regional and world levels that the globalization of the world economy requires more comparable and timely statistics for decision making. In a period of rapid change and growing uncertainties, governability becomes more difficult. As a result, national and world leaders need statistics to help them make difficult choices. At the same time, the market economy becomes the dominant form of economy at the world level. The markets need statistics to perform adequately and as market operators become more active and better educated, their demand for statistics (including internationally comparable data) becomes greater. The increase in demand for statistics stems also from the changes of socio-economic situations surrounding us, such as aging population

structure and diversification of the value premises of the people. Also, introduction of the local self-governing system in Korea in 1995 contributed to the increase in the demand for statistics. Furthermore, being a member country of OECD as of the end of 1996 is another component to the increase in demand for statistics. OECD requires a total of 63 questionnaires covering most areas of statistics. Article 3 (a) of the Convention of the OECD (1991) requires its Member countries to supply statistical information which is either already available in national administrations, or which can be generated from data available in the administrations.

Secondly, it is recognized that privacy and confidentiality concerns are heightened. There is an increasing reluctance of individuals and firms to accept and respond to statistical inquiries. Reluctant individuals refer to respect of privacy as their main rationale to refuse responding, while firms refer to response burden and protection of individual data. As a result the statistical information collected about society would diminish its quality. As discussed by Fienberg and Willenborg (1998), the situation is "On the one hand, there is the agencies' public obligation to provide maximum information to society, while, on the other hand the agencies must ensure that the privacy of individual entities represented in the data is sufficiently protected" and should be balanced.

Thirdly, the role of private sectors in producing statistics has been increasing. There has been a big increase in the volume of data that is being collected by non-governmental organizations. These may be profit or nonprofit oriented organizations. In the not so distant past, it was only the government, which had both the access to data about its citizens and the ability to process this data into information. In other words, the production of official statistics remains a public good, for ethical reasons and because the market is not ready to invest in the costly infrastructures of this sector. In some countries including Korea, this situation has changed already and in others, it will change in the near future. Some examples may serve to clarify this point. Point of sale scanners now routinely collect masses of data about which and how many products are sold and their cost. These data sets, along with the computer networks that allow sharing of the information and the software that will process the data enable private concerns to offer

exceptionally timely consumer price indexes at very small local areas. Now, most statisticians would assert that this data is biased and is not a representative sample. In any event, the pressures from the increasing role of private sectors force official statistical systems to become effective and efficient producers and disseminators.

Fourthly, the loss of unquestioned authority of official statistics is found in our society. Official pronouncements were taken as fact. However, nowadays the lay public, including politicians, gave deference to the authority of the official statistician in his or her field. They may have discarded the results presented by the official statisticians but they usually did not enter into public debates about whether the methodology was correct or if a different model should have been used.

Fifthly, in the case of the rapid advancement in information technologies, it has both positive and negative effects on statistical fields. The rapid developments in electronic data processing and data transfer technology directly affect the relationships between suppliers and customers of statistics. Increasingly, they have access to fast computing power and sophisticated data transfer facilities. As a consequence, new ways of electronic data interchange, both on the input and on the output side, have to be devised. Technological progress in automation has also had profound consequences for the statistical production process. At the same time, this creates many challenges for the producers of statistics.

4. Statistical Development Schemes

4.1 Gaining Users' Trust for Official Statistics

Users of a statistical agency's data must be able to trust that the data were collected and analyzed in an objective, impartial manner and that they are as reliable as the agency can make them. An agency should also make every effort to provide accurate and credible statistics. If a statistical agency cannot gain users' trust for statistics, it is possible that the respondents will not be cooperative with statistical surveys or censuses. As a result the

quality of the statistical information would diminish, which is undesirable for society. Thus, gaining trust from the general public is crucial for statistical agencies to undertake its role. There can be many ways to enhance the credibility of statistics. Most important is to observe the basic principles of official statistics. Among them, three studies are introduced in this paper.

The first is "Principles and Practices for a Federal Statistical Agency" published by The National Research Council (2001) of U.S.A. (1st edition in 1992 and 2nd edition in 2001). It presents three principles for a federal statistical agency; i) an agency must be in a position to provide information relevant to issues of public policy, ii) an agency must have a relationship of mutual respect and trust with those who use its data and information, and iii) an agency must have a relationship of mutual respect and trust with respondents who provide data. The second is "Fundamental Principles of Official Statistics", first adopted by ECE in 1992 and subsequently endorsed by The UN Statistical Commission in 1994. De Vries (2000) depicts its ten principles; i) relevance, impartiality and equal access, ii) professionalism, iii) accountability, iv) prevention of misuse, v) cost-effectiveness, vi) confidentiality, vii) legislation, viii) national coordination, ix) international coordination, and x) international statistical cooperation. The third is an article on "The Responsibility of the Chief Statisticians" by McLennan (2000). The article presented six responsibilities of the Chief Statistician. They are i) relevance of the statistics, ii) good planning, iii) integrity, iv) trust of the suppliers of data, v) quality, and vi) privacy issues.

It seems that the above three studies are overlapped in some way. In any event, these principles should be practiced by statistical agencies as a way to gain the trust for official statistics from the general public.

4.2 Production of Small Area Statistics

Since local autonomy has been practiced in Korea since 1995, demands for regional statistics have been increasing. However, it is found that small area statistics are lacking. Regional statistics are compiled two ways. One

is through the regional offices of central governments, and the other is through local governments (see Table 4). However, the role of the regional offices of central governments is confined to the activities of data collection only ordered by the headquarters. They are not in a position to play a role as a data dissemination center or as a producer of regional statistics. The role of the local governments is also shown to be very limited. Their major functions are to publish an annual statistical yearbook, and to cooperate with central governments in case of conducting censuses or large-scale surveys. However, looking into the contents of the annual statistical yearbook reveals a poor quality of statistics. Some of regional statistics in the annual statistical yearbook are lacking in accuracy, timeliness and relevancy. It is very natural that the statistical activities of local governments are very weak since the number of statistical personnel is so few. Each provincial statistical division has 6.5 staff-members on average and each county's statistical section has only one person. With this limited number of statistical personnel, it is not easy for local governments to develop and carry out their own statistical programs.

NSO is compiling various kinds of statistics for small areas from the annual Census of Basic Characteristics of Establishments, the quinquennial Population & Housing Census and the quinquennial Agriculture Census. However, local governments are not satisfied with the timing of the availability of the statistics that NSO provides on the basis of the results of

Table 4: Regional Statistical Activities

Through NSO's Local Offices	Through Local Governments	Other Regional Offices
Headquarters ↓ 12 Local Offices ↓ 35 Sub-local Offices	7 Metropolitan Cities, 9 Provinces (Statistical Unit) ↓ Cities, Counties and Districts (256) ↓ Sub-district s, town sand townships (3,701)	Ministry of Agriculture & Forests, Ministry of Labor, The Bank of Korea, Chamber of Commerce & Industry ↓ Local Offices, Branches

the above mentioned censuses. They also need statistics on employment, industrial activities and prices, which are important in policy making for local government. But they are not compiled for each county and district. It is therefore essential for central and local governments to compile small area statistics that can be used in various ways.

One way is to reinforce both the numbers and the qualifications of the statistical personnel at the local governments. In the meantime, NSO should do its utmost to compile and provide small area statistics in a timely fashion. If NSO is not able to provide small area statistics in a timely manner, it is better for local governments to be given a right to process and tabulate data by themselves.

4.3 Introduction of Marketing Approaches and Concepts

As discussed in Section 3, we are now in an era where: i) our previous unquestioned authority is now suspect in many people's minds, ii) the demands for timely and relevant information exceed our capacity to supply it, and iii) we have powerful competitors able and willing to supply information that was previously only the domain of the statistical agencies, including NSO. These challenges should be taken into consideration especially in terms of how they affect official statistics. How do we prepare ourselves for an uncertain future? One of the feasible solutions is to introduce marketing approaches of statistical products. As Habermann (2000) says, the development of marketing approaches can be done by identification and cultivation of users, the use of focus groups, dealing with the media, making changes in statistical law, brand identification and pricing of statistical products.

In addition, statistical products should be made to be easily understandable to users. Statistical agencies should keep in mind that many users are rather ignorant of statistics. If they produce statistics only from their point of view, it is natural that the statistics will not be widely used. Consequently, no widespread use of statistics leads to a social loss since statistics is a tool for decision making rather than an ultimate goal itself. In other words, the production of understandable statistics is one of

the components for raising the overall productivity of societies.

