A LOOK INTO THE FUTURE OF MICROELECTRONICS IN CHINA

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ABSTRACT

The rapid development and wide application of microelectronics has been making the production activity and life style changing, with the great reformation in world economies. Weather or not can a country make achievement in developing hi-teches such as microelectronics is a serious challenge to both developed countries and developing countries including China. What can be done by China under the chelange and how about the future of microelectronics in China are of most concerns amonog decision makers in China.

A brief study is presented in the paper on the interrelation between microelectronics and socio-economic environment and all the effects from the relevent environmental factors. The paper also shows the research work on the development of scienice and technology in Chinia which is considered the most concerning problem to the development of microelectronics. Some viewpoints on the future of microelectronics in China derived from the research are given at the end of the paper.

I. INTRODUCTION

The economic reform and the implementation of open-door policy have brought about the rapid development of economy and technology in recent years. We have known in the same time much clearly about the changing world, and the big difference between China and developed countries which exists not only in conventional economic fields, but also in hi-teches such as microelectronics. People have worried about the tendency of the enlarging gap in microelectronics in the country.

Microelectronics, based on integreted circuits (IC), has been extended to the fields of military, communication, industry, commerce, transportation, management, and even the home activities by means of wide application of IC chips in electronic computers, instruments, radio and vidio facilities, affecting almost all socioeconomic fields. There is no any other technology like microeletronics today which could have such great impacts on socioeconomy all over the world.

If someone tries to evaluate impacts of microelectronics on socioeconomy only in terms of the output proportion of microelectronic industry in total output of society, he would get a wrong idea about it. In fact, microelectronics has been applied in most fields of social activities, which is considered, from

the experience of several succeeded countries, to be connecting with the most advanced manner of social production and management. Therefore the development and microeletronics application is now an index to evaluate the level of industry, science and techonology of a country. We should not expect microelectronic techonology replacing most of existing techoniques or expect computer doing most of activities of human beings. We could get an understanding of the importance of microelectronics to a modern society by imagining that what the society would be without microelectronics.

Microelectronics is the outcome of industrial society, and is dominated by just most advanced countries -- the United States and Japan. Now the questionos are, which have puzzled lots of people, how should a developing country of China advance and apply microelectronics, and what about the future -- optimitic or pessimistic.

We have learned from the experience of some countries that although there are different modes in developing microelectronics, we can conclude the law that the development of microeletronics depends greatly on the socio-economic situation, the industrial level and the market condition both domestic and around the world. To answer the question above, we should first look into the factors and conditions about the problem we are concerned with.

II. MICROELECTRONICS AND SOCIOECONOMIC CONDITIONS

The development of microelectronics is, like most new techniques, the outcome of the interactions among socioeconomic and scientific factors. Miroelectronics emerges from modern science and technology with the most advanced requirements from military, science and technology being the first force of application. It then becomes a wholy new branch of technology having ever greater impacts on social activities by its powerful permeatibility to other fields. Without the development and application of microeletronics, it would be impossible to advance most of modern science and technology.

It is obvious that microelectronics is the fruit of the most advanced science and technology of human beings. The research and manufacturing of IC or microprocessors, which form the core of microelectronics, depend on the most complicated techniques of large scale production, need lots types of high-level equipment and hundreds kinds of superpure materials, gases and reagents. Without the support of advanced mechanical, electric, chemical and metallurgical industries, the development of microeletronics would be on the base of desert.

But to a larger extent, the huge potential demands and the great benefits from applying microelectronics are the key powers to the development. The United States and Japan, the superpowers of microelectronics, have not only the most advanced industrial and

scientific foundations, but also the great domestic markets. The large scale economy, the great absorbibility to new techniques, and the inclining for renovation, all contribute to such a domestic market. With the development of microelectronics under bitter competition, the market is enlarged from domestic to the world.

Another notible fact is that some medium-developed countries, such as South Korea, also make a great achievement of microelectronics. South Korea has had a rapid increase in economy during 1960s and 1970s. Under the support of the United States and its government, South Korea get an average increase of 45.5 per cent from 1972 to 1982. The output of the industry takes a proportion of 6 percent out of GNP. Now South Korea becomes one of the biggest producers of electronic components and parts.

