SYSTEM DYNAMICS MODEL

FOR STUDYING THE IMPACT OF TECH-PROGRESS ON ECONOMICS

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ABSTRACT

The consumption of resources and the environmental pollution caus-
ed by the discharge of waste materials and waste heat occur as
useful products are being turned out in the social-economic activit
activities. Based on the concept of entropy, the paper deals with
the impact of tech-progress on every link of this process. This
is the major mechanism for the impact of the tech-progress on
economics.

One of the characteristics of the modern seciety is an interaction
of the three closely related factors, namely, technological pro-
gress, economic growth and social progress, of which science and
technology, serving as a productive force, is the most active one.
Without it, research on both the revitalization of economics and
the issues arising from the social reform could not be done.

The impact of tech-progress on economics is a rather compligated
problem. In order to reveal the essence of it, a "System Dynamics
Model for Studying the Impact of Tech-Progress on Economics" was
constructed by applying the methods of system dynamics. The model
presents the dynamic varying process of the tech-progrss--national
economy system in 1980--2010 and offers some proposals on the basis
of simulating a number of policies.

The tech-progress may affect economics in many aspects. There are
six factors being considered in the model, that is, the macroecono-
mics, the investment space, the tech-progress, the overexploited
resources, the environmental pollution and microeconomics. The
cause and effect relationship of the model is shown in figure 1,
in which the positive feedback loop is composed of the net output
value indecating the macroeconomics, the investment space, the
tech-progress and microeconomics. This is a major mechanism for the
impact of tech-progress on the economic growth. The development of
the macroeconomics boosts the advancement of technology by providing

it with necessary financial resources. Basically speaking, the development of tech-progress depends on the revitalization of the macroeconomics and in turn the tech-progress gives a stimulus to the macroeconomics. This is a process for the tech-progress to be transformed into the productive capability. All accumulated achie-vements in scientific research and improved techniques should be regarded as a kind of potential tech-progress before they are app-lied to the socialized macro-production. To turn the potential technology into the benefit-yielding technology calls for certein conditions, such as social demand, investment, etc. Even if these consitions are given, it also takes time for the potential technolo-gy to fulfill the transformation. Here, the "social demand" stands for the demand for developing new technology evoked by the increa-singly rapid improvement of the people's material and cultural life. It also includs the demand of enterprises and workers for adoping new techniques to facilitate the production process. Likewise, the "investment" here also has two connotations: investment by the government for developing new technology (investment in research development) and investment by the enterprises for technical trans-formation and introduction (investment in technological development). The time required for the potential technoloty to be transformed into both the benefit-yielding technology is an intricate parameter, having something to do with people's concept of value, their mana-gement level, their insight as well as their pioneering spirit.

As the tech-progress is chiefly embodied by the fevitalizing of the microeconomics, the model gives a description of two major micro-elements: the progress of enterprises and the progress of farmer households. The level of these two elements directly affects the net output value of the macroeconomics. The microeconomic astivi-ties do create the macroeconomics, but they are also a cause for the environmental pollution and over-exploitation of resources. The two side-effects from the microeconomic activities form a nagative feedback loop. The more prosparous the microeconomics is, the more serious the environmental pollution becomes and the more severe the consumption of resources will be. The other way around, both the aggregation of the environmental pollution and the over-exploitation of the resources will frustrate the microeconomic activities by limiting their capabilities. The way to tackle this problem is to resort to the tech-progress. The development of tech-progress will result in a lessoning of environmental pollution and a rational

utilization of resources, which will and two more positive feedback
loops to the system as a whole.

As it is known to all, gross national income is composed of inductry,
agriculture, commerce, building industry and communications and
transportation industry. Investment comprises two parts: investment
in research development and investment in technological development.
The fulfillment of the two kinds of investment is dependent on
enterprises and farmer households as well as macro-financial
resources.

The key elements to bring about the advancement of technology are
research development, technological potential, technological demand,
and technological progress. Research development, if defined, inc-
luds three kinds of research activities, that is, scientific rese-
arch, exploring development and application research, each possess-
ing its own technological potential. Tech-demand reflects the needs
of the society for certain technology. The technical subjects
adopted in the model include microelectronics, bio-engineering, new
materials, energy engineering and transportstion and communications.
Between technological potential and all sorts engineering technology
is a relation matrix describing the presure exerted on the demand
for new technology by the tech-potential accumulated from various
development activities. Besides, the development level of enter-
prises and farmer households is also a source of influence on the
technological demand. It makes relevant progress in technology in
demand and with necessary investment. Thus, through research ac-
tivites, investment in research development aids the formation of the
tech-potential and further, the formation of demand (presure) for
developing new technology. The presure from the demand along with
the investment in technological development constitutes the condi-
tions for the tech-progress to take place. However, it takes time
to enble the tech-progress to yield benefits in industry. This
process of prolonging exists in the tech-progress, being regarded
as its dynamic varying process.