NSO has done its efforts to disseminate statistics in a convenient way for users to use. One of the efforts has resulted in the set-up of a portal site named Stat-Korea (www.stat.go.kr), where users can find all kinds of statistical information if they visit the portal site. NSO has also striven for identifying users and their need for statistics. This has been reflected in the Statistics Using Status Survey conducted on a biennial basis. Among the major findings, the following three aspects are revealed to be mostly needed by users; i) micro data, ii) data on newly emerging sector, and iii) data on the future.

In summary, the introduction of marketing of statistical products such as identification and cultivation of users, pricing of statistical products, etc. is the solution to meet such requirements. Perhaps more important, however, is that we will need to change our mindsets. Marketing is not simply how to create additional revenue. The more important change is to understand that we will be entering a highly competitive world where new marketing approaches and marketing concepts, such as brand identification, are fundamental to the survival of the NSO.

4.4 Strengthening of Statistical Coordination Activities

National statistical service systems can be classified into two types. If a single autonomous government agency is responsible for the management and operations of the statistical programs, the system is a centralized type. Meanwhile, if the statistical programs are managed and operated under the authority of several government departments, the system is a decentralized one. The Canadian system is a typical example of the centralized type, while the systems of U.S.A. and Japan are typical examples of the decentralized type. The Korean statistical system is regarded as a decentralized one in that each government agency (26 agencies) has the responsibility to collect those statistics relating to its particular field.

Both centralized and decentralized systems have advantages and disadvantages. The advantages of decentralized system are as follows. Each statistical agency is in a better position to ensure optimum use of the

data (easier exploitation of administrative records). This leads to a better understanding of the uses of the statistics for policy purposes and accordingly to better and more relevant statistics being produced. Further, each government agency is in a better position to be responsive enough to the changing needs of users. On the other hand, the decentralized statistical system has some disadvantages. It is not easy to take advantage of the economies of scale, especially in terms of the utilization of skilled human resources. It is also found not to be easy for a Central Statistical Organization (CSO) to maintain balance in the priorities assigned to different statistical fields, that is, to coordinate the entire service. Other disadvantages stem from the fact that it is not easy for each statistical agency to be free from special departmental influences and interests. Thus, it is not easy for a CSO to gain a reputation for objectivity. Thus, it is essential to establish a central coordinating body to promote the integration of statistics and coordination of activities, if a national statistical system is decentralized.

The Korean situation, specifically, requires a stronger statistical coordination body. Although Korea's statistical system is a decentralized one, the statistical activities of some government agencies are very weak. The number of statistical personnel is typically very few in ministries in charge of public health, commerce, construction, transportation, education and environment. Only three agencies (NSO, The Ministry of Agriculture & Fisheries and The Bank of Korea) are playing their own roles having a large number of statistical personnel. The weaker statistical activities in various ministries are seen more clearly, if one compares them with those of other countries. It is shown in Table 5 that the statistical activities are very strong in countries such as U.S.A., Japan and France. Although these countries adopt the decentralized statistical system, they also keep a large number of highly trained personnel in various ministries.

In Korea, the Statistical Coordination Division of NSO is charged with the responsibility for coordinating the statistical activities of the various departments. This division fulfills its functions with the practical means such as authorization by giving power to collect data to the statistical agency, and approval of the statistical results for publication. These

Table 5: Statistical Personnel in Ministries

Ministries	Korea ('01.2.1)	Japan ('94.4.1)	U.S.A (1999)	France ('92.12.31)
· Economic Planning	0	89	n.a	n.a
· Education	0 (3)	25	570	431
· Health	5 (84)	427	n.a	176
· Agriculture	1,252	6,410	1,107	709
· Industry & Trade	3 (24)	440	n.a	303
· Construction & Transportation	3 (44)	187	n.a	298
· Labor	40 (62)	247	2,485	274
· Justice	0 (3)	14	n.a	76
· Environment	3 (37)	n.a	n.a	n.a

Note: 1) The number of personnel include those working for regional offices under each ministry.

2) The figures in brackets in Korea refer to total number of persons working for non-statistical units but doing the compilation of statistics based on administrative records.

provisions are stipulated in Statistics Law that was enacted in January 1962 and most recently amended in January 1999. It is, however, found that the actual implementation of coordination works by NSO is not carried out well due to various reasons. The NSO does not have a power to outpost staff to other departments and to allocate statistical budgets. Furthermore, in the Korean context, it is not easy for NSO to maintain effective horizontal influences with other agencies since the NSO Commissioner's post is at the assistant minister's level in the governmental hierarchy, which is not compatible with that of a minister. Another constraint is the small number of statistical personnel in The Statistical Coordination Division of NSO. Thirteen staff-members are not enough to handle the statistical activities of

130 agencies.

Examples of some other countries indicate the highly well organized fashion in statistical coordination. The President of INSEE of France has power in outposting senior staffs to other governmental departments. In the case of U.S.A., the statistical system is highly decentralized, with more than 70 federal agencies and offices engaged in statistical activities. However, The Office of Management and Budget is responsible for coordinating statistical work, issuing standard classification systems, consulting on statistical budgets, identifying programs that may be duplicative, and reviewing all questionnaires for the collection of data from 10 or more respondents. In the case of Japan, there is a Law on Statistical Coordination in addition to a Statistics Law. The examples of other countries imply that the statistical coordinating work should be strengthened in Korea.

4.5 Reinforcement of Statistical Personnel

Table 6 shows the number of statistical personnel working for the central and local governments for some selected countries. In the case of Korea, the total number is shown to be 4,809 persons as of 1 Feb. 2000. Out of them, 1,692 persons are in the NSO, 1,668 persons are in 25 other central government departments, and 944 persons are in local governments. The last three lines show the ratios of statistical personnel to the population size per million. The first one (A/D) indicates the ratio of total statistical personnel to total population. The second one (B/D) shows the ratio of CSO personnel to population, while the third one (C/D) indicates the ratio of CSO's headquarters' personnel to population. It is found that the ratio of total statistical personnel to total population (A/D) is only 102 in Korea. The level is about half of that of other countries such as Indonesia (255), Germany (212), Netherlands (210), Japan (195), Australia (179), France (172) and Italy (171). This implies that the overall statistical activities in Korea are weaker than those of the above mentioned countries.

It is also observed that the size of personnel at NSO is relatively small in comparison with those of some other countries. The ratio of NSO

Table 6: Comparison of Statistical Personnel

	Korea[1] (2000)	Japan (1996)	China (2000)	Australia (1997)	U.S.A. (1996)	Canada (1995)	Germany (1996)	France (1995)
Total(A)	4,809	14,191	n.a	3,320	n.a	n.a	17,270	n.a
CSO(B)	1,692	1,688	19,500	3,250	9,357	6,906	11,968	7,000
· Headquarters(C)	430	1,688	1,500	1,650	5,292	4,908	3,110	5,400
· Branches	1,262	0	18,000[3]	1,600	4,065[4]	1,998	8,858	1,600
Central Gov'ts	1,668	7,997	n.a	50	n.a[5]	n.a	1,302	3,000
Local Gov'ts	944	14,683	70,000	20	n.a	n.a	4,000	n.a
· Provinces	104	2,418	n.a	n.a	n.a	n.a	n.a	n.a
· Counties	840	12,265[2]	n.a	n.a	n.a	n.a	n.a	n.a
Pop.(Mill., D)	47.3	125.1	1,277.6	18.5	265.7	29.5	81.6	58.0
A/D	102	195	n.a	179	n.a	n.a	212	n.a
B/D	36	13	15	176	36	234	147	121
C/D	9	13	1	89	20	166	38	93

Note: 1) The numbers are not identical with the numbers in Table 2 due to the different definition.

2) It includes the personnel (10,177) doing both statistical and other administrative work at sub-local governments.

3) The numbers are comprised of those working for Urban Survey (3,000), Rural Survey (8,000), and Establishment Survey (7,000).

4) Among them, 3,356 persons are interviewers at 12 regional offices.

5) For example, there are 570 persons in BEA, 2,485 in BLS and 1,107 in NASS.

personnel to population is calculated to be 36 in Korea, while some other countries show a bigger number: Canada (234), Australia (176), Germany (147) and France (121). Although one takes into account the high degree of centralization in those countries, the number of personnel at NSO is still relatively low. Making things worse is the quite small number of personnel at the headquarters of NSO. The ratio of statistical personnel at NSO's headquarters (C/D) is shown to be only 9. This level is comparatively small compared to those of some other countries: Canada (166), U.S.A. (20) and Japan (13). All of the above three ratios for Korea indicate the necessity of reinforcement of statistical personnel. Especially, the reinforcement of

statistical personnel at NSO's headquarters is imperative in order for NSO to play a role as a central statistical organization.