The fact doesn't contradict with the discussion above. A good economic and industrial foundation is still indispensable to such achievement, but the outside conditions and the opportunity are even more important, which are the support from the United States and Japan in advanced microeletronic technique and equipment, the good condition in the west world market. We could say that the microelectronis industries of South Korea and the countries alike are in fact just the extensions of that of the United States or Japan.

III. THE KEY-POINT TO THE APPLICATION OF MICROELECTRONICS

There are several factors relating to the development of microelectronics. The development of socioeconomy brings about the demands for new techniques, the advancement of science and technology makes the emergence of microelectronics possible. The combination of the demand and production leads to the application of microeletronics, which in turn affects economy, science and technology, and makes the demands even more if the benefits are good.

Here we could see that the key determining whether the development of microelectronics in a country could be healthy is the benefits of the application. The direct benefits can inspire the demands from enterprises and individuals, the indirect benefits can be the main goal of the government who have the power to affect the process by investment.

The effectivity and benefits of applying microelectronics depend on the industrilization level, the science and technology, the people's living standard and the inclinatioin for such technique. Under a certain condition, different products or systems in different fields will have different applying results.

The inventment of IC was connected with electronic computers which now are still one of the main streams of microelectronic application. As the technique becomes more applicable, it appears in lots of measuring, testing and controlling instruments used in

production, even various kinds of consumer products. The three application categories of microelectronic computer systems, eletronic instruments and electronic consumer products require different conditioins and have different amounts of demands.

Generally speaking, the application of computer systems has lot to do with the most advanced socioeconomy and high level education. For example, the development of computer-aided techniques (CAD, CAT and CAM), which are the main forms of the application in production, facilitates people greatly in designing, testing, and manufacturing. It becomes one of the key levers to the renovation of techniques and products. The application of computer-aided techniques has realy very good benefits from the facts in some countries. But techniques are very sophisticated to manage, concerning of the hardware and software knowledge, the computer-oriented drawing techniques, engineering design and manufacturing. To make good use of CAD, CAT or CAM systems, the complicated re-development to the system is required according to the concrete situation. This could not be accomplished without all-round knowledged scientists and well-trained technicians. The high expenses of computer systems also contribute to the poor effectivity in developing countries where the production scale is small, productvity very low, and in serious shortage of funds.

On the other hand, the third category, that is the application of microelectronics in electronic consumer products, shows prosperities in some developing countries. Such products are much better than those without the using of IC chips and are very easy to manage. Another reason is that electronic consumer produts are relatively very cheap compared with other electronic equipment or instruments, so there would likely be a huge potential market for such products by hundreds thousands families and individuals. Here the law of scale economy can explain what happened in China. The electronic instruments are somewhere between two other kinds of electronic products both in the requirement for enviornment and the size of demands.

It could be said that real demand is the dominant cause for the development of microelectronics. Now let's take a look at China.

IV. WHAT HAPPENED IN CHINA

China has experienced a tortuous way in developing microelectronics. We have launched the IC research in the mid 1960s, not very late. But in ten years thereafter, we mainly did the work under the principle of self-reliance. We have achieved certain progress which may be great in China, but the distance between China and advanced countries is actually enlarged. This becomes obvious especially after the implementation of the open-door policy. The very problem in IC production is that the home-made products can not compete with imported IC products.

From the analyses in part II and III we know that IC production

requires a lot of high level supports from other industries and scientific research departmants. It also needs a good market condition. But we fail to have all these factors by now. We have over a hundred factories but can produce only tens millions of IC chips, a large proportion being small and medium scale integreted circuits. Because of the small-scale production, poor equipment and management, the prices of the products are much higher than the prices in the world market, not to mention the quality. Now under the impact of imported products, the proportion of the domestic microelectronic market hold by home-industry dwindles even more to less than 40 percent. How to face this challenge arouses a good debate.

On the point of application, the quantity of IC chips used in electronic products gets a big increase in the past years. The quantity of IC chips used in 1985 are approximitely the same of that of the U.S. in 1968 or that of Japan in 1972.