The five kinds of tech-progress are weighted to act on the progress
of enterprises and farmer households. The macroeconomics hings on
three factors: the progress of enterprises, the progress of farmer
households and the ecological losses and damages (environmental
pollution and over-exploitation of resources). Proceding from the

concept of ecologic-economy, here we tryed to show that the evalua-
tion of the gross national income should not only rest on the out-
put value, but also on the ecological losses and damages. For
instance, how many pollutants are discharged for each 100 RMB
worth of net output value? How many resources does it cost? And
how much money these sacrifices would be worth? In a work, when
ap plying ourselves into the economic growth, we'll have to pay
attention to the economic results. We should weigh the pros and
cons from an objective, long-term point of view. This, we might
say, is the right purpose of making this mode.

Figure 2 is the rough flow chart of the "System Dynamics Model for
Studying the Impact of Tech-Progress on Economics", in which only
level variables and major auxillary variables are presented. As
for the variables of current velocity that control the level, a
sketch is made so as to make it easy to display the basic structure
of the model.

The model involves the following seven sub-models:

1. Sub-Model for the Macroeconomics
It consists of five level variables from the output values of
capital construction, transportation, commerce, industry and agri-
culture describing the net output value of the macroeconomics. The
GNP standard is adopted in calculating the output values given in
the model. Both the output-value-generating valve and the r
material-consuming valve are controlled by the tech-progress. And
the generating valve is simultaneously controlled by the progress
of enterpreses, the progress of farmer house holds and the ecolo-
gical losses and damages.

2. Sub-Model for Tech-Progress
The essential factors promoting the tech-progress are research
development activities. The level variables adopted here are
scientific research, exploring development and application research.
The generating valves of the three level variables are controlled
by the progress of enterprises andthe progress of farmer house-
holds as well as the investment, and these level variables are
disappearing at a certain rate. The level variables derived from
the research development are the tech-potential--- the resultant
levels corresponding to the three research activities above. The

factor controlling the tech-potential valve can be found in the
relevant research activities, and this sort of level is terminating
at a certain rate as well.

The demand for technology is also a level variable, whose generat-
ing valve is initiated by the activities involving three research
developments along with the levels of the progress of enterprises
and the progress of farmer households. The interacting relations
between them are displayed by the relevant multipliers.

Described as a level variable, the tech-progress is defined in
accordance with the technical categories corresponding to the tech-
demand. The various generating valves for tech-progress are res-
pectively controlled by the investment and the demand coming from
the relevant categories of technology. A prolonging device (de-
ferrer) is contrived between the generating valves and the levels
of tech-progress so as to manifest the stagnation in time, the
period of which begins with the investment and ends with the tech-
progress coming into being.

3. Sub-Model for the Progress of Enterprises
One ofthe most active factors in the mechanism for the impact of
tech-progress on economics is the development level of enterprises
(hereafter referred to as"the progress of enterprises"). The so-
called progress of enterprises here does not specifically mean the
progress made by a certain enterprise but the progress of enter-
prises in terms of macrostructure. In the model, it means the
progress of enterprises evaluated by taking a comprehensive view of
the situation throughout the country. Attached to the model, this
sub-model for the progress of enterprises is composed of the newly-
built enterprise, the muture enterprise, the outdated enterprise
and the progress of enterprises, which are streamlined to describe
the development level of the enterprises. The factors affecting the
level of the progress of enterprises include the tech-progress and
the state of enterprises themselves. For the latter, such aspects
as the quality of workers, the quality and number of technical staff
members, the quality of managerial personnel and the fixed assets
may tuen out to be very complicated. In the model, an experiment
is conducted on the increasing process for the newly-built enter-
prises with reference to the growth of investment in the fixed
assets in China. The annal growth rate is 17.8 per cent. As

newly-built enterprises are expanding too fast with a slow increase
of technical capability (10 per cent), there emerge a great number
of newly-built enterprises in 1970's---1980's and the number of
mature enterprises.tend to decline. When the investment in newly-
built enterprises is reduced to 4 per cent and the growth rate of
technical capability is enhanced to 15 per cent, the curve repre-
senting the newly-built enterprise moves up at first, and begins
to come down year by year after 1980 whereas the curve represent-
ing the mature enterprise markedly goes up and keeps a stable trend
of increase from the second half of 1970's to the year of 2000
figure 3.