4.6 Exploitation of New Data Sources

The range of statistics produced by statistical agencies can be expanded by exploiting new data sources such as administrative and transaction data holdings both in government and business. It can reduce the costs and the burden to respondents by using the administrative records for statistical purposes.

The exploitation of administrative records for statistical purposes is well developed in some countries. France has developed a so-called Unified System of Enterprise Statistics since the middle of the 1970's. The INSEE of France gives a unique identification number when an establishment reports its set-up to local government offices. This system has been fully used for production of statistics on births and deaths of establishments as well as benchmark data for use in surveys. Another example of extreme use of the system was the comparison work of the system with the questionnaires of the 1990 Population Census. It was analyzed by Picard (1997) that 73 percent of industrial classification was mutually matched between the register and the population census. Meanwhile, in the case of the Netherlands, a successful revision of the Statistics Law was made in 1996, which enabled the statistical office to access the taxation data. In the case of Australia, the Australian Bureau of Statistics (2000) made an agreement having a Memorandum of Understanding with the Australian Taxation Office in 2000. On the basis of this arrangement, the bureau is developing programs to exploit the new data source for statistical purposes.

In the NSO, such statistics as vital, internal migration and cause of death statistics are being compiled on the basis of the administrative records of vital events. However, the system is not yet established to use taxation data for the compilation of economic statistics. It is, however, found that continuing advances in information technology are gradually eroding many of the threshold barriers to exploiting the taxation data for statistical purposes. In Korea, three kinds of taxation data can be used for the

compilation of economic statistics: register of births and deaths of establishments, register of value added tax (VAT) which is updated biennially and register of legal enterprises which is updated annually. The register of births and deaths of establishments has items on ID number, kind of activity and number of employees. In the case of the register of VAT, the amount of turnover is reported twice a year to the tax office. In the case of the register of legal enterprises, the balance of payment and the profit-and-loss statement are reported to the tax office on an annual basis. These three business registers for taxation purposes are regarded to be good data sources for the compilation of economic statistics. The examples of other countries suggest the urgent revision of Statistics Law in order for NSO to access various administrative records, including the taxation data.

5. Summary and Conclusion

This study attempted to show the trend of changes that our society is experiencing recently, a few statistical issues raised by the changes and countermeasure-schemes to deal with the issues. It was pointed out that there are trends of globalization, increasing complexity in society, localization and rapid advancement in information technologies. The impact of these changes on the field of statistics are summarized as follows: heightened privacy concerns, the prevailing lack of integrity for statistics, the increasing role of the private sector in producing statistics, the rapid increase for statistical demands and the application of new information technologies.

As for countermeasures, the following six schemes were emphasized. Firstly, the trust for official statistics from the general public should be attained. In collecting, processing and releasing statistical information, the basic principles of official statistics should be practiced by statistical agencies as a way to gain the trust in statistics from the general public. Secondly, regional statistical activities should be upgraded by reinforcing both the numbers and the qualifications of the statistical personnel at the

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local governments. Thirdly, the concept of marketing is to be introduced when statistical agencies produce and disseminate statistics. Fourthly, the strengthening of statistical coordination activities by the Korean NSO is necessary. The effective way to strengthen the coordination activities is to empower the NSO with the authority to appoint statistical personnel at its discretion from central and local governments. It is also necessary for NSO to have the power to control the statistical budget of other agencies. Fifthly, it is imperative to boost the size of personnel in statistical agencies, especially at the headquarters of the Korean NSO. Lastly, the administrative records should be fully exploited for statistical purposes. It is necessary to revise the Statistical Law in order to access various administrative records including the taxation data.

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The Historical Changes of the Statistical System in Korea

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Abstract: The Korean Statistical System, which maintains a decentralized statistical system, has changed over time, and each specific era had its own characteristics to reflect user needs. Just after Korea's national foundation in 1948, the central statistical agency belonged to the Office of Public Information. The government wanted to produce basic statistics and make public relations so as to guide people with poor basic statistics. After the Korean War, the agency was transferred to the Ministry of Home Affairs in order to effectively get practical statistical data through the administrative channels. It was transferred again in 1961 to the Economic Planning Board which was established to coordinate national economic development. The National Bureau of Statistics was enlarged and upgraded in 1990, and the name was changed to the National Statistical Office.

Keywords: Decentralized Statistical System, United States Statistical Consultant, Statistics Law, Socioeconomic Development Plan, Statistical Development Policy, Information-oriented Society

1. The Establishment of the National Statistical System and Compilation of Basic Statistics

When the Second World War ended in 1945, Korea was liberated. At that time the statistical activities in Korea were very poor, because there were very few statistics available. Furthermore, there were many inconsistencies and errors due to the fact that there was no central statistical agency to prevent duplication, omission and contradictions among the statistics. A general election was conducted in South Korea under the

United Nations' supervision, and Korean constitutional law was promulgated in 1948. A new government was founded, and the Office of Public Information under the prime minister was established.

At that time, the Bureau of Statistics was established in the Office of Public Information. The Bureau of Statistics had one officer and 4 divisions (General Services, Planning, Population Census, and the Vital Statistics Division) with about 1,000 staff members. The Korean government announced a presidential decree for a Population Census which was the first official statistics. This means that population statistics were the most important in support of national development policy. Also, the government legislated a Population Survey Law in 1949, and stipulated a decennial Population Census and Simple Survey between censuses in years ending in 0 or 5. The government decided to conduct a Population Census in 1949 in order to get basic demographic data to help an economic development plan. However, they could not tabulate the total results of the Population Census because the Korean War broke out suddenly in 1950.

The Year-end Population Survey which had been conducted since 1896 was one of the major statistics along with the Population Census. However, the Current Population Survey was a reporting statistics gathered through administrative channels. Therefore, the survey result was only used for administrative purposes among the administrative agencies because its reliability was low.

At that time, Vital Statistics was transferred to the Bureau of Statistics from the Ministry of Health and Social Affairs under the US military government. The Vital Statistics Survey was conducted in 1949, but the results disappeared during the Korean War which broke out in 1950. The Household Economy Survey which has been conducted in 120 households in Seoul since 1950 enlarged its sample size to 600 households in 1959. The basic characteristic of this survey was the first sampling survey based on probability sample theory in Korea.

Furthermore, the Bureau of Statistics conducted a Labor Force Survey, a Survey on Industrial Equipment, a Resource and Production Survey, and a Housing Census, etc.

The other ministries also compiled statistics in the process of

accomplishing their own affairs. The Ministry of Agriculture and Forestry had three statistical divisions to compile basic agricultural statistics such as cultivated acreage, number of farm households, agricultural products, livestock, etc.

The Korean government required a large proportion of the national budget for national defense and civil relief work because it was just after Korea's national foundation. The governments financing was supported by the Bank of Korea and foreign countries' assistance because the national tax was not enough to cover government expenditure. Therefore, the government requested the Bank of Korea to conduct some basic statistical surveys. To help the government's development policy, the Bank of Korea established a statistical department and compiled monetary and financial statistics.

As stated above, some statistical structures were already established and compiled basic statistics necessary for national administration in the early stage of national foundation. The basic statistics in the field of demographic, agricultural and economic aspects were compiled in undeveloped ways.

2. The Statistics in a State of Disorder and the Activities of a US Statistical Consultant

2.1 The statistics in a state of disorder

Korean statistical activities were extremely limited during the Korean War(June 1950～July 1953). But the statistical system was reorganized in 1955 after the war in order to effectively compile statistics. The Bureau of Statistics, which had belonged to the Office of Public Information, was transferred to the Ministry of Home Affairs. In this context, the number of personnel of the bureau was decreased to 253(58 full time, 195 part time). This meant that the financial difficulties of the Korean government were serious after the Korean War, and there was a need to reorganize the government structure. The government wanted to collect basic data through administrative channels under the Ministry of Home Affairs.

In fact, the statistical activities were poor as a result of insufficient budget allocation and the small size of statistical personnel after the Korean War. Therefore, the Korean government established 'The Outline to Strengthen Statistical Administration' in order to enlarge the statistical function in an attempt to coordinate and develop statistics.

The new government which held political power through military force established the Economic Planning Board in 1961 to effectively establish and coordinate the national economic development plan. In this process, the Bureau of Statistics, under the Ministry of Home Affairs, was transferred to the Economic Planning Board. Also the Bureau of Statistics was renamed to the National Bureau of Statistics. The newly established Statistical Council took over the function of the Population Census Council in 1962.

The other ministries such as the Ministry of Agriculture and Forestry, the Ministry of Health and Social Affairs, the Ministry of Commerce and Industry had statistical functions pertaining to their own affairs, respectively.