The use of IC chips has been mainly in electronic instruments and computers for some time, but now the balance inclines to electronic consumer products. The proportion is over 50 per cent in 1985, and may not be the end with the ever increasing demand by Chinese families and individuals. But the demand for eletronic computerss dropped sharply in 1985 compared with previous year's quota. This tells us that we cannot expect a large market of computers systems in China, even it is a big country. We don't have good conditions mentioned earlier in the paper. The big difference in culture from western world, particularly in language, also obstructs the application of computers in management etc..

The world we have is no more the world before. It is not easy to get high benefits from the production of microelectronic products under the bitter world-wide competition. The technique is maturing, the market has be dominated by a few countries, the chance no longer exists. We should re-estimate the situation and set proper strategies and policies. But first, another critical problem is discussed below by which we could get a rough idea about what we are concerned

V. THE DEVELOPMENT OF SCIENCE AND TECHNOLOGY IN CHINA

What are the factors that enhance the level of science and technology in a developing country of China, when and how could China catch up with the most advanced countries in science and technology, if possible, are very concerning questions. To get the answers we have recreated the Technology Sector in SDNMC (System Dynamics National Model of China). Here are the main points and results.

In the new sector, we still adopt the technology level represented in Cobb-Douglass production function, and suppose the technology in the most advanced country (now the United States) levels up exponentially at an average rate of 1.37 percent with

the initial value being 3. The distance or gap in technology level in the paper is the time required for the technology in China to reach the present level of the advanced country at an average rate likely in the future. The very problem in the sector is to determine the growth rate of technology.

The growth rate or annual speed equals the average rate of the advanced country multiplied by an aggregate multiplier. It is believed that the rate should approach the average rate of the advanced country as the gap decreases, since no country can sustain a higher growth rate of technology time-unlimited.

There are two major causes concerning the growth rate --- the outside-cause and the inside-cause. The outside-cause is the technological transfer from the advanced country to the backward country, the inside cause is literally the motive force from inside the country. The two causes are addictive in the new sector.

There are at least two necessities for technology transfer to occur. The first is the distance between the two levels where transfer occurs. When the distance disappears the net transfer flow world stop. The secend is that there must be some flows of materials, personnel, or culture which can bear the transfer of technoligy.

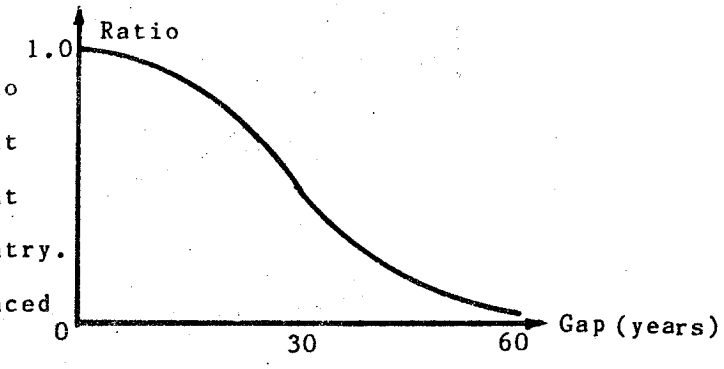
We take Research and Development (R&D) investment as the key force to push technology forward. The R&D investment in China is incomparable to that of the advanced country in terms of R&D investment proportion in GNP and absolute amount as well. This is indeed a potential danger. Why we could make great achievement with a little R&D investment is not because there is something magic in China. It is the big difference of technology between China and the advanced country that makes technological transfer the major cause for the development. We would see that every step toward the most advanced level of the world would be very difficult when the gap approaches zero which means the very limited net-inflow of technological transfer we could get.

To evaluate the effect of R&D investment on technology, we introduce technological progress index which indicates how large proportion of R&D investment in the advanced country is required to keep step with the increase of the advanced technology. This index is the function of technology gap as shown below .

Figure 1 .

Ratio: The desired ratio of R&D investment to R&D investment of advanced country.

Gap: The gap from advanced country.