The current situation of the outdated enterprises is also an
imperative problem in our country. The experiment conducted in
the model indicates that any increase of investment in technical
transformation would mean allocating more funds to the out-of-date
enterprises or introducing equipment from foreign countries or
increasing investment in other capital construction. This will
result in an obvious reduction of the number of the enterprises
that need to be transformed. But because.the capability of
these enterprises to materialize the technology is insufficient
and the technology can not come into effect for a long period of
time, an increase of the number of newly-built enterprises is
seen in the model. The percentage of the muture enterprises
depends merely upon the enterprises' vatility and technical ca-
pability. To bring in new equipment for enterprises but fail to
help them improve their technical absorbingability to deal with
the equipment at the same time is just like keeping this part of
the introduced equipment in the newly-built enterprises forever.
So the key to carry out the technical transformation of the out-
of-date enterprises lies in the enhancement of technical capabi-
lity, namely, the research capacity and the development capacity.

4. Sub-Model for the Progress of Farmer Households
This model consists of small farmer households, midium-sized
farmer households engaged in the specialized production, advanced
specialized households and the progress of the farmer households.
The small farmer households are the little families formed with
the natural growth of the rural population. With the development
of the specialization in the rural production, the small farmer
households will have to undergo changes. Some of them have already

turned into midium-sized specialized households and will further
develop into the advanced specialized households. Meanwhile, a
large number of suplus labour forces produced by small farmer
households will constantly be entering into the "third industry"
in the rural areas. This, to a great extent, will futher streng-
then the specialization campaign in the countryside and in turn
stimulate the further transforming of the small farmer jouseholds.
Here, the condition for the transformation is the service space.
The tech-progress plays a major role in providing this space. In
the experiment, the varying performances of the three kinds of
farmer housrholds are rendered under the respectively defferent
state of the tech-progress. It happens that when an increase of t
tech-progress is urged at an average rate of 10 per cent, 15 per
cent and 18 per cent, the curve moves towards indicating the
markedly reduction of the number of the small farmer households
while the curves representing medium-sized and advanced specializ-
ed households move towards indicating a gradual increase of their
numbers until reaching the top value. With the development of the
tech-progress, the top value is likely to appear ahead of schedule.

5. Sub-Model for Laod Sources
Land is an another striking problem in respect of the surface
resources. The sub-model for land sources presented here is de-
signed in the light of the general trend that the green land and
arable have continuously been occupied. It comprises the green
land, the land for industrial use, the land for agricultural use,
the land for governmental use, the land for building's use and the
forest land. Both the generating and disappearing (terminating)
velocities of all sorts of land are affected by the tech-progress
and the government policy. The result of the experiment in the
model shows that the green land and arable land have roughly the
same tendency of reduction. This phenomenon shall be attributed
to a drastically fast increase in the land occupied for the gover-
nmental use, the building's use and the industrial use. It neces-
sary to have the use of land strictly planned and limited. But
it is almost impossible to completely control its decrease,
especially at a time when the arable-land-decreasing-trend can be
hardly altered, though tech-progress and necessary ad inistrative
measures may help diminish the decreasing speed.

However we hold that the enormaus potential of our land sources
does not lie in its absolute area but in the improvement of its
quality so as to bring the land efficiency into full play. There-
fore it is imperative to develop a scientific way for farming, to
improve the quality of land, to make an effective use of water
sources and develop fine breeding. In China, agriculture still
has a great potential to tap. This is also an important aspect
for the impact of tech-progress on economics.

6. Sub-Model for Energy Sources and Environmental Pollution
The other sub-model in the section of resources is the model
describing the energy sources and pollutants discharged by the
necessary energy generated by energy sources. As energy sources
can be derived from a wide range of resources, ther must be a
variety of contaminated materials thereupon. In the model, howe-
ver, only coal and petrolium are selected.