The Bank of Korea established a new division of Industrial Statistics Division to compile statistics on basic industrial fields after the Korean War in 1953. Also, the bank was in charge of statistics on national accounts, monetary, finance, and industrial production.

In 1960, the Korean Statistical Association was established and participated in the 32nd Session of the International Statistical Institute in Tokyo. This was the first statistical activity of the private sector in Korea.

2.2 The activities of the United States statistical consultant

The United States Survey & Research Corporation had conducted consulting services for the Japanese Statistical System after the Second World War and made a contract with the International Cooperation Administration of the United States government on the consulting services to develop the statistical system and help the statistical activities in Korea in 1958. The consultant continued its services for five years in Korea.

The statistical consultant made recommendations to the Korean government on the Population and Housing Census, and Agriculture Census

as follows:

1) The ministries concerned should take charge of the affairs of the planning, survey and tabulation on the Population and Housing Census, and Agricultural Census, while the Population Census Council should supervise the progress of the censuses.
2) The Bank of Korea should conduct the Agriculture Survey which was already drafted.
3) The data processing facilities should be concentrated under the Population Census Council, and the facilities should be jointly used by various ministries.

As such, each ministry had its own responsibility to conduct the censuses, and the National Bureau of Statistics would play a pivotal role as a central statistical agency in coordinating statistical activities.

The statistical consultant reviewed every aspect of statistical activities, such as statistical accuracy, survey technique, data processing, legislative problem, government statistical system. It was recommended that the Korean government should reform the current statistical system.

According to the recommendation, the Korean government established the Council on Statistical Publication in 1959 to review statistical publications, and the Council on International Statistical Research in 1960 to discuss the standards of industrial classifications. Whenever the councils had meetings, the United States statistical consultant attended them and gave advice on their research and decisions. Those two councils were later absorbed into the Statistical Council which was mandated by Statistics Law.

The United States statistical consultant recommended to the Korean government some important issues on statistical activities. They were mainly on the reformation of statistical structure, and training of statistical members such as:

1) The general purpose of statistics except special cases should be controlled by the National Bureau of Statistics. The National Bureau of Statistics should serve the ministries as the United States Census Bureau did. The National Bureau of Statistics should consult and supply its specific

techniques and experiences to the other statistical agencies.

2) The National Bureau of Statistics should establish a sampling research institute, and adopt a sampling technique in order to reduce the survey personnel and budget. The personnel of the institute should be well trained.
3) The National Bureau of Statistics should establish a data processing institute, and the institute should operate with modern IBM facilities which had been used for the 1960 Population Census. IBM facilities would be used as the main data processors in Korea.
4) The structure of agricultural statistics should be strengthened to compile various kinds of agricultural data to help agricultural development. The Agricultural Statistics Division should be upgraded to bureau level or controlled directly by the minister.
5) The coordination function of statistics should be strengthened to develop statistical activities in Korea. For this purpose, the Korean government should establish a special coordination agency, or the National Bureau of Statistics should have this function.
6) The Population Census Council should be reformed to the Statistical Council in order to strengthen its power and keep an independent function.
7) The Korean government should make Statistical Law to establish an effective statistical system.
8) The universities should open statistics departments, and the graduates from statistics departments should be preferred for employment in the public sector.

The statistical consultant also indicated that enumerators in the Agricultural Census were not qualified, and they did not have enough equipment for the survey, and recommended that the Economically Active Population Survey instead of the Labor Force Survey should be conducted in order to improve sampling techniques, questionnaire designs etc. Also, they recommended that the Vital Statistics Survey should enlarge its sample size and strengthen the reporting system.

The statistical consultant monitored the activities of various Korean

statistical agencies for 3 years commencing in 1961, and reported to the United States Government the current state and future directions of Korean statistical activities.

In fact, the Korean statistical activities were so poor in the early 1960's that the United States statistical consultant recommended that the Korean statistical system establish a theoretical background, practical techniques, and a well-designed system. But the statistical consultant ignored the Korean historical background of statistical development, and evaluated Korean statistical activities and social circumstances from a point of view of the United States. Korea had many problems because all of the facilities and the system were destroyed during the Korean War. The Korean government obviously tried to restore the economy and society as its main priority rather than develop statistical activities. Therefore, the statistical consultant indicated shortage, incompleteness, and fickleness of Korean statistical activities. However, the Korean government wanted to comply with the consultant's evaluation and opinion on statistical activities in Korea.

The consultant also insisted that the National Bureau of Statistics should have the responsibility of coordinating statistical activities of various statistical agencies. Therefore, the Korean government made the necessary changes according to the statistical consultant's request. In 1962, the Korean government promulgated Statistics Law, and established a Statistical Council. The Ministry of Agriculture and Forestry enlarged and upgraded its statistical division to bureau level in 1971. In practical surveys, the Korean government conducted the Economically Active Population Survey, and developed the Vital Statistics Survey, etc.

3. Statistical Development in the Economic Growth Period

3.1 Reform of statistical system to help the economic development plan

In the planning of economic development, the government needed many kinds of statistics to measure the current situation, and tried to strengthen statistical activities. The statistics which were made by various agencies had

inconsistencies with each other and their reliability was very low because there was no coordinating agency. The statistics could not effectively assist an economic development plan. Strong countermeasures were required to develop a statistical system and activities. This provided the incentive for the Korean government to legislate Statistics Law which became a fundamental law in the field of current statistical activities. The Statistics Law prescribed the decentralized statistical system which enables each ministry or non-governmental agency with the responsibility of compiling various statistics related to its own field, and empowered the central statistical agency to function as coordinating agency to remedy duplication or omissions among statistics. Under these circumstances, the National Bureau of Statistics, which is the central government agency in the field of statistics, plays a key role in the Korean statistical system. It has the responsibility of integrating and coordinating the national statistical services as well as compiling fundamental statistics and disseminating statistical information.

According to the Statistics Law, the official statistics shall be divided into two categories; 'designated statistics' and 'general statistics'. Designated statistics are the statistics which shall be designated and announced publicly by the Commissioner of the National Statistical Office among the statistics compiled by a statistical agency 1. Since the designated statistics are important as the basic data for policy-making, individuals and juridical persons or bodies are obliged to report the statistical data required for compilation of the designated statistics. General statistics are statistics other than the designated statistics compiled by statistical agencies. The government increased the number of designated statistics and strengthened the coordination function to establish an effective statistical system. In this context, the new Statistics Law absorbed the previous Population Survey Law, Resources Survey Law, etc. and the reporting obligation of raw data and a penalty for violating Statistics Law were strengthened. Also, the government set up a total of 25 rules including the Economically Active Population Survey Rule by 1971. In particular, the Rule on Approval for

1 Article 3 of Statistics Law.

Statistical Publication greatly contributed to strengthen the reliability and consistency of Korean statistics.

The Bureau of Statistics had dispatched enumerators to local provinces since the 1950s. From 1963 the National Bureau of Statistics directly controlled supervisors and enumerators according to the new rule. This means that the Bureau enlarged its structure and strengthened its function at the same time. The local provincial governments also upgraded their statistical departments.

The National Bureau of Statistics established 16 sub-committees under the current Statistical Council to have them discuss statistical problems by specific field.

Standardization for statistical classifications was required in order to enhance the comparability among statistics. Therefore, the National Bureau of Statistics set up the Korean Standard Classification of Occupations, the Standard Korean Trade Classification, and revised the Korean Standard Classification of Diseases, and the Korean Classification of Administrative District on the international agencies' advice.

Various statistical agencies issued their own publications such as annual or monthly reports. At that time 'Definitions of Statistical Terms' which had been published by the United States statistical consultant in 1963 explained in detail 1,734 specific terms which were used, after Korea's national foundation, for all statistical activities in Korea.

The important thing is the Resident Registration System which originated in 1942 in order to distinguish permanent address and present address. However, the residents neglected to report their personal changes. Therefore, the government made the strong Resident Registration Law to enforce the reporting system. The current Resident Registration System requires administrative reporting in cases of migration, marriage, divorce, birth, death, and its results are utilized for administrative purpose such as listing the voter's names, levying tax as well as compiling statistics.

3.2 The development of economic statistics during the growth period

The number of statistics were increased, especially in the economic field,

by virtue of positive support from the government. The Korean government required economic statistics in order to effectively carry out economic development plans.

They developed the Current Mining and Manufacturing Survey, Inventory Statistics Survey, Construction Work Survey, Construction Orders Received Survey, Establishment Survey, and the Industrial Accidents Survey. Also, the National Bureau of Statistics could compile domestic migration statistics using the strengthened resident registration system. Vital Statistics became one of the designated statistics. This enabled the compilation of statistics on the cause of death, life table, and population projection.