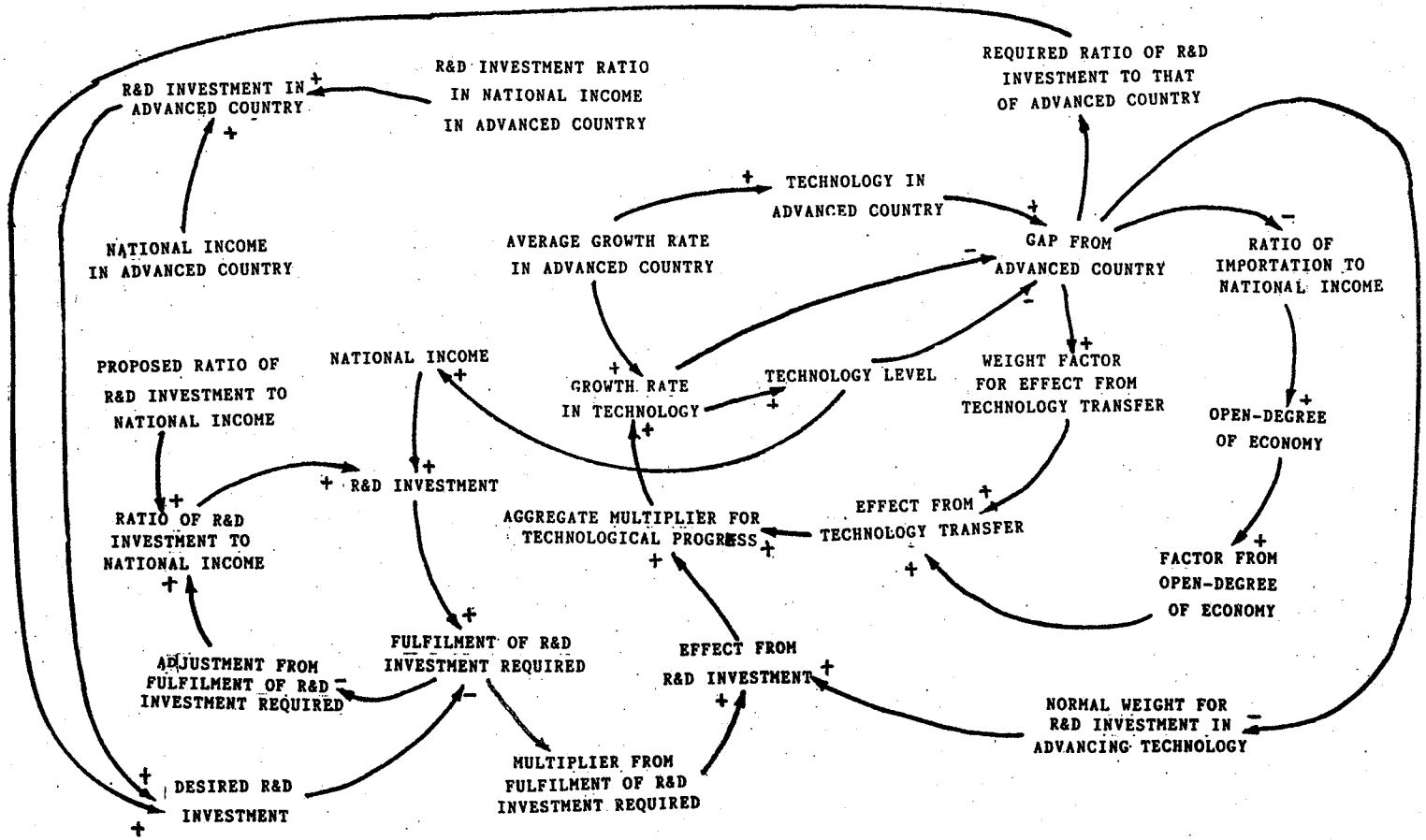


Figure 2 Causal loops of Technology Sector

The curve in Figure 1 tell us that when there exists a big distance in technology, it needs only a little proportion to advance technology at the same rate of the advanced country. When the gap approaches to near zero, it would need almost the same amount of R&D investment of the advanced country to keep the rate, while the net-inflow of technology transfer becomes null.

Figure 2 shows the causal loops of Technology Sector in SDNMC from which we can see some dominant loops around technology Level. There are five loops in Figure 3 with Loop I, Loop II and Loop V being positive, and Loop III and Loop IV negative. Loop I says that the progress in technology promotes the national income which in turn makes it possible to take more R&D investment and increases technology by the end. Loop III tells the fact that it requires more and more R&D investment to advance technology as the gap from the advanced country decreases. We could get good understanding to the results in Figure 4 and Figure 5 from Loop III. It is possible to open our economy to a larger degree when the gap dwindles, but in the same time we get less opportunity to gain net inflow from technology transfer. The effect of Loop IV would surpass that of Loop V over time, so the only way to advance science and technology at last is to better the education and invest more in research and development activities.

