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SUSTAINABLE SOCIAL ECONOMIC EVOLUTION OF THE GLOBALIZED SOCIETY
⇒ Joint Responsibility of Control Engineers

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Abstract: By means of a global social economic dynamic model the diversified reasons for the momentum of the technical economic development are analyzed. Under additional regarding of the resources and environmental exploitation as well as of the growth of population it is shown that a further increase of these three integral acting influences inside of the strongly intermeshed social economic society can be lessened mainly by ecology improving global restrictions.
The applied investigation is based on time dependent data series taken from world-wide existing statistic data banks.

Keywords: increase of automation, globalisation, unemployment, growth of population, resources exploitation, sustainable evolution.

1. INTRODUCTION

Although many technical developments had been made already in the 18th and 19th century, like steam engine 1782, railway 1835, motor car 1862, electric motor 1866, the industrial large-scale production did emerge just a few generations ago. In the second half of the 20th century automation in the area of process and production industries caused a significant improvement of the working conditions and also contributes to raising standard of living in the industrialized countries. During the last two decades broad use of information technology has also led to the automation of office- and engineering-operations.
Due to this rapid development – illustrated in Fig. 1/1 and 1/2 by means of two typical examples – the momentum of science, technology, and particularly of the economy is increasing steadily.
Moreover, modern communication and traffic technology caused the globalization of business transactions during the last decade.

a) France / 1908 b) D – F / Airbus 380 >2001


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Fig. 1/1: Historical survey about airplanes

However, the always faster development and spread of the industrial production, combined with the worldwide use of industrial products causes an extensive use of the worldwide remaining raw material and energy resources as well as a steadily increasing environmental pollution.
Therefore the question concerning a reasonable and sustainable further development of the industrial society is important for the engineers, too. For this purpose holistic and long-term considerations of the industrial, environmental, and population future trends are required. With other words, we need – at least for the lifetime of our children and grandchildren – trend

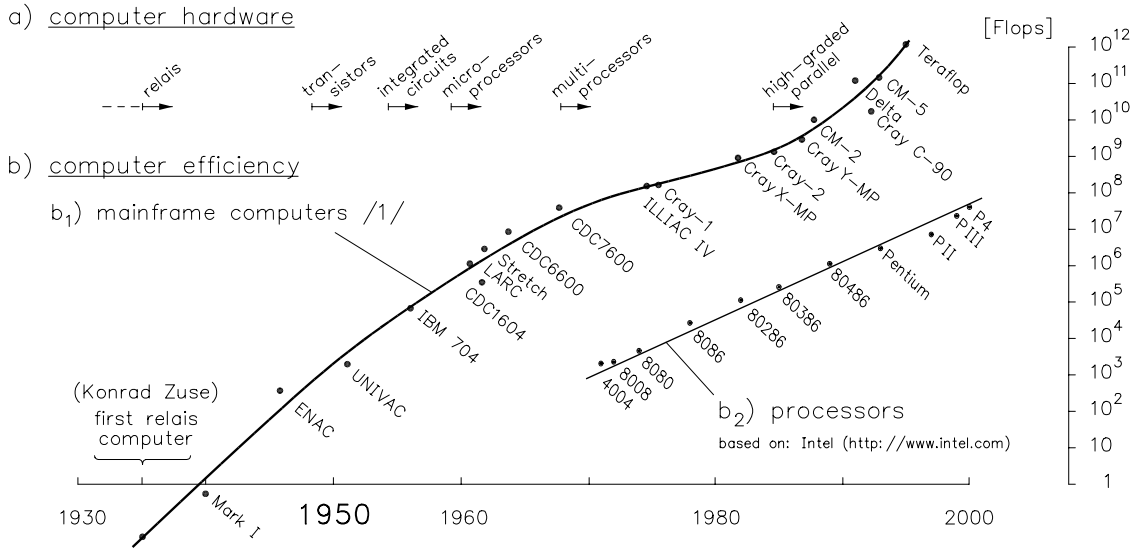


Fig. 1/2: Growing of computer efficiency [Floating point operations per second]

setting targets. Even though we will have to update the set goals, it is quite better than to have no targets. For „without any long-term objectives we are blind " /2/.

Besides the magnitude of verbal contributions and simulation studies already carried out to this thematic /3-5/ as well as listed up in /6/, there exists the concrete question for Control-Engineers, whether they could specifically contribute to the solution of this interdisciplinary subject. Just Control-Engineers are able to analyze the momentum of very complex technical processes and they are also capable to control processes being structure- or event-instable by implementing proper stabilization and limiting control-concepts.

Following this basic idea, a supranational social-economic dynamic model has been developed by the authors allowing qualitative analytical investigations as well as quantitative simulation studies. The overall structure of this flexibly applicable model has already been described in /7/. Within this paper continuous considerations and already aimed results will be presented.

2. STRUCTURE AND FUNCTIONALITY OF THE HOLISTIC MODEL

The holistic model is structured hierarchically and divided into different supranational economic/population areas, as shown by Fig. 2/1. Further subdivisions like "Germany" and "Rest of Europe" are possible.

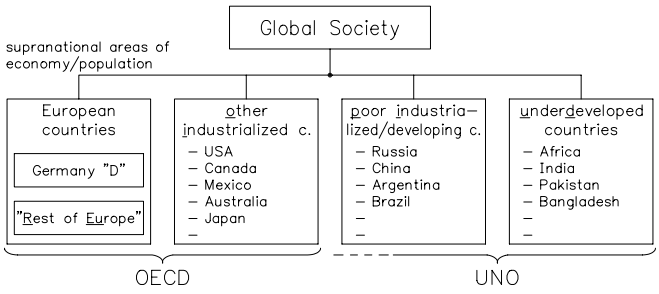


Fig. 2/1: Overview about the global model

Every supranational/national area of the holistic model is subdivided following national economical criteria, into the sectors "Households" , "Enterprises", "Banks/-Insurances", and "Public Authority/Government". All these sectors are strongly intermeshed, as shown by Fig. 2/2a. Fig. 2/2b gives an overview of different effects that should be investigated by the model.

Therein the automation degree η, indroduced here and considered in more detail in the following, comprises the total rationalization in the areas of production as well as of services.

As shown in chapter 4.1b the automation degree η results to the ratio of the production orders $\dot{O}$ to the total yearly working hours $\dot{W}$. This is also to be seen by Fig. 2/3b. Overall this picture illustrates the structure of the sector "Enterprises", comprising the following components:

- supply and demand,
- production and service,
- investments for manufacturing- and office-building as well as for equipment
- expenditures, i.e. for workforce and intermediate consumption, as well as
- credits and debits.

In the case of shortcoming liquidity, i.e. $C_{credit/debit} \rightarrow \dot{C}_{debit\,max}$ the companies management have to improve the business operation. The different possibilities for such an interference in the model sector "Enterprises" are visualized by dashed lined adaptation signals.

The structure of the other sectors "Banks/ Insurances", "Public Authority/Government", and "Households" /7/ is equivalent. Interactions between the sector modules are implemented by so called "switching matrices". The same belongs to the interaction of the superordinated supranational/national model areas. Inside of the switching matrices the output/input connections between different model areas are carried out by logical 1-gains.

The structures of the different sector models as well as the corresponding interactions are based on the methods of macro political economy /8/ applied by the statistical offices of the national countries /9/ as well as

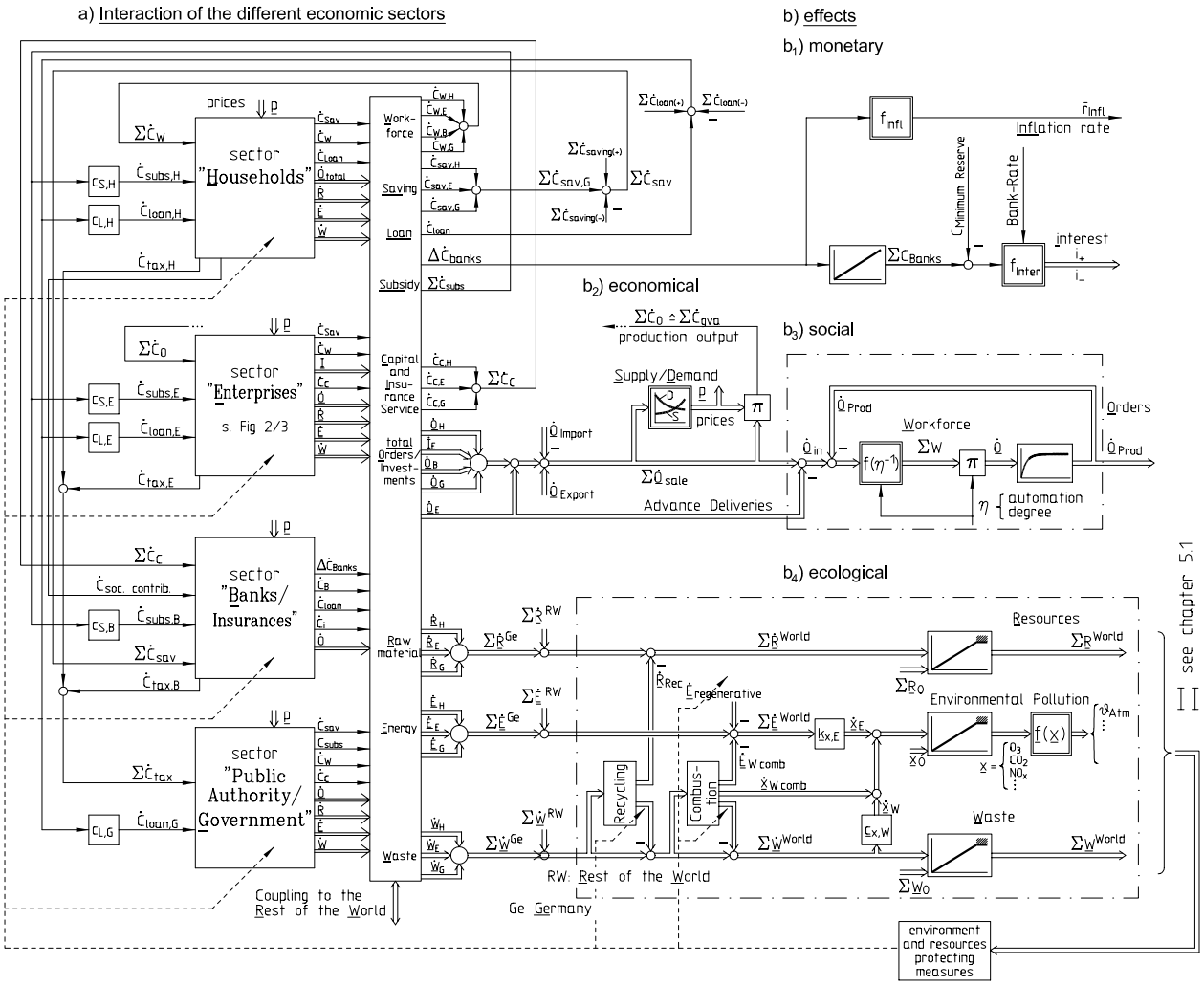


Fig. 2/2: Survey about the principal model structure of one economic area (i.e. Germany)

the international organizations like the European Communities /10/, the OECD /11/, the UNO /12,13/ and the World Bank /14/.

3. BALANCING AND PARAMETERIZING OF THE HOLISTIC MODEL

Realistic data specifications for the input and output variables as well as for the internal variables of the model are determined using time dependent data series from statistical yearbooks. The calculations are designed in such a way, that not only the internal balances of each sector model are coherent, like $\dot{C}_{yield} = \sum \dot{C}_{in} - \sum \dot{C}_{out}$ in Fig. 2/3, but also the couple balances between the different sector-models, e.g. concerning the labour income $\dot{C}^{(H)}_{income} = \dot{C}^{(H)}_{W} + \dot{C}^{(E)}_{W} + \dot{C}^{(B)}_{W} + \dot{C}^{(G)}_{W}$. The same is applied to import and export flows between different supranational/national model areas.

As illustrated in Fig. 3/1 by means of the cost flows $\dot{C}_{inc.}$ and $\dot{C}_{soc.}$, the statistical evaluation has been carried out for the last 20 years. Even structural changes like the German reunification, occurred in the meantime, can be eliminated. To make the data consistent, two regression curves have been calculated, using the least square method, one for the West-Germany data from 1980-1990 and one for the data of the reunited Germany from 1991-1999. Afterwards the two regression curves have been fit together by corresponding adjustment.

Comparing the regression curves of the single variables the related model parameters can be identified, too. This has also be done by using the least square method. In Fig. 3/1 this is exemplarily shown for the factor c_{soc}. Therein the data series without inflation are preferably used for balancing and identification purposes due to less time dependency than appearing in the corresponding nominal data, comp. Fig. 3/1a and 3/1b.

According to this procedure the model area „Germany“ has already been completely balanced and parameter-identified. Currently the other supranational model areas, classified in Fig. 2/1, are balanced and parameterized, using the corresponding statistical yearbooks /9-15/ and data banks.

4. MOMENTUM OF THE TECHNICAL AND ECONOMICAL EVOLUTION

The momentum of the technical/economical evolution is caused by strong positive feedbacks inside of the whole system. These positive feedbacks are partly based on technical reasons and partly on business and national economic reasons.