The Labor Force Survey which had been originated from 1930 in order to recruit military manpower changed its survey method to labor force approach method in 1957 according to the International Labor Organization's request. In 1962, the Labor Force Survey was renamed as the Economically Active Population Survey according to the statistical consultant' recommendation, and it was conducted quarterly covering 4,400 households in a stratified multi-stage sampling method.

The new sampling method based on the enumeration district of the 1960 Agriculture Census was also adopted for surveys on agriculture statistics. It became possible for civil and government sectors to actively study sampling technique because agricultural production statistics were the most important factor for economic development policy.

In addition to the Agriculture Census, the Fishery Census was also conducted in 1970 to compile statistics for collection and cultivation of aquatic products.

The Labor Office has conducted the Labor Condition Survey covering establishments hiring 10 and more employees since 1952, and the newly developed Basic Wage Survey since 1966. On the other hand, the National Bureau of Statistics conducted the Mining and Manufacturing Census in collaboration with the Korea Development Bank. Also, the National Bureau of Statistics conducted the Commercial Census in collaboration with the Ministry of Commerce and Industry, the Bank of Korea, and the Industrial Bank of Korea.

Furthermore, the National Bureau of Statistics developed analytic

statistics such as Indexes of Industrial Production, Inventory, Consumer Price Index, Index of Agricultural Wages, and the Input-Output Table using the results of other primary statistical surveys.

The Price Statistics which was formulated in a simple geometric average method from 1910 adopted a weighted arithmetic average method in 1947, and this was improved to the current Wholesale and Retail Price Index.

In 1968, the Korean Government developed the National Wealth Survey to provide basic information for establishing national development policies and to measure the results of socioeconomic developments. In the first survey, each of the various sectors were surveyed by a different agency. The National Bureau of Statistics, acting as the headquarters, conducted the survey on the household sector. The government sector and the net foreign claims portion were surveyed by the Bank of Korea, the incorporated enterprise sector by the Korea Development Bank, and the unincorporated enterprise sector by the Small and Medium Industry Bank. Furthermore, the Bank of Korea compiled National Accounts using Monetary Flow Charts and Input-Output Tables, and developed the statistics on business operation analysis, cost analysis and so on.

4. The improvement of statistical system during socio-economic growth period

4.1 Socioeconomic development plan and statistical development

The Korean Government revised the name of the 5-year Economic Development Plan to the 5-year Socioeconomic Development Plan in 1977 so as to effectively support social development policy as well as economic development policy. The government included establishing a welfare society as one of 4 major national policies in 1980. The most important fact was that the government chose, for the first time, the statistical development plan as one of major guidelines of the 5-year Socioeconomic Development Plan during 1987 to 1991. Because the Korean government wanted to revise the current aggregate development plan to a balanced development plan by

region and industry, they put a great emphasis on statistical development to gather the necessary data and information to support the development policy. In this context, the structures of the statistical agencies were enlarged and their functions were strengthened. The National Bureau of Statistics was upgraded with its name changed to the National Statistical Office in 1990, and the Statistical Training Center was newly established in 1991.

Furthermore, the government set up long-term and short-term plans for statistical development to help regional development. The demand for regional statistics has greatly increased since the local self-government system was adopted in 1991. Also the national development policy emphasized a balanced social and regional development. About 200 regional statistics were mainly administrative reporting statistics by prefectural government. These statistics included social indicators, a business composite index, and gross regional domestic products, etc.

4.2 Socioeconomic development plan and the development of social statistics

The Korean government also adopted Health and Social Development Policy as one of the major guidelines of the 5-year Socioeconomic Development Plan during 1987 to 1991. Therefore, it accelerated the development of social statistics to get the necessary data to support social development policy. So many kinds of health and social statistics were developed such as medical, life, public health, social security, national

Table 1 : Number of approved statistics

(Unit: kind)

	1970	1975	1980	1985	1990	1995
Approved statistics	233	317	439	351	357	371
· Designated statistics	34	38	43	46	50	36
· General statistics	199	279	396	305	307	335

pension, and social welfare service.

This enabled us to estimate the level of national welfare and showed the direction of welfare policy in the future.

Therefore, the total number of statistics had significantly increased in the 1970's because many social statistics as well as previous economic statistics were developed.

At that time various social statistics were developed such as the Fertility Survey, Labor Force Flow Statistics Survey, National Survey on Nutrition, Survey on Social Welfare Center, Migration Survey, School Attendance Statistics, and Physical Examination Statistics of Students. Also, they tried to develop systematically comprehensive social statistics including labor statistics, statistics on cause of death, and some regional statistics. They also developed many specific statistics in the field of demography, agriculture, fishery, trade, and business.

Many economic statistics were developed in the process of execution of heavy industry development policy in the 1960's to the 1970's. Also many new social statistics were required in the 1980's to help social development policy. However the government strongly coordinated all the statistics of statistical agencies in order to remedy duplication or omission of statistics. In this context, occasional statistics were discontinued and various statistics were merged by way of combining similar statistics. So, the number of statistics was decreased from 439 in 1980 to 351 in 1985. After that time, the number of statistics gradually increased because new statistics were annually developed, and they grew to 409 in 2001.

The major statistics of the 1970's came from the National Wealth Survey, Employment Structure Survey, Life Table, Social Statistics, Business Survey Index, Productivity Index, and Farmer's Income Statistics. In particular, the National Wealth Survey was designed to get information on stock assets and natural resources of the Korean economy, in a different manner from the National Accounts and Input-Output Tables.

The Employment Structure Survey, a specific survey of the Economically Active Population Survey, was developed in 1983 to provide information on both national and regional structures of people engaged or not engaged in work, and job changes for the last 5 years. The survey

covered all persons aged 15 and over who usually reside within Korean territory. The armed forces, prisoners and foreigners are excluded from the survey. The purpose of the Life Table is to formulate life expectancy and population projection using death rates, and it is utilized for demographic, national welfare, public health, and economic development policy. Social Statistics were developed to describe the living condition and the state of the society by measuring people's lives with respect to quality and quantity. It was based on the joint study by the National Bureau of Statistics and the Korea Development Institute in 1978 following the United Nation's recommendation. At that time the number of social indicators was 128, but it has grown to 481. They can be divided into 13 fields such as population, family life, income and consumption, employment, education, health, housing and transportation, information and telecommunication, environment, welfare, culture and leisure, public and safety, and social participation. To formulate these indicators, 350 basic data from various agencies are collected and classified, and the other data are surveyed through the Social Statistics Survey about people's subjective thought and social concern which are not produced by any other agencies.

Korea accomplished remarkable progress in the 1970's and the 1980's, and the government required a wealth of international statistics. Therefore the government chose an external cooperation plan as one of the guidelines for a 5-year Socioeconomic Development Plan. The government was very interested in cooperation with OECD countries and developing countries, as

Table 2 : Trend of social indicators

(Unit: kind)

Year	1979	1980	1985	1990	1995	2000
Number of Social Indicators	128	151	208	262	290	481

a countermeasure to the European Community, and changing environments of overseas economies. Therefore various statistical agencies issued publications such as Major Overseas Economic Indicators, Statistical Activities of International Agencies, Korean Economy in the World, Economic Indicators of Major Countries, Weekly Bulletin of Home and Abroad Economy, Major Indicators of Overseas Economy, and Trend of Overseas Economy, etc.

5. Statistics in the Information-oriented Society

5.1 Information-oriented society and the changing environment of statistics

The new society is becoming an information-oriented society along with the development of computer technology and communication. Answers from respondents shall be gradually fractionized, but nowadays some respondents are apt to refuse to answer a questionnaire due to their privacy concerns or time restrictions. To tackle these problems, the statistical agencies should develop surveying techniques to counter respondent's refusal. Also to meet the increasing needs of regional statistics, the number of regional statistics, in addition to current regional statistics, should be enlarged in the future since these statistics are indispensable to help regional development policy.

Recently electronic commerce has greatly increased along with the development of computer technology and telecommunication, but it is difficult to get data on this kind of business. After thorough study, the National Statistical Office developed the basic surveying method for electronic commerce. However there are still some problems yet to be solved.

Also, the statistical activities of the advanced countries should be reviewed in order to adopt necessary statistics or improve current ones.

The important fact is that systematic preparations for the integration of statistics between North and South Korea should be made. If it is possible,

the experiences of German reunification should be studied, and precautions taken regarding statistical integration by region, industry, and time-series.