The discussions above can give explanations to the results shown in Figure 4 and Figure 5. From the figures we know, the technology transfer contributes largely to the progress at present and the succeeding years. After the year 2000 when the gap becomes less and less, the factor from technology transfer levels down quickly, while the factor from R&D investment grows gradually to be a dominant factor in the progress. The very surprising results which do not match the ideas from mental models lies in the so called "catch-up-with problem". Lots of people have made the estimation that China would catch up with or even surpass the most advanced country in technology in some time, for example forty or fifty years. But the results from the model does not give such support. Any way, we should not be pessimistic about it. The situation would be quite well even there still exists a gap of ten years. Some view-points would also be true to microelectronics.

VI. THE DEMAND FOR IC PRODUCTS

The demand for IC chips comes from electronic industry. It can be derived from the demand for electronic products and the number of IC chips used in a unit of electronic products which may change over time. Based on the variables about the technology level and the gap in technology from the advanced country given above, also based on the model about the development of electronic industry in China presented in 1986 International System Dynamics Conference, a simple model is created concerning mainly about the IC chip market in China and the market share by home-made IC products.

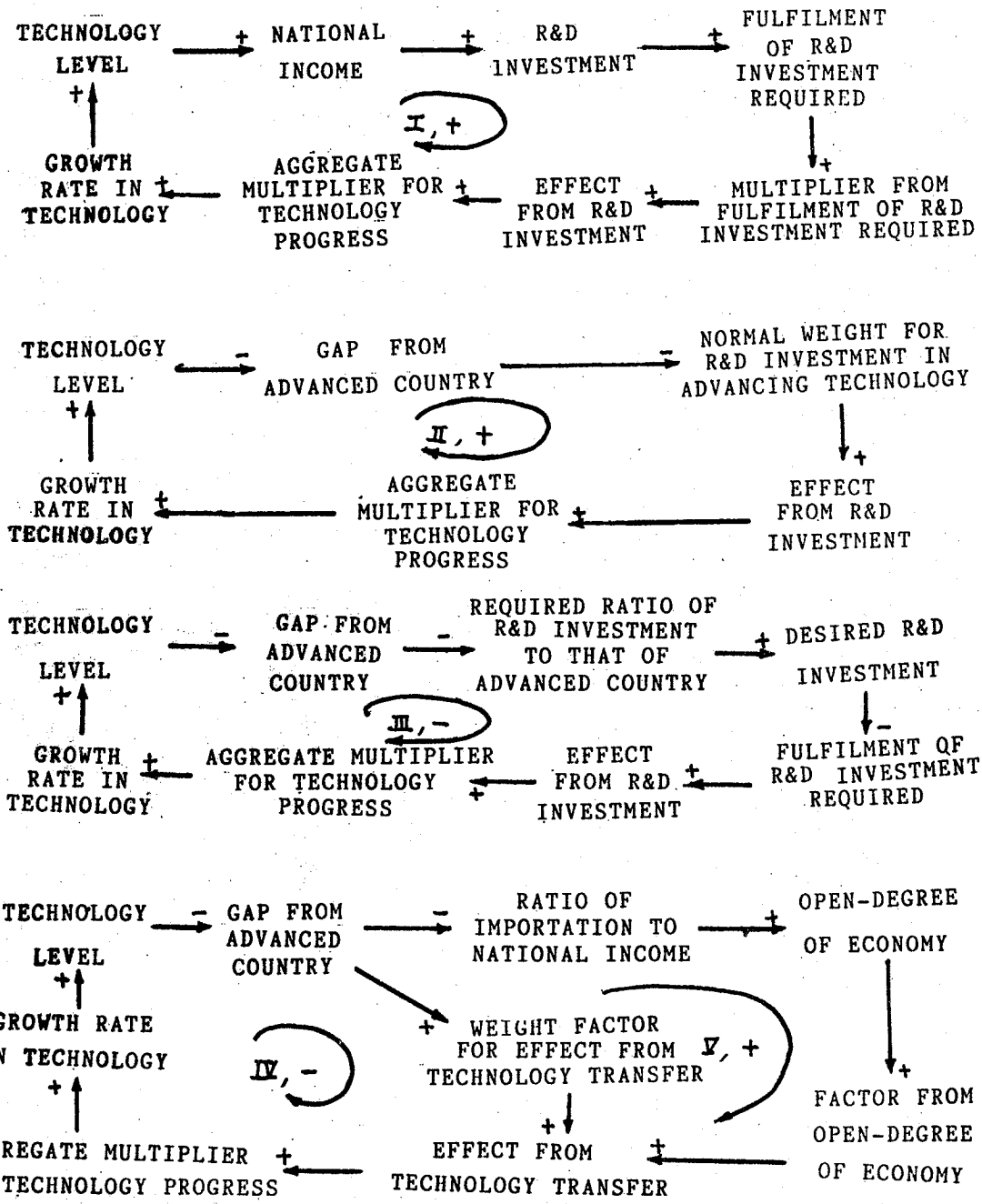
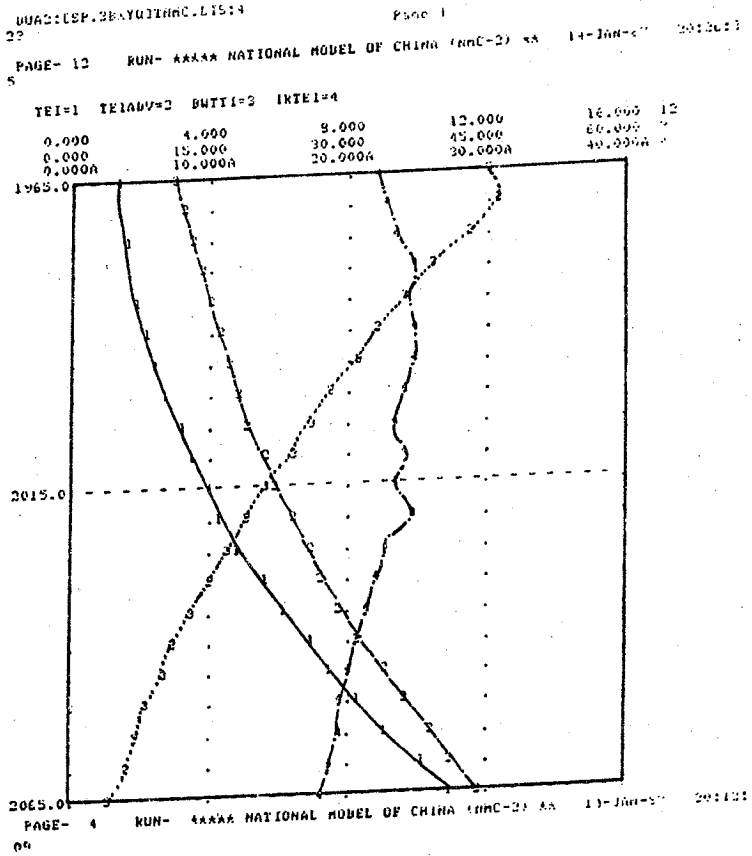


Figure 3 Dominant Loops in Technology Sector



—— Technology

---- Technology in advanced country

-.-.- Growth rate in technology

..... Gap from advanced country

Figure 4 Base-run results of SDNMC (1)

—— Fector from technology transfer

--- Fector from R&D investment

... Availability of R&D investment

Figure 5 Base-run results of SDNMC (2)