The coal flow is made up of the reserves, the inventory, the coal
for electrical use, the coal for industrial and civilian use as
well as such variables as CO, NOx, SO and smoke dust. Petrolium
flow is made up of the deposits, the inventory, the petrolium for
electrical use, the petrolium for motor vehicle's use and the
petrolium for other purposes. It also condists of the variables
discharged by energy-generating precess, such as, CO, NOx and SO
The tech-progress plays a part in the course of the two flow move-
ments. In fact, the model has attempted to seek a policy, under
which, financial resources permitted, the tech-progress works to
its full expent so that the discharge of harmful materials can be
minimized.

7. Sub-Model for Water
Water, as one of the component parts in the organism of resources
and envirnment, is made up of the variables of water for indus-
trial use, the waste water from industry, the water for agricul-
tural use, the water for civilian use and the sewage from such a
use and the water for township enterprise's use. The industrial
waste water couldn't be disposed progerly without the scientific
and technological progress.

Above are the simple compositions of the seven sub-models. The
purpose of this designing is to describe such a macro-system

stating that the state of macroeconomics is dependent on such
factors as the level of micro-production, the degree of pollution
and the level of discovery and utilization of resources. And the
level of the micro-performances is decided by the tech-progress.
In that way, macro-policy-making is confronted with this alterna-
tive as to how many financial resources would be considered as
appropriate for the investment in science and technology in view
of a long-term interest. The process of the so-called impact of
the tech-progress on economics is just developed in the above
micro-processes. And the macro-policy-making will determine the
degree and effect of each micro-process.