5.2 Statistical improvement to meet a changing environment

The Korean statistical system is in principle a decentralized system having 130 statistical agencies such as the National Statistical Office, the Ministry of Agriculture and Fishery, and the Ministry of Health and Welfare, etc. They comprise a total of 409 approved statistics including 79 designated statistics. The National Statistical Office plays the role of central statistical agency in Korea, and coordinates every efforts to remedy duplication or omission of statistics.

As we mentioned above, the demand for statistics is gradually becoming diversified, and the environment for statistical activities is rapidly changing nowadays. To meet these difficulties, effort should be made to improve the current statistical methods and develop new techniques. The National Statistical Office adopted an on-line data input system from establishments to conserve time and reduce errors. This method shall be soon improved through the use of an Internet input system. Also, the enumerators use

Table 3 : Status of approved statistics (as of 1 Mar. 2001)

(Unit: kind)

	Number of Statistical Agencies	Number of Approval Statistics	Type	
			Designated Statistics	General Statistics
· Central Government	27	221	51	170
(National Statistical Office)	(1)	(53)	(34)	(19)
· Local Government	36	89	16	73
· Civil Statistical Agencies	68	99	12	87
Total	131	409	79	330

laptop computers, so they can input data on the spot. Presently, the National Statistical Office is trying to develop Information Contents Industry Statistics and Venture Establishment Statistics. Also, the office places an emphasis on quality control techniques to review the process of statistical activities.

The National Statistical Office improved data management and dissemination methods, and developed the Korean Statistical Information System (KOSIS) to provide a database system to allow systematic loading of statistical data. Furthermore they concentrate their efforts to disseminate data on the Internet or via CD-Rom.

To meet positively the changing environment of statistical activities, the coordinating function of the central statistical agency should be strengthened, and the statistical structures of various statistical agencies have to be concentrated. This will help to improve statistical quality by effectively using statistical personnel, resources, and techniques like Canada, Germany, Sweden, and the Netherlands. On the other hand, it is necessary to continuously study the statistical user needs in order to create an appropriate system.

6. Conclusion

As stated above, the Korean statistical system has changed during each era, and each specific era had its own characteristics to reflect user needs.

Just after Korea's national foundation, the central statistical agency belonged to the Office of Public Information because the Government wanted to produce basic statistics and make public relations so as to guide people. Only basic statistics could be compiled due to poor financial resources. Therefore, basic statistics could be produced through administrative process except for the Population Census in the field of population, agriculture, and poultry. The consistency and reliability of statistics were weak because there was no central coordinating agency.

After the Korean War (June 1950 - July 1953), the government urgently required relevant data and information to restore the destroyed economy.

The government transferred the central statistical agency from the Office of Public Information to the Ministry of Home Affairs in order to effectively get practical statistical data through administrative channels, and reviewed the whole statistical activities with the support of the United States statistical consultant.

The new government, which was established in 1961, transferred the Bureau of Statistics from the Ministry of Home Affairs to the Economic Planning Board. This was done in order to coordinate the national economic development plan since the government required various economic statistics and information necessary for economic development policy. To strengthen statistical activities, the government reorganized statistical systems making Statistics Law, and reformed statistical organizations. It resulted in a great improvement of statistics. From 1961 until the end of the 1980's, the National Bureau of Statistics contributed to the foundation of national economic development plans by producing fundamental statistics and coordinating national statistical services. The government also executed the work of statistical classification with the aim of improving the comparability and consistency of statistics, and established the Statistical Council as a consultative body for the Commissioner of the National Statistical Office to assist statistical activities.

The government put a great emphasis on economic development in the 1960's and the 1970's, and social development only after the 1980's. Therefore the Government developed mainly economic statistics during the 1960's to the 1970's, and social and regional statistics after the 1980's.

In particular, the government chose Statistical Development, Health and Social Development, and External Cooperation Development as major guidelines among the 5-year Socioeconomic Development Plan (1987-91). It was a peak time for statistical development in Korea. At that time, the National Bureau of Statistics was enlarged and upgraded with the name changed to the National Statistical Office, and the Statistical Training Center was established. Various statistics in the field of health, society, and region were developed. Also various international statistics were developed, and international cooperation was actively pursued.

However, the environment surrounding statistical surveys deteriorated

even though statistical tabulation techniques were greatly improved with the development of computer technology. The National Statistical Office now has enumerators use laptop computers to input data for household surveys. They also help establishments input data through computers of themselves. However, there now exits a problem that respondents are more likely to refuse to answer a questionnaire in order to protect their privacy, and there is much difficulty in getting data on electronic commerce, which has recently appeared. Furthermore, various new industries were born, making it difficult to process statistical classification and time-series analysis. In addition, preparations should be made for the integration of statistics between North and South Korea because the relationship between both sides has recently become closer.

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Milestones in the Korean History of Statistics

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Abstract: Since the foundation of the first dynasty, Korea has made its today through its 5000-year history. Statistics in Korea has kept its role in the development of all succeeding dynasties. In this paper, development of Korean statistics is investigated and annual records of important events are provided. For the period of ancient Korea, we focused on the organizations whose roles were related to producing statistics. For the period of modern Korea, we summarized the changes and role of central statistical agency and survey methods applied. In addition to that, the changes in statistical education and research activities are presented.

Keywords: census, the National Bureau of Statistics, statistical education, the Korean Statistical Society (KSS), annual record

1. Introduction

Korea has blossomed into a cultural flower of a unified nation in its 5000-year history. Since *Tan-gun* founded *Kochosun*, also called *Old Chosun*, in BC 2333, Korea has made its way through the period of *Three Kingdoms* (*Koguryo*, *Shilla*, *Baekje*) and followed *the Unified Shilla*, *Koryo*, *Chosun*, the Japanese Ruling period, and the period of US Military Government for three years, which began with the end of the Second World War in 1945. Statistics in Korea has maintained its role in the development

of all of the periods throughout Korean history.

The statistics in ancient Korean societies were mainly used for the purpose of tax collection and conscription; therefore, most interests in statistics were related to organizations that had taken charge of census reporting. Later, at a time closer to modern society, the range of statistics produced by the various ruling parties has been expanded to agricultural, astronomical, and meteorological statistics such as the amount of farm products and rainfall, etc.

In the modern era, as Korea has changed from an agricultural to an industrial society and from an industrial to an information society, not only the acknowledgement of statistics, but also the demand of more precise and faster production of statistics on various fields has grown. Under such situations, the numbers of official statistics produced by the government has expanded rapidly, and the methods applied to generate them have been modernized. In the meantime, the need for statisticians has grown in various fields of Korean society, and this has caused the growth of the areas of education and research necessary for cultivating statisticians.

This paper is organized as follows. First, statistical organizations of ancient Korean societies, their products, and the systems used for informative collection are summarized. Next, development of modern Korean statistics are investigated, including the trend of statistical institutes for the production of official statistics and the changing role of the central statistical agencies, the representative statistics produced and the methods for surveys newly tried and applied by the institution. Lastly, in the view of cultivating statisticians and activities satisfying the social and national demand, the changes of statistical education and research activities, focusing on the Korean Statistical Society, in the modern era of Korea are introduced. In this paper, from *Kochosun* until 1945 is classified as ancient Korea, and since then to present as modern Korea. The detailed times of important events in Korea are shown in chronicle tables.

2. Statistics of Ancient Korea

The Republic of Korea, since the foundation of the first nation *Old Chosun* (also called *Kochosun*), has kept its 5000-year history as a unitary nation through the *Three Kingdoms* period (*Koguryo*, *Baekje*, *Shilla*), the period unified by *Shilla*, *Koryo*, *Chosun*, and the Japanese Ruling Period (see Kim, Busik (1145), Gardiner (1969), and Sohn et al. (1970)). As with most ancient societies, statistics of ancient Korean society were connected with organizations that had taken charge of census reporting for the purpose of tax collection and conscription.

Since *Kochosun* established an office called *Joo-myong* for accounting and census, all the succeeding dynasties have had similar divisions of administration in charge of population census, synonymous with today's statistics bureau, for example *Jeomgoobu* in *Baekje* and *Jobu* in *Shilla* (see Iryŏn (1972), Han, Woo-keun (1971)). Particularly, in the period of *Koryo*, *Minkwan*, an office for census - triennially for the nobility and annually for the common populace - was established. From 1354, the system of *Hopae* (an identity tag) like today's resident card, with a name and birth date, was instituted to help statistics on migration.