In the simple model we have

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A  DICP.K=MFID.K*NMICR*DELP.K/100
C  NMICR=1.4
A  MFID.K=TABHL(TFD,TEI.K/NTEI,0.4,1.6,0.2)
T  TFD=0.05/0.21/0.55/1/1.3/1.4/1.5
```

where DICP ---- Demand for IC chips
DELP ---- Demand for electronic products
NMICR --- Normal number of IC chips in a unit of DELP
MFID ---- Factor from technological prograss

DELP is the result of the model in Reference 3 with a flucuation of 8-year period. MFID indicates that with the prograss of technology the IC products are more widely used in electronic equipment and products. DICP is the domestic IC market but not simply the market our IC industry could hold. How to determine the possible IC market share by home-made IC products is critical to the problom. We have functions as follows.

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A  DDICP.K=DRTIC.K*DICP.K
A  DRTIC.K=TABHL(TIC,DTYIC.K,0,1,0.1)
T  TIC=0/0.3/0.47/0.6/0.7/0.8/0.87/0.93/0.96/0.985/1
A  DTYIC.K=TABHL(TRTIC,TEI.K/NTEI,0.2,1.6,0.2)
T  TRTIC=0.04/0.1/0.2/0.3/0.38/0.46/0.52/0.55
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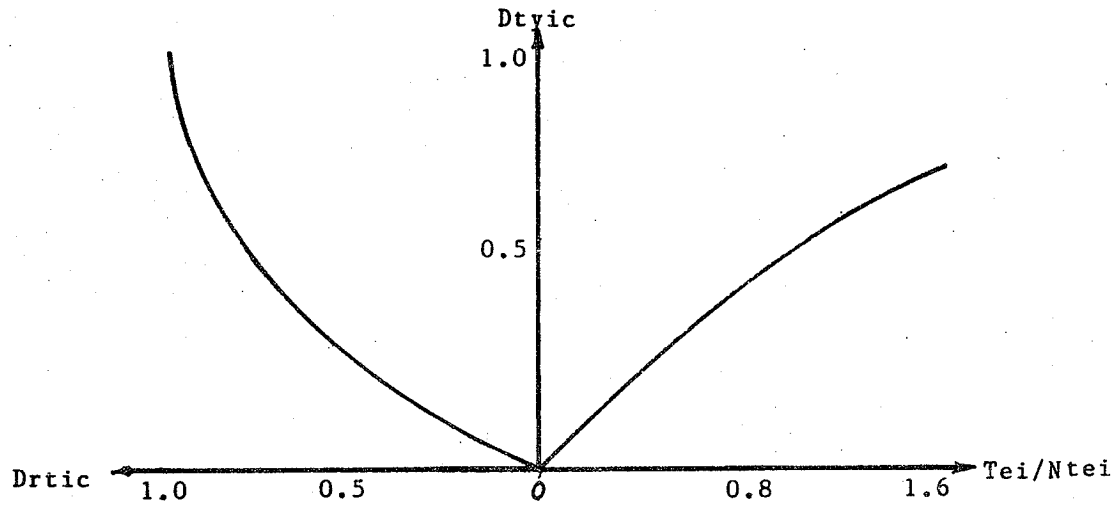
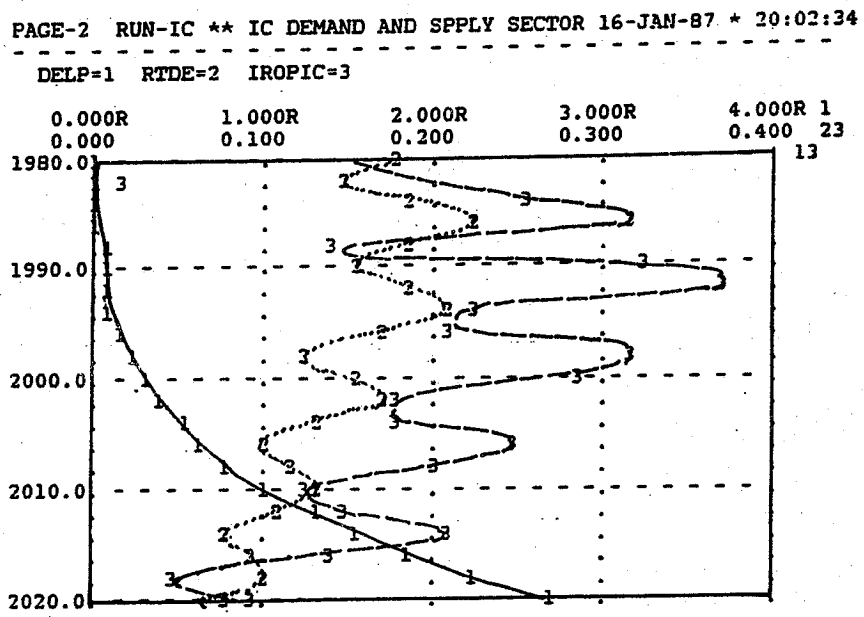
here DDICP ---- Potential demand for home-made IC products
DRTIC ---- Desired market share by home-made IC products
DTYIC ---- Desired share of IC types by home IC industry



Tei: Technology Ntei: Normal technology

Dtyic: Desired percent of home-made IC types. Drtic: Desired percent of home-made IC products.

Figure 6 The possible market share by home-made IC products

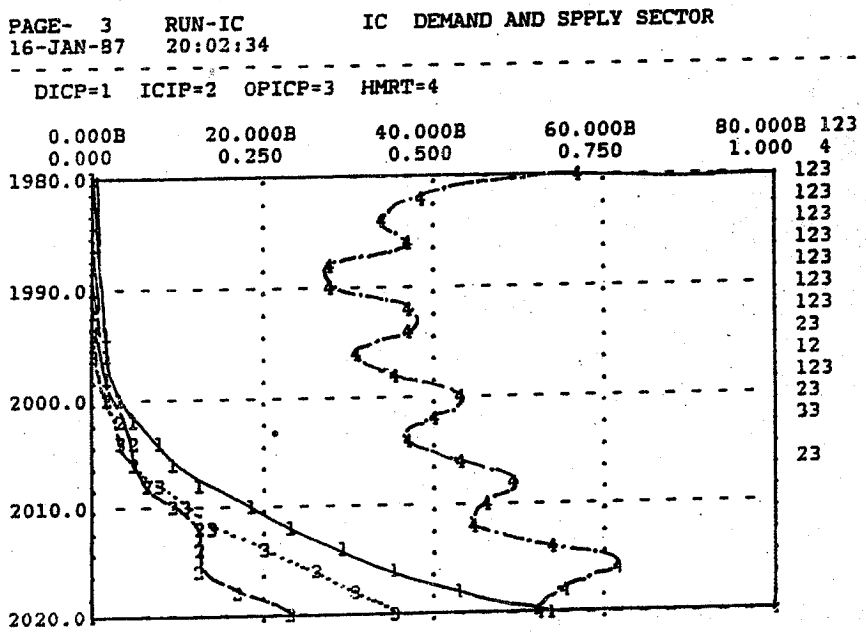


—— Demand for electronic products

•••• Growth rate of the demand (——)

---- Growth rate of IC production

Figure 7 Base-run results of IC (1)



—— Demand for IC products

•••• IC production

---- Importation of IC chips

-.-. Market share by home-made IC chips

Figure 8 Base-run results of IC (2)

The relations above would be clear in Figure 6. The curve in right hand reflects the situation in China that only a few kinds of IC products could be produced, which may change over time as the increase of IC demand in quantity and the progress in technology. The left curve can be drawn from the type distribution of IC chips.

