

A STRATEGIC STUDY ON THE DEVELOPMENT OF ELECTRONIC INDUSTRY IN CHINA

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Abstract

With the rapid development and wide application of microelectronics, the electronic industry is playing an ever more important role in modern economies. Backed by the socioeconomic circumstances, a system dynamics model (SDEIC) is constructed to investigate the development of electronic industry and to give a description on the future of microelectronics in China in some way. The analyses and simulation results show that there will be a prosperous period for the development of the electronic industry in the coming twenty years with a vigorous investing requirement and at a relative high growth rate. A notable characteristic is that the development is unbalanced with electronic consumption products dominating the market in terms of volume in the period concerned.

I. INTRODUCTION

One of the most striking event in this century is the rapid development and wide application of microelectronics which is considered the token of the new revolution of science and technology. It is believed that the hard-foreseen development of hi-techs is an opportunity for some developing countries to advance their economies by leaping over certain stages of technology. And a serious challenge also lies ahead to broaden the gaps between developing and developed countries in the economic sector. Then what about the future development of microelectronics in China is still in argument--optimistic, pessimistic, or somewhere between the two ends.

The development of microelectronics is considered, in a broad sense, the evolution of microelectronization of electronic industry and informization of social life. To get an answer, in some way, to the question above a system dynamics model is created to investigate the development of the electronic industry in China under the consideration of the interaction with socioeconomic circumstances in the evolution. The problems concerned in the paper are as follows:

- . The demands of electronic products
- . The production and importation of the electronic products
- . The investment in the electronic industry
- . The growth rate of the electronic industry

. The proportion of the electronic industry in the national economy

. The shares of production of each sector in the electronic industry, etc..

An analysis on the main mechanism and structure of the system is given in the paper followed by the simulation results and the conclusion on the development of the electronic industry in China.

II. THE SYSTEM AND ITS ENVIRONMENT

The definition of the system determines the structure and function of the model. Now the first question is where to draw the boundary and how to deal with the interactions between the system and its environment.

There emerge various types of modes in developing electronic industry in the world. The United States has invested much efforts in advancing the production of military and investmental electronic products. Japan, on the other hand, set the sail by expanding the production of electronic consumption products. South Korea then took the production of electronic components as a ticket into the world market. As for application of electronic products, some countries rely mainly on their own efforts, some depend greatly on importation. What about our country? China has experienced a zig-zag way in developing its electronic industry in the past years, especially in advancing both IC and computer productions.

The lessons derived from experience tell us that the development of electronic industry is restricted and affected by socioeconomic circumstances to a great degree. We should, therefore, keep our research in a wider scope to capture the dynamic behavior of the electronic industry in a long term.

As a result of the lasting construction from 1949, China now has a solid industrial and scientific foundation of its own, and can focus its power on the development of critical fields and key techniques in its modernization. The most favourable factor is that there would be a great potential demand for electronic products in the domestic market.

But the obstructions are still tangled with the stimuli in many aspects. The economy in China, as a whole, is far from modern based on the lower level of industrialization. The backward predicament of science and technology is hard to be reversed in a short period and the extent of competition in the world of electronic products market is much higher than before. All these make the development mode of electronic industry in China different and special from others, which is just the problem we want to study into.

The demand for electronic products is one of the key-points in

the interactions between electronic industry and socioeconomy. Another is the restriction to the investment in electronic industry. It is considered that the evolution of national economy is insensitive to a small change in the development of electronic industry. We could therefore make a proper trade off between perfectness and simplification by introducing some variables exogenously without much affecting to the variables of the model.

Here are some important concepts before further discussion. Electronic consumption products (ECP) is defined as the electronic products being used privately by families or individuals, e.g. radios, TV sets, cassette recorders. On the contrary, we define electronic investmental products (EIP) as the products employed in industry or other public sectors, such as computers, communications equipment and robots. The products belonging to elementary sector are electronic components (EEP) for making final electronic products.

It should be noted that the definitions of ECP and EIP here are according to the utility and users of products which take notice of the fact that some electronic products actually belong to both ECP and EIP. They are somewhat different from those in common terms. Another note is that some products adopting electronic technology should not be simply and wholly classified into as electronic category. Making clear the concepts will be helpful in understanding the conclusions derived from the simulations.

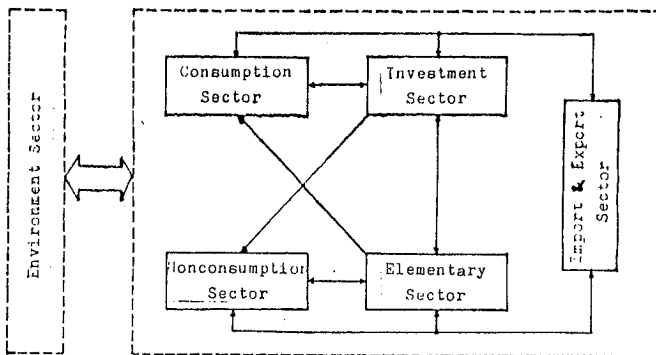


Figure 1 The frame diagram of SDEIC

SDEIC model has been simulated on VAX-11/780 with about 400 DYNAMO equations grouped into six sectors:

- 1) Environment Sector
- 2) Consumption Sector
- 3) Nonconsumption Sector
- 4) Elementary Sector

- 5) Investment Sector
- 6) Import and Export Sector.

Figure 1 shows the frame diagram of SDEIC.

Environment sector creates a socioeconomic environment concerning the development of electronic industry by providing some table functions and auxiliary variables based mainly on the System Dynamics National Model of China (SDNMC) developed by Qifan Wang, et. al.. Consumption Sector, Nonconsumption Sector and Elementary Sector deal with the demand, production, selling, etc. respectively for ECP, EIP and EEP. Investment Sector handles the requirement for and restriction to the investment in electronic industry. The variables in Import and Export Sector express the functions by their name themselves. The key problems in the model are discussed in the next section.

III. THE MAIN MECHANISM OF SDEIC

The market mechanism forms the nucleus of SDEIC, consisting of demand, production, inventory, selling, importation, exportation, and investment. The causal loop diagram of SDEIC is shown in Figure 2. Our discussion covers only a part of the whole.

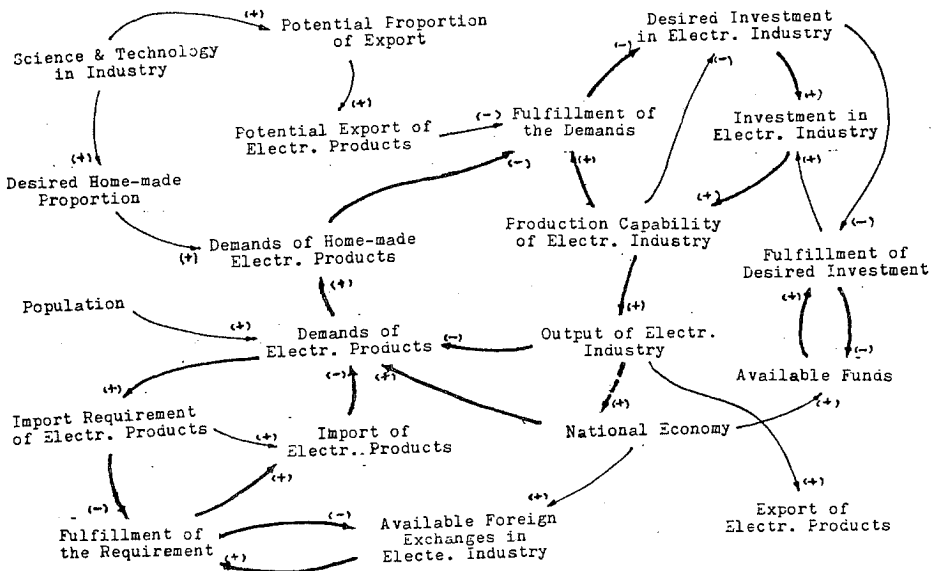


Figure 2 The causal loop of SDEIC

III.1 The Demands of EIP

The application of microelectronics in industry, transportation, commerce, banking, and some other government sections form the main stream in the development of microelectronics, hence, they are of great importance in the study.

The production of EIP is usually concerned with various types, smaller batches, and more complicated techniques in manufacturing. Moreover, the application efficiency of EIP is related to the socioeconomic institution, modern economy and the re-exploitability to the products. These are the important factors in the development of EIP.

We should firstly introduce an index to indicate the level of industrilization before calculating the demands of EIP. The productivity and capital-intensity in industry are both general indexes of industry, with the former emphasizing the production efficiency and the latter reflecting directly the means of production. So the level of industrilization is defined in the paper as the sum of weighed indexes of productivity and of capital-intensity in industry.

Electronic investmental products (EIP) are applied in industry, service trades, military section etc. in the forms of equipment. Thus the demands of EIP can be classified into public demand and government demand. The government demand of EIP are the demand of military electronic equipment and some other electronic devices for government uses. The public demand of EIP comes from industrial departments and is calculated as the equipment investment in industry multiplied by the desired proportion of electronic equipment according to the level of industrilization. The effect of the upward trend of the performance-cost ratio of electronic products and the floating around normal price is also under consideration.

III.2 The Demands of ECP

How to evaluate the function of the production of ECP in electronic industry and how to develop it have still been an outstanding issue in recent years. An understanding to this is given in the paper.

There are two ways to compute the demands of ECP. One way is to determine the proportion of the share in total consumption funds for ECP, but it is hard to find statistic data to support such a method and even impossible to capture its trend in changes of the proportion in the future. Another defect is that this way is not identified with the real situation in micro mechanism.

An alternative approach is adopted in the paper to determine the demands of ECP. There is, in fact, a desired but realistic consumption level of ECP for each family which is in

accordance with mainly the income level and some other factors. The demands of ECP then can be defined as the difference between desired and real consumption of ECP of society. Here the desired consumption of ECP is the average desired consumption level of ECP multiplied by the number of families in the country, so the key point is how to get the average desired consumption level of ECP.

Some statistic work shows that the average income per capita in family in our country approximately displays a normal distribution, and the absolute differences in average income among families show a little trend of rising. We suppose in SDEIC model that the average income in family possesses a normal distribution, with the means of average income in family equaling the average income per capita (i.e. the expectation of group-means being the same as total-means), and the standard variance being a linear function of the means of average income in family.

Obviously, the families in different income levels have different desired consumption for ECP, the relation between the desired consumption of ECP and the average income in family can be shown as a S-shaped curve in Figure 3. This means that, a family at a very low income level would desire nothing over and above the basic needs for foods, clothes and the like. When the average income acrosses a certain threshold, the desired consumption level of ECP for a family will increase steeply as the average income rises. But when income increases further to a high level, the rising of the desired consumption for ECP would asymptotically approach to a gentle slope, since the need for ECP has been largely met and the desire for consumption would turn to some other fields.

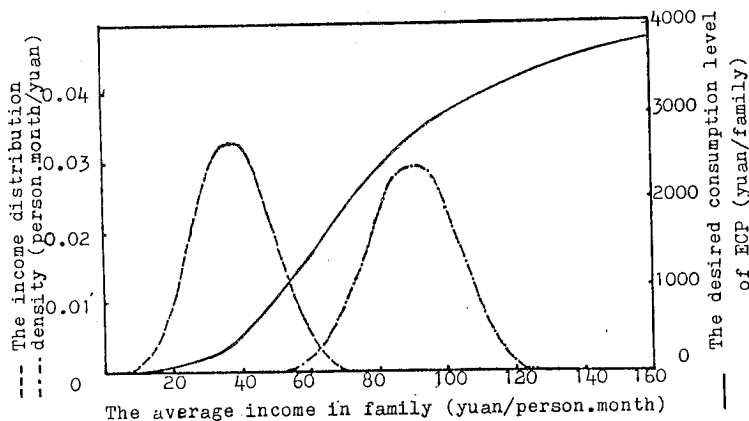


Figure 3 The desired consumption level of ECP

A statistic investigation is needed to determine the curve in Figure 3, but we can now only make an estimation on some

points on the curve and test sensitivity with respect to the changes of parameters within a reasonable range. Let x be the average income in family, $f(x)$ be the distribution density function of average income in family, and $d(x)$ be the demand function shown in

Figure 3, then we have the average desired consumption level of ECP

$$y = \int_0^{+\infty} f(x)d(x)dx .$$

III.3 The Demands of EEP

The demands of EEP comes from EIP and ECP production sectors, and can thus be determined by the desired output of EIP and ECP and by the proportion of component to final products in electronic industry.

The production of EEP is of much importance in electronic industry. The production of final products of EIP and ECP can not even sustain without the input of EEP, and the quality of final products is determined largely by the quality of EEP. On the other hand, the production of EEP is related to the higher techniques of production and management, the continued renewal in EEP and the intensive competition in market. The gap between China and advanced countries in electronic industry lies mainly in the techniques and means of manufacturing EEP. Therefore the key to the sustainable development of electronic industry is to arrange properly the production of EEP for the output of EIP and ECP and to advance the performance-cost ratio of home-made EEP.

III.4 The Production and Importation of Electronic Products

The co-existence of domestic production and importation is a natural phenomenon in a country with a vast potential market but much backwardness in science and technology. There in fact exists a desired but possible proportion of home-made electronic products in the market which could be a function of the backward-time in science and technology. For the consideration of the demand of suitable techniques and products and the incomplete competition in electronic products market, we can draw empirically a curve shown in Figure 4. The demand of home-made electronic products is then equal to the total demand multiplied by the desired home-made proportion.

The importation demand of electronic products rises from the demand unsatisfied by the domestic production sector, including the demand for EIP, ECP, EEP and specified equipment in electronic industry. The realization of the importation demand depends on largely the sufficiency of foreign exchanges. The foreign exchanges for the importation of electronic products are determined by the total importation, by the reference proportion for electronic industry and by a feedback adjustment to the proportion from the sufficiency of

foreign exchanges in electronic industry. The exportation of electronic products is also included in SDEIC and amounts to part of total demands of electronic products.

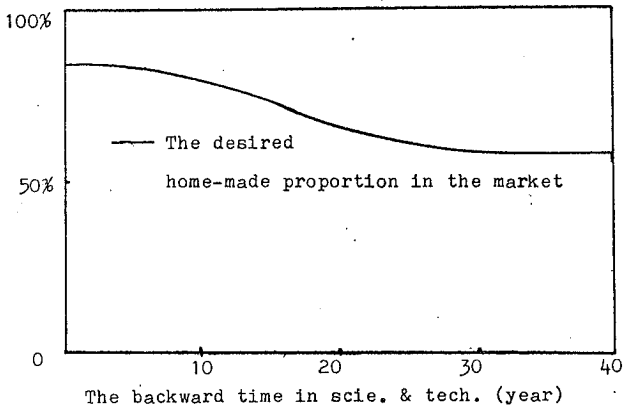


Figure 4 The desired home-made proportion

III.5 The Investment in Electronic Industry

One of the most troublesome problems in the economic development in China is the severe shortage of funds for investment in industry which would last for a long time. The investment in electronic industry is then one of the critical problems in the research which is considered from both the real demand for investment and the possibility of funds.

The requirement of investment from electronic industry comes from the unsatisfied demands of home-made electronic products and is affected by the tendency of the demand. The obtainable funds for the electronic industry may be a main constraint to the development in the coming period. They are determined by the total investment in industry and by the reference proportion of investment in the electronic industry, which in turn is set up in accordance with the development of the economy (indexed by the industrilization level). A feedback adjustment to the proportion is applied from the real situation as well as from the possible elasticity. Now the only business is to ration the funds to the sections of electronic industry according to the shortages of supplies of EIP, ECP and EEP.

A general description has been given to the main mechanism of SDEIC with a good many details omitted. The real capability of production, the depreciation of inventory, the cancellation of the orders unsatisfied, and some others are introduced in SDEIC to make the model more "real". Now we shed some light on the simulations and analyses.

IV. THE SIMULATIONS AND ANALYSES

A series of simulations have been executed on VAX-11/780 consisting of base-run, parameter-test-runs, policy-test-runs, parameter-sensitivity-test-runs. The main results are as follows.

IV.1 A General Description of the Development of Electronic Industry

The base-run shows that, in Figure 5 and Figure 6, with the economic development and wide application of microelectronics especially by the stimuli of vigorous demands, there would be a prosperous period for the development of the electronic industry in the coming twenty years. The proportion of investment in the electronic industry to total capital investment would be up to 4 percent, but the available funds could still hardly meet the requirement of investment from the electronic industry. Under the increasing investment, the electronic industry expands at an average growth rate of 12 percent, the share of output of electronic industry out of the total output of society would gradually increase concurrently with the over-investment, and would reach its peak of more than 3 percent around 2005. As the result of the rapid development, electronic industry would become a major section in the national economy.

IV.2 The Shares of EIP and ECP Productions

The development of electronic industry in China is unbalanced. Base-run indicates that the output of ECP would dominate the market for a period concerned. Although the production of EIP would develop simultaneously with that of ECP and the relative proportion of EIP would rise a little after 2000, it is still hard for EIP to overshadow the dominant role now played by ECP.

Two test-runs are arranged to see the effect of the changes in the parameters on the relative proportion between EIP and ECP. In test-run 1, the parameters determining the demands of ECP are increased by 25 percent and the parameters concerning the demands of EIP are decreased by 25 percent. In test-run 2 the conditions are just the opposite. Figure 7 shows that the argument about the relative proportion between EIP and ECP still holds up.

It is believed in this paper that the unbalanced development in EIP and ECP is a typical characteristic determined mostly by the real situation in China. The first reason is that EIP and ECP have different environmental requirements in their applications so they have different behaviors with the economic development. The second, the application of microelectronics in ECP is the indication that microelectronics has stepped into a mature stage in its evolution, since microelectronics could penetrate into lots of consumption fields only when electronic industry can supply a

great quantity of microelectronic products with new properties and lower prices. This makes the application of microelectronics boundless. The third, there is such a big population of one billion in China and the size of family shows a dwindling trend, the relative consumption of ECP is very low compared with advanced countries. All these are responsible for the huge potential demands of ECP which would subsequently grow into a real demand as the increasing of income per capita is realized. The last is that the definitions of ECP and EIP are somewhat different from the common-used terms.

We should make distinctions among the stresses and stages in science, technology and production in the development of the electronic industry. Efforts should be put on the breakthrough of key components, devices and systems in scientific research. In technology then the stress should be layed on the electronic techniques having much to do with the development of socioeconomy, especially the applying microelectronic techniques. In order to have the electronic industry grow faster, a higher priority should be given to the products of large quantity of demands and of much importance in the modernization on the law of scale-economy.

The conclusion above does not mean that the development and production of EIP are not important in economy. On the contrary, although ECP dominate the market by volume, the production and applying techniques of EIP and EEP promote directly the development of electronic industry and socioeconomy and thus are of much importance.

IV.3 The Results in Policy-Test-Runs

The policy parameters in SDEIC are the reference proportions of investment and importation in the electronic industry, the feedback adjustment elasticities to the proportions, etc.. To investigate the effect of changes of these parameters on the development of the electronic industry from the changes of these parameters, four runs are arranged:

. Test-run 3--the reference proportion to investment is reduced by 25 percent, the reference proportion to importation is increased by 25 percent.

. Test-run 4--the changes are just the opposite to test-run 3.

. Test-run 5--both reference proportions are reduced by 25 percent.

. Test-run 6--the feedback adjustments to the investment and importation are enhanced.

Base-run shows that the share of home-made electronic products in the market does not change much over time except a valley around 1990. The changes as in test-run 3 and test-run 4 have just a weakened impact on the share. There is only a small space for such parameters to control the proportion of domestic production and importation which is believed to be largely determined by the policy-mechanism and the things

themselves from the view of long-run.

Because of the vigorous demands and the shortage of funds, the fulfilment of demands of electronic products would slide into a deep hollow as shown in Figure 11. The flexible investment and importation policy as in test-run 6 would ease the situation to some extent, the tightened finance policy like test-run 5 would then make it worse. Figure 12 tells us that the electronic industry would develop steadily if we choose the policy of test-run 5. If we loose the limits to the investment and importation then the electronic industry would advance more dynamically.

It is believed in the paper that there are many complicated interactions and feedback relations among the factors in socioeconomic systems, and what determine the behavior of a system greatly are the policy parameters and feedback mechanism. What a policy-maker should do in dealing with economic problems is not to react the phenomena passively or to try to reach the goal by brain-born policies, which are no use to the economic development from the lessons we have got. How to create more effective policy mechanisms and make policies inside the policy-space are big problems of socioeconomists.

V. THE ANALYSES TO THE BEHAVIOR AND RESULTS OF SDEIC

The behavior modes of a system are mainly determined by the internal mechanism. The existence of multiorders and nonlinear relations makes the characteristics of SDEIC special.

V.1 The Stability of SDEIC

It is easy to see in Figure 2 that the main loops in SDEIC are all negative, then the development of electronic industry depends largely on the stimuli from the advancement of the environment. The unbalanced development of EIP and ECP is because the different responses to the changes in the economy. The parameter sensitivity analyses indicate that SDEIC is of better properties of stablization and robustness.

V.2 The Periodicity of SDEIC

The simulations show much of dynamics of SDEIC, one of which is the periodicity. The short-cycle period is about 4 to 6 years which could be perceived by the investment in ECP production shown in Figure 8. The investment in EIP production in Figure 9 or the total investment in electronic industry then shows the long-cycle period of 15 to 25 years.

The short-cycle in the dynamic behavior of SDEIC is believed to be caused by the delays of both information and material in the production, shipment, selling, and investment. The long-cycle phenomenon is considered the result of unbalanced response to the changes in enviorment as well as the delays

in SDEIC. Take the production of ECP for example. There would be a peak of demand for ECP in the coming years because of the nonlinear demand function and relative small variance in income. During this period the market is often in shortage of supply thereby the producers will gather funds as much as possible to invest and make the production advance at a higher rate. But when the peak is over, there would be a overshoot in production because of the inertia of the system, which then might induce a drastic declining in the investment, thus a longer cycle is formed.

The understanding to the periodicity of the development of the electronic industry would help to make farsight strategy and to hold the long-run of the electronic industry in China without much swinging from side to side we have experienced.

V.3 The Evaluation to the Results

In socioeconomic systems, the statistic data are only a small fraction of the knowledge of human being, the more important are the perceptual knowledge and qualitative analyses to the system. To a nonlinear system with structure and parameters changing over time, whether the behavior of the model presents the real system depends not only on how close the output of the model with that of past world but on the correctness of the consideration to the structure, the interacting mechanism, and the likely changes of the system in the future.

The production of the electronic industry is increasing rapidly these years which is considered the result of constricted development under closed-door policy for a long time, but it is impossible to endure so high a speed of development much longer. The SDEIC model is far from completed, the results here could only show a general trend of the development of the electronic industry. But we could still say, in confidence, something about the future of the electronic industry in China.

VI. CONCLUSION

The rapid development and wide application of microelectronics are bringing about drastic changes in socioeconomic activities worldwide, which are believed to be the processes of microelectronization of electronic industry and informization of social life. A system dynamics model is created to investigate the development of the electronic industry--the direct applying field of microelectronics in the view of long-term.

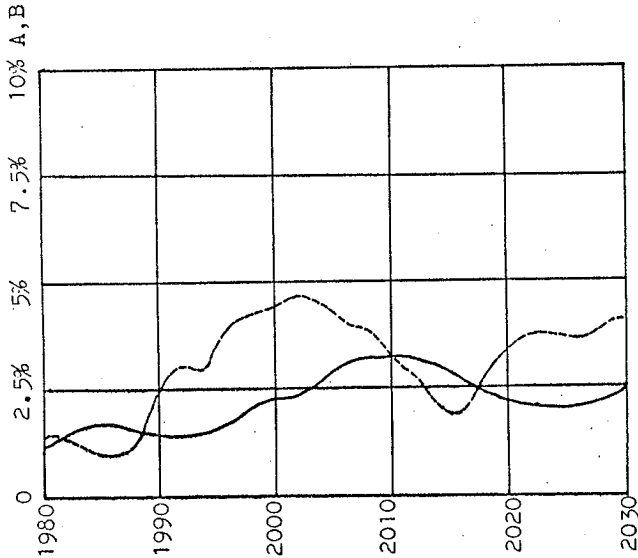
The simulations and analyses show that with the socioeconomic development and wide application of microelectronics, the electronic industry will advance at a higher growth rate in a period of 20 years around 2000, and the output proportion of the electronic industry out of the total output of society is expected up to more than 3 percent in about 2005. The main

obstacle in this period is the shortage of funds for investment in the electronic industry. Although the development of EIP and EEP is very important in socioeconomy, the production of ECP will dominate the electronic industry in terms of volume for the period concerned, which is a most characteristic in the development in China.

We should make distinctions among the stresses and stages in advancing the science, technology, and production of the electronic industry, particularly take notice of the balance in the development of final electronic products and electronic components, and try to hold the long trend of the development.

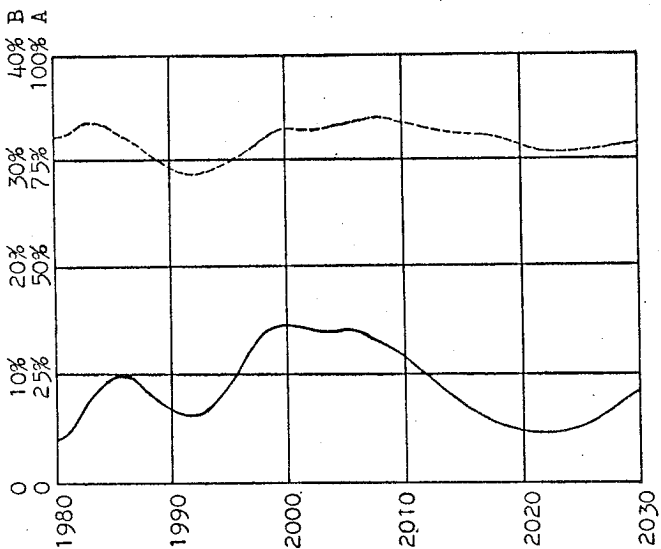
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A:--- The proportion of the invest. in total captial invest.
 B:— The share of electr. indu. in total output of society

Figure 5 The base-run of SDEIC (1)



A:--- The home-made proportion in the market
 B:— The growth rate of electronic industry

Figure 6 The base-run of SDEIC (2)

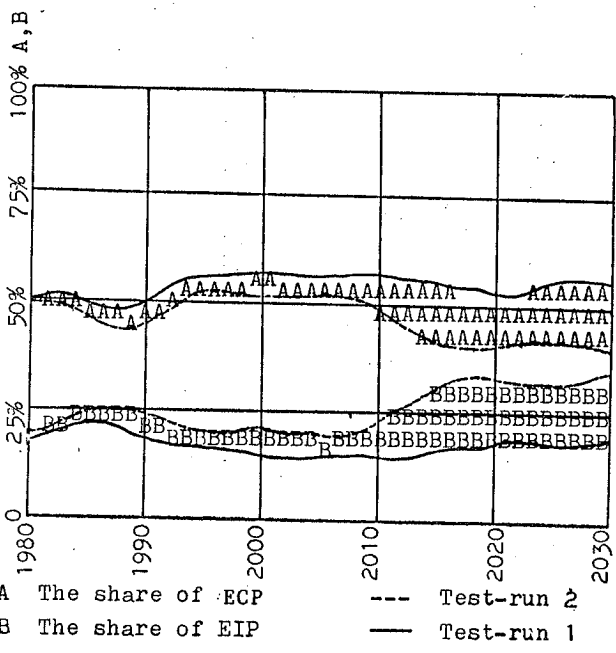
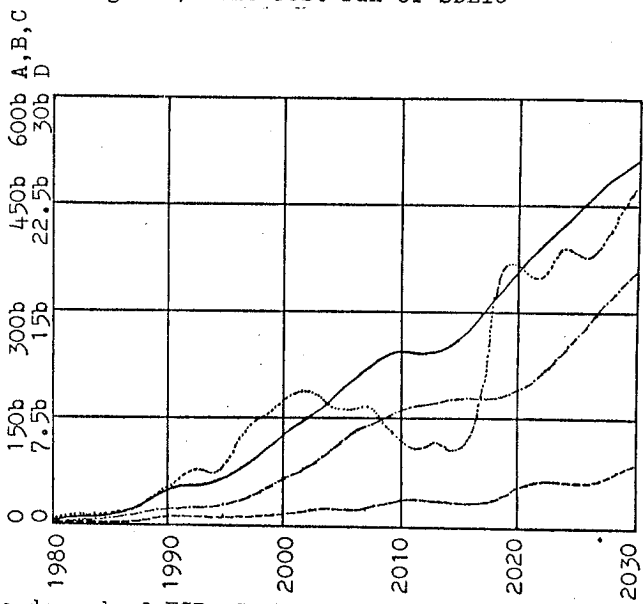
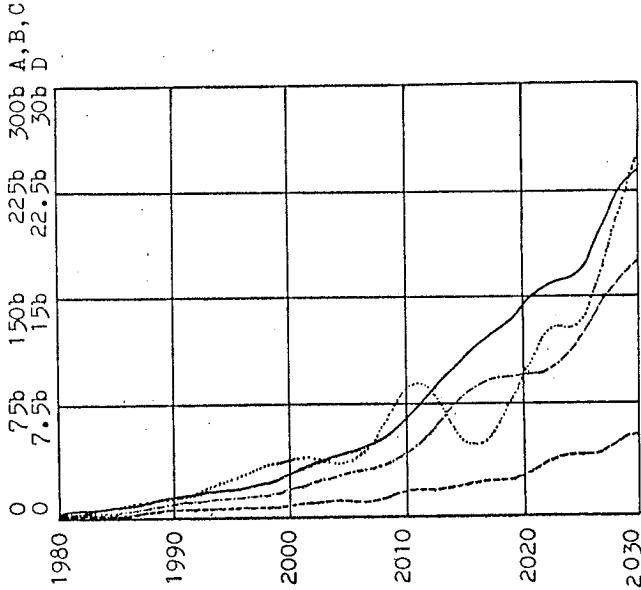


Figure 7 The test-run of SDEIC



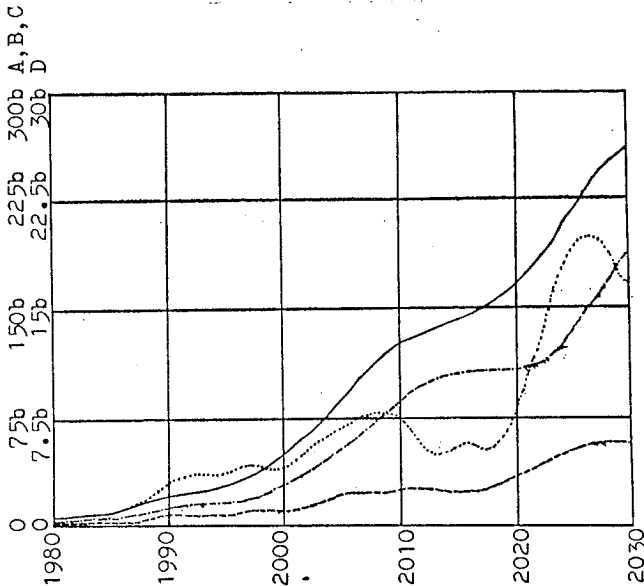
A: — The demand of ECP C: --- The importation of ECP
 B: The output of ECP D: ... The invest. in ECP sect.

Figure 8 The base-run of SDEIC (3)



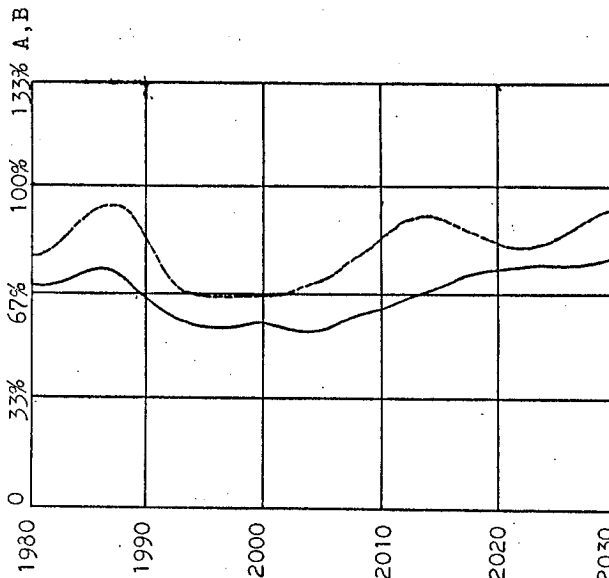
A:— The demand of EIP C:--- The importation of EIP
 B:..... The output of EIP D:... The investment in EIP sect..

Figure 9 The base-run of SDEIC (4)



A:— The demand of EEP C:--- The importation of EEP
 B:..... The output of EEP D:... The investment in EEP sect..

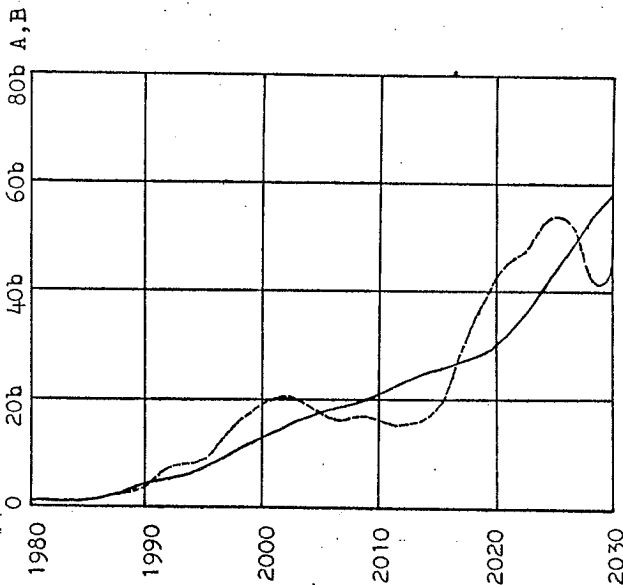
Figure 10 The base-run of SDEIC (5)



The fulfillment of the demand for electronic products

A: — Test-run 4 B:--- Test-run 3

Figure 11 The policy-test-run of SDEIC



The investment in the electronic industry

A: — Test-run 5 B:--- Test-run 6

Figure 12 The policy-test-run of SDEIC