In the era of *Chosun*, which was founded in 1392, *Hojo* had been the administrative division in charge of population census and *Hopae* was instituted again in 1398 by the new nation. It is interesting to note that *Hojo* conducted a public opinion census of the tax system and reflected the results to national affairs. Later, it also produced statistics on agricultural, astronomical, and meteorological statistics such as crop production, rainfall and others as well as population. A book with surveys on the number of populations was published in 1789, and the survey of population statistics was compiled for 1903-1907 in the book, *Jungbo Munhun Bigo*. During the period of Japanese Rule (1910-1945), an office similar to today's statistics bureau was established in 1917, and the first vital statistics was carried out in 1925 (see National Bureau (1961)).

The detailed times of important political and statistical events are shown in Table 1, in which political events are highlighted in boldfaced letters.

Table 1 : Annual record of Korean statistics before 1945

BC

2333 **The foundation of Kochosun by Tan-gun.**

Joo-myong, accounting and census office, established.

The period of Three Kingdoms

BC

57 ***Shilla* founded.**

37 ***Koguryo* founded.**

18 ***Baekje* founded.**

AD

375 *Jeomgoobu*, *Baekje* census office, established.

580 *Jobu, Shilla* tax and compulsory labor office, established.

668 **Three Kingdoms unified under *Shilla*.**

788 Jangjuk, a civil administration document, compiled (triennially for the number of populations and households, the area of farms, etc.)

918 ***Koryo* founded.**

991 *Minkwan*, census office, established.
From 1070, census conducted (triennially for nobility/ annually for common populace).

1354 *Hopae*, "resident card system" instituted.

1392 ***Chosun* founded.**

1789 *The Total Numbers in Census*, a survey book of the number of populations, published.

1903 *Jungbo Munhun Bigo*, the Survey of Population Statistics, compiled.

1910 **Japanese Imperialism began.**

1917 Statistics division established in the Bureau of General Affairs.

1925 The 1st simple vital statistics conducted.

1937 The rules of the vital statistics survey enacted.

1945 The change in formation of *Chosun* government-general; the office of statistics established in planning division.

Surrender of Japan; Independence of Korea

The vital statistics survey and settled population survey carried out.

3. Development of Modern Korean Statistics

3.1 Trend of the Central Statistical Agency

It can be said that the period from 1910 to the early 1960's was the dawning era of modern Korean statistics. In 1910, the *Chosun* period ended, and since 1918 (the beginning of the Japanese Ruling Period), the national census of the *Chosun* government-general took charge of all statistical reports. Later, when the Second World War ended in 1945, Korea was liberated from Japan's rule and the statistical organization moved to the Office of Public Information in the US Military Government. At the time that the Korean Government was established in 1948, the organization moved to the Bureau of Statistics, established in the Office of Public Information, and was set up as the Central Statistical Agency.

Around 1960, the Korean Government had a great chance to innovate statistics. In preparation for the International Population and Housing Census of 1960, the Census Committee was founded in 1959. The year before, President Rice of the Survey Research Corporation in the U.S. and the Korean-American Statistical Consultancy led by Dr. Tepping, came to Korea under a 5-year contract and contributed greatly to the development of

Korean statistics. The Population and Housing Census taken in 1960, instead of the normal National Population Census previously carried out every five years, was a great start for Korean statistics and statistical surveys, which was spurred by the structural change in 1961 of the Statistical Bureau of the Ministry of Home Affairs to the Economic Planning Board (see, National Bureau (1961)).

In 1962, the Statistics Law was declared and enacted. In 1990, the Statistical Bureau of the Economic Planning Board was upgraded to the independent National Statistical Office (NSO), whose role covers the compilation of statistical surveys as well as statistical education.

3.2 Changing Role of the National Statistical Agency

Until 1990, the Statistical Bureau had served successfully in its role as the statistical research office, producing and offering the country basic standard demographic statistics, i.e. population, industrial and pricing. Since it was the first to start measuring economic trends of the country by means of its Composite Index, the Bureau developed new methods to satisfy the various and increasing demands of statistics.

In 1995, the National Statistical Office began the direct input by Towns (Kun and Ku) of data for the statistical survey of the Mining and Manufacturing Industries, which enabled the results of the survey to be announced faster; thus, the office prepared the base for local self ruling-groups to report statistics themselves. In late 1998, the office was responsible for importing the method of CAPI (Computer-Assisted Personal Interview), thus enabling itself to realize on-site-survey by mass media.

It has also recently enhanced the CAPI method to ground paperless (electronic) surveys in Korea, beginning surveys by e-mail, and has imported the Statistical Quality Evaluation System to Korea, to review the quality of Korean statistics. Simultaneously, it has been trying to introduce Korean statistics across the world by its zealous participation in international conferences related to statistics, all the while developing new statistical methods, such as E-commerce statistics, cultural-industrial statistics, and environmental statistics, etc.

3.3 Korean Statistical Education

In 1906, Korea introduced statistics into the normal school curriculum for the first time, and has been practicing statistical education from the elementary level upward. Statistical education is divided into basic and professional levels, with the initial level educating elementary, middle and high school students, in such areas as probability measure, descriptive statistics, probability distribution and statistical estimation and tests, while the professional level is taught in graduate and undergraduate schools, and other high-level curriculums (e.g. Choi, Young-hoo (1990)).

In the early 1960's, the Ministry of Education successfully predicted the extreme increase of demand in statistical theory and methodology caused by the increase in heavy chemical industry, the rapid modernization of the country, and the government's promotion of its five year plan for economic development, and established statistics as a major in three private universities in Seoul, the beginning of education for statistical experts.

Since then, the demand for statisticians has increased, so that there are now 115 departments relevant to statistics major established in public and private universities offering professional education for statistical experts (see Figure 1). Also, most of those universities have graduate programs, with considerable numbers of students enrolled in doctorate programs,

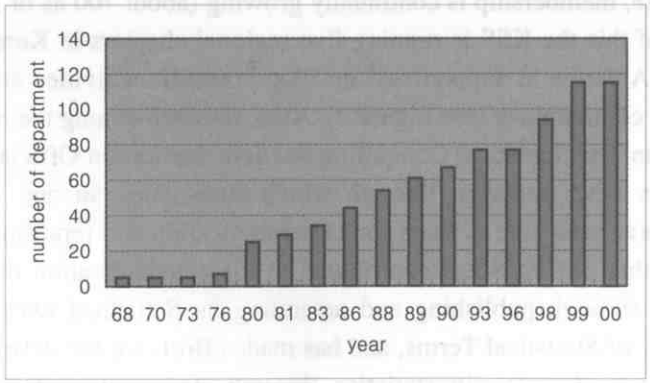

Figure 1 : Number of universities offering statistics major

which produce statistical experts. With this, the National Bureau of Statistics, the Korean Statistical Association and other statistics-relevant institutes are performing training and re-education for statistical agents and statisticians.

3.4 The Korean Statistical Society

The Korean Statistical Society (KSS) was established in 1971, with 43 members including professors of statistics. After two years, the KSS published "The Journal of the Korean Statistical Society (JKSS)" in March of 1973, "The Korean Journal of Applied Statistics" in March of 1987, and "The Korean Communications in Statistics" in April of 1994; today the KSS still publishes these three journals and widely provides the area for the reporting of research related to statistics through them.

Since the foundation of the KSS, conferences and scientific activities have been held every spring and autumn. The 58th national conference of the KSS was recently held, and the Korea-Japan Joint Statistical Conference holding every other year, began in 1982, has been held 10 times in the two countries by turns. Moreover, the KSS has commenced large and small sized international conferences, such as the International Conference on Statistical Methods and Statistical Computing for Quality and Productivity Improvement (ICSQP '95) and the Asia-Pacific Statistical Forum (1999). Meanwhile, membership is continually growing (about 700 as of 2001), and because of this the KSS is running five regional chapters in Korea and one in North America to support and develop scientific activities among local members' communities (see Figure 2). Also, research among the members is vigorous in The Statistical Computing Section, Section on Official Statistics and seven other sections, through which statisticians in and out of the country have been able to share joint communication and reporting.

With this, the KSS has contributed to the standardization of statistical education through publishing and amending its Statistical Dictionary and Dictionary of Statistical Terms, and has made efforts for the development of professional education in statistics through statistical contests for best papers among university students, best homepages among statistical majors

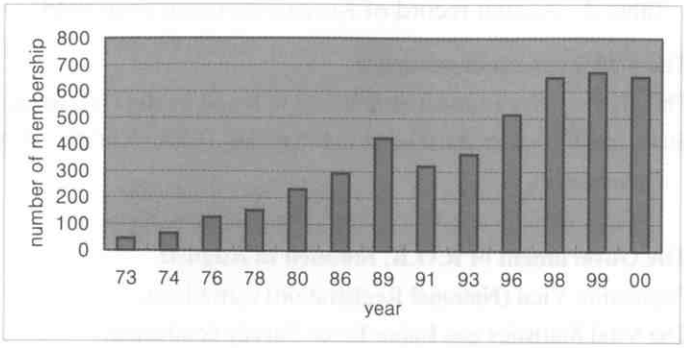

Figure 2 : Number of memberships in Korean Statistical Society

of schools, and symposiums for the development of an educational curriculum in statistics.