The base-run results are shown in Figure 7 and Figure 8. We learn from the figures that the demand for IC products rises as the demand for electronic products increases but at a higher rate which indicates a wider application of IC chips in electronic products over time. The market share by home-made IC products shows a drop to below 50 percent now and after. It would turn up gradually from the year 2000 but never exceeds 80 percent as shown in Figure 8. By the law of scale economy, the most likely IC products in the production are the chips used in consumer products which usually have a large quantity of demand. More important are the policy on IC importation and the strategy of the development of microelectronics.

VII. THE FUTURE OF MICROELECTRONICS IN CHINA

Microelectronics is changing. The world is no more the world before. The development of microelectronics should adapt to the situations of China, in according to the economy, the education, the management and the culture.

Some opportunities are gone, but we realy have an opportunity -- that is the application of microelectronics. China is a developing country, the technology is far behind that of developed countries. But the imbalanced development in different regions makes it possible to promote the application in some regions with good conditions. Different environmental requirements by microelectronic prodcuts then determine the different modes in the development of microelectronic consumer products, microelectronic equipment and instruments and electronic computer systems.

Even in IC production we still have some opportunities. We could introduce the advanced techniques and equipment to modernize the industry. We have a huge potential market of microelectronic products and an all-round fundation of industry, science and technology which are not possible for most developing countries. But a large proportion of imported microelectronic products in domestic market would be a long phenominon in China. Don't expect too much but be sure about the progress, that's the answer.

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