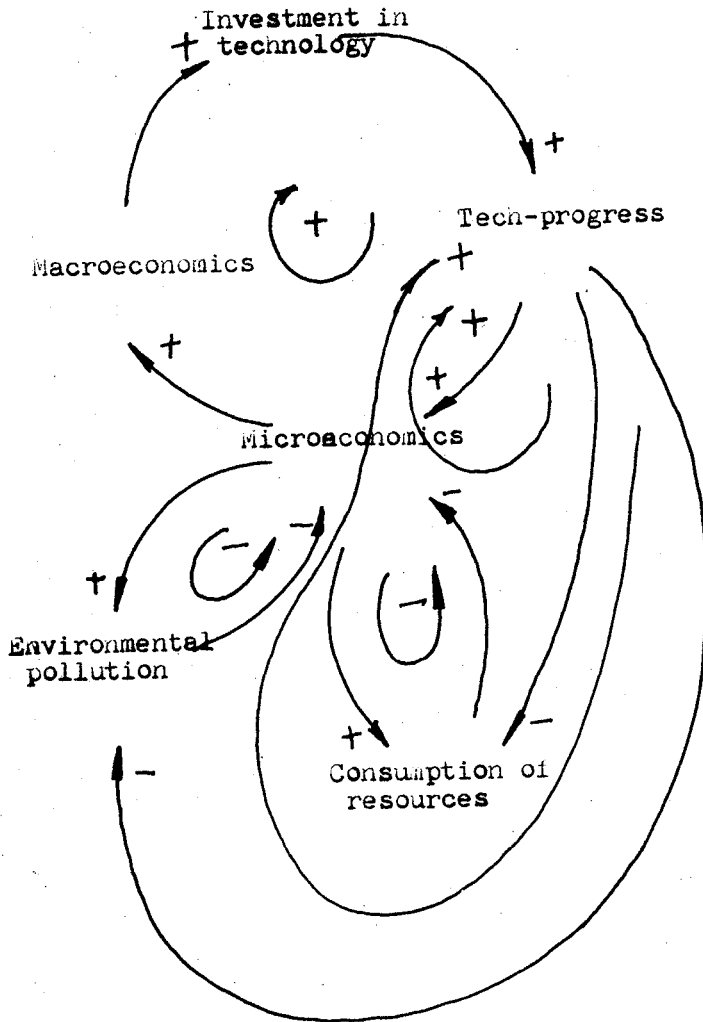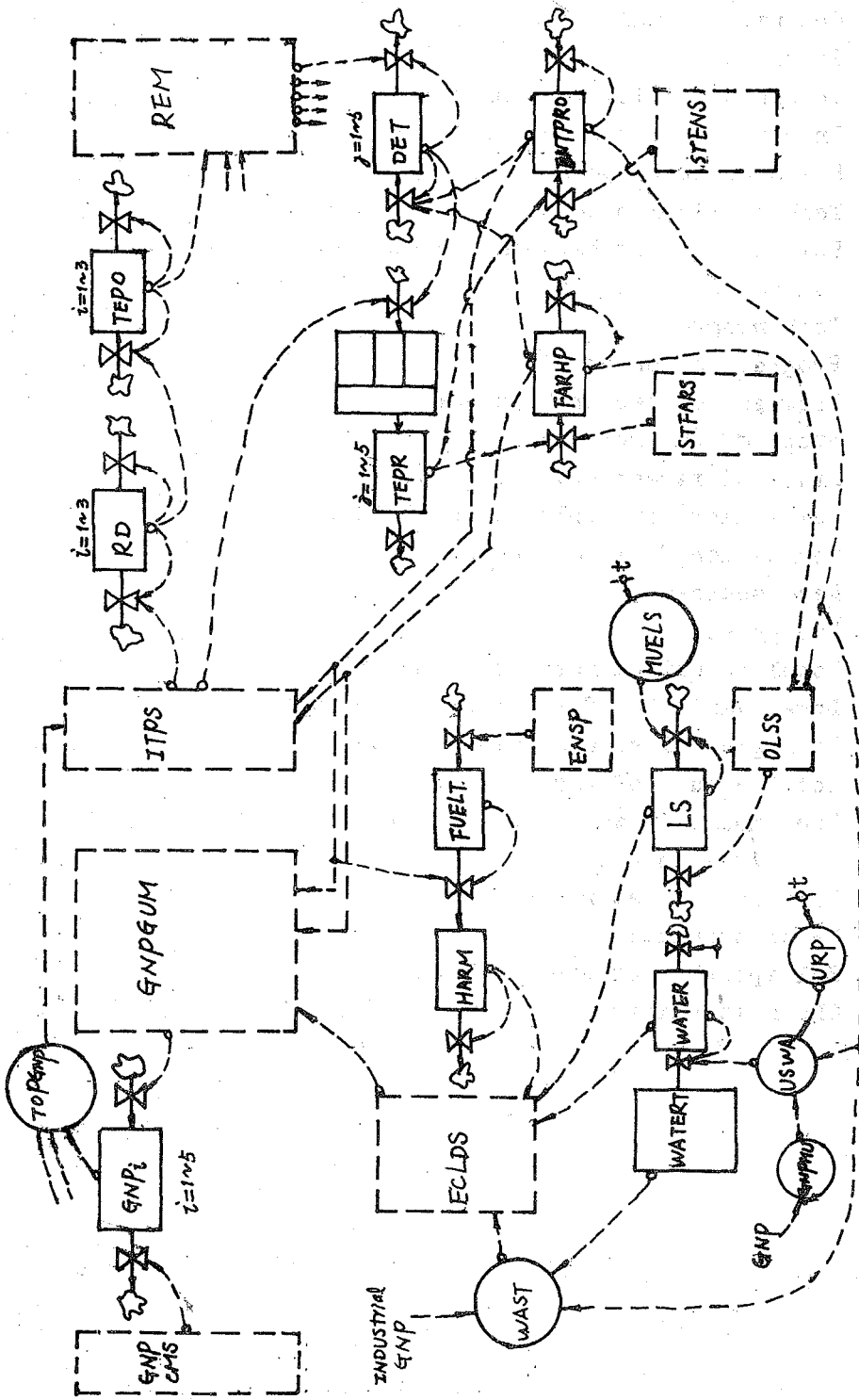-------THE END------

Fig. 1

Fig. 2

GNPCMS   Consumption multiplier space
TOTGNP   Total GNP
GNPGUM   Generating multiplier matrix
ITPS   Investment in tech-ptogfess space
RD   Research development
TEPO   Technological potential
REM   Relation matrix between tech-potential and tech-progress
DET   Demand for technology
TEPR   Tech-progress
ENTPRO   Progress of enterprises
FARHP   Progress of farmer households
STENS   State of Enterprises space
STFARB   State of farmer households space
MUELS   Multiplier for explotation of land sourxces
OLSS   Occupation of land sources space
LS   Land sources
ENSP   Energy space
FUELT   Total amount of fuelrfor combustion
HARM   Level variables for harmful materials
ECLDS   Ecological loss and damage space
WAST   Total amount of waste water
WATERT   The amount of water for industrial, agricultural and
             civilian use
WATER   Richness of water sources
URP   Urban population
USWA   Multipliers for use of water
GNPMU   GNP multipliers

500,00	1000,0	1500,0	2000,0	2500,0
0,00000E+00	2000,0	40,000	60,000	80,000
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the newly-
built
enterprise

the mature
enterprise