Also, with the acceptance of various organizations producing, reporting and using statistics, such as the National Statistical Office, the Bank of Korea, and the National Association of the International Management Institute, the KSS makes efforts in distributing and educating about statistics, through publications like "Simple and Interesting Statistics for Everyone", while also developing statistics through cooperation between governments and academia.

4. Summary

Korea has blossomed into a cultural flower of a unified nation in its 5000-year history. Therefore, the history of Korean statistics actually emerged from the history of Korean national culture. Early in BC 2333, with the beginning of the foundation of *Kochosun,* seeing future power of the nation, arduous efforts of politicians have impacted the past history of Korea, and this could cause all the periods and ages in Korean history - the period of three kingdoms (*Koguryo, Shilla, Baekje*) and followed by the unified *Shilla, Koryo*, and *Chosun* – not to lose the spirit of the nation under

Table 2 : Annual record of Korean statistics after 1945

1945	**The 8.15 Korea Independence**.
	The Military Government established in Seoul by the U.S. Army.
	Statistical Office established in the Planning Division of the US Military Government.
1947	**The Government of R.O.K. founded in August:**
	Population Vital (National Registration) carried out.
	The Vital Statistics and Labor Force Survey conducted.
	The Bureau of Statistics established in the Office of Public Information.
1949	The 1st Population Census conducted.
1950	**The Korean War (6.25)**
	The Bank of Korea founded.
	Survey on Population, Vital Statistics, Sampling Survey, City Household and Economy Survey carried out.
1951	**The 1st Currency Reform (devaluated by 100:1)**
	Economical Survey conducted.
	The 1st National Income Estimation conducted.
1953	**Signing of a cease-fire agreement**
	Agricultural Census carried out.
1954	The Statistics Yearbook of 1952 published (the Bureau of Statistics).
	"*Modern Statistics*", the first statistics book in Korean published.
1955	**The opening of the Securities Market**
	The National Bureau of Statistics transferred to the Ministry of Home Affairs.
	University's teaching statistical theology and methodology begun.
1957	Survey on the employed and unemployed (until May of 1962) carried out.

1958 The Korean-American Statistical Consultancy led by Dr. Tepping came to Korea.
Official estimation of GNP conducted (the Bank of Korea).

1959 The Korean Statistical Association founded (private).

1960 **The 4.19 Democratic Revolution**
Rand Corporation visited to Korea (in preparation for the 5-year plan).
The First Population and Housing Census taken.

1962 **The 2nd Currency reform (devaluated by 10:1)**
The Dictionary of Statistical terms published by the Bureau of Statistics.
The Statistics Law promulgated.
The Economically Active Population Survey carried out.
In three universities of Seoul, Statistics major authorized.

1963 The Standard Classification of Diseases instituted.
Definitions of Statistical Terms published.

1965 The Vital Statistics Yearbook (The Office of National Tax Administration) published.

1966 The 1st Korean Life Table published.

1967 Economic Movements Index (The National Bureau of Statistics) published.

1968 **Resident Card issued.**
Commercial Census carried out.

1971 The 1st Conference of Statisticians and Statistical Seminar commenced (The Korean Statistical Association).
The Korean Statistical Society (KSS) founded.

1972 The 1st conference of the Korean Statistical Society held.

1973 The first issue of Journal of the Korean Statistical Society (JKSS) published.

1977 The Social Statistics Survey carried out.

1981 Energy Census conducted.

1982 The 1st report of the statistical survey on Death Causes of 1980 published.
The 1st Korea-Japan Joint Conference commenced (Okayama University of Japan).

1983 Survey on the Households of the Houseless carried out.

1987 The 1st issue of the Korean Journal of Applied Statistics published.

1988 **The 24th Olympics held in Seoul (~10.2).**
The Statistical Vocabulary Dictionary published by KSS.
The Korean Statistics Survey Section, Statistical Education and Consulting Section founded.

1989 Five regional chapters (Kangwon-Kyunggi-Inchon, and Choongchung) established.

1990 Biometrics Section and Industrial Section established.
The National Bureau of Statistics of the Economic Planning Board upgraded to the *National Statistical Office* (N.S.O.).

1991 **The simultaneous entry of South and North Korean signatory to the UN**
The Statistical Training Center in N.S.O. founded.

1992 The prize for young statisticians (KSS) commenced.

1993 Agreement of Korea-China Statistical Cooperation concluded.
The 15th conference of Population Census in Asian and Pacific area commenced in Seoul.

1994 The first Annual Census on Basic Characteristics of Establishments carried out.
Statistical Information System of the N.S.O opened.
The 1st issue of Korean Communications in Statistics published.
The 1st estimation of population by city and province conducted.
The Statistical Vocabulary for the standardization of statistical terms (N.S.O.) published.

1995 "Moogunghwa", the first satellite, successfully launched.
Korea-France agreed on cooperation of statistical techniques.
International Conference on Statistical Methods and Statistical Computing for Quality and Productivity Improvement (ICSQP '95, Seoul) held.
The 1st ceremony of Statistical Day commenced.
Agreement of Korea-Russia on the regular statistical communication.
Korean statistics estimated by Statistical evaluators of OECD (10 persons).
Official Statistics Section founded.

1996 **Korea signed for an OECD member nation**
International Statistics Yearbook published.
Statistical Computing Section founded.

1997 The Dictionary of Statistical terms published by KSS.
The KSS chapter in the North America established.
Signing of an agreement on statistical cooperation of Korea and Germany.

1998 Statistical pavilion opened.

International seminar of Human Resource Accounting held.
The seminar of Korea and ESCAP for practical use of informational techniques held.
CAPI (Computer-Assisted Personal Interview) method introduced.

1999 The survey method by using computers practiced by the N.S.O.
The Statistical Quality Estimation System completed.
Unemployment rates by the OECD standards announced.
The 1st statistical contest for children held.
The Asia-Pacific Statistical Forum held in Seoul.
The System of General service for statistical information established.
Statistical training course for foreigners established by the N.S.O. and SIAP.

2000 **The summit of the South and North Korea**
The 3nd general assembly of ASEM in Seoul held in Seoul.
President Kim Dae-joong awarded the Nobel Prize.
The three-year plan of "NEW STAT 21" promoted by the N.S.O.
Service of Statistical Electronic Book practiced.
Statistics of electronic commerce developed.
The Service Activities Index published.
The 1st annual symposium for statistical development held.
The KSS section on Bayesian Statistics established.
The International seminar of the Statistical Quality Estimation held.

many rises and falls. Statistics in Korea has maintained its role in the development of all of the periods throughout Korean history.

Since the first nation, *Kochosun* established an accounting and population survey bureau called *Joo-myong,* all the nations shown in Korean history have had their own agencies with exactly the same function as today's National Statistical Office, although smaller in size. The Bureau of Statistics during the *Koryo* period, *Minkwan,* regulated population survey triennially for the nobility and annually for the common people, and at the same time recorded statistics of migration using a newly introduced system known as the *Hopae* (identity tag), the same as today's resident card. Also, *Hojo* of *Chosun,* established in 1392, practiced a tax system survey whose results were applied to national affairs, while statistics on agricultural production, rainfall, population etc. were effectively used to research social and economic activities.

Through the US Military Government, which started with the end of the Second World War, a new Korean Government was founded in 1948 and, at the same time, statistical administrative organizations of the Western and managing systems were introduced. The introduction of the American educational curriculum to Korea became the base for statistical education through elementary school to college. After 1960, graduates in statistics from Korean universities met the demand for expert skill in statistics caused by rapid economical development. In 1971, with the foundation of The Korean Statistical Society, academic exchanges among statisticians in and out of the country, and joint research became active, and in 1990, the National Bureau of Statistics was enlarged and independently upgraded with the name changed to the National Statistical Office, and entered fully into its role as the central statistical agency, executing complex compiling functions and statistical education. Therefore, the educational environment of statistics in Korea, the activities of the KSS and statistical administrative organizations are considered as the driving forces in the development of an information-oriented society in modern Korea.

The Annual Statistical Record, present throughout Korean history, covers the dawn, the beginning, the maintaining and the developing periods of Korean Statistics. In the history of Statistics, this meant the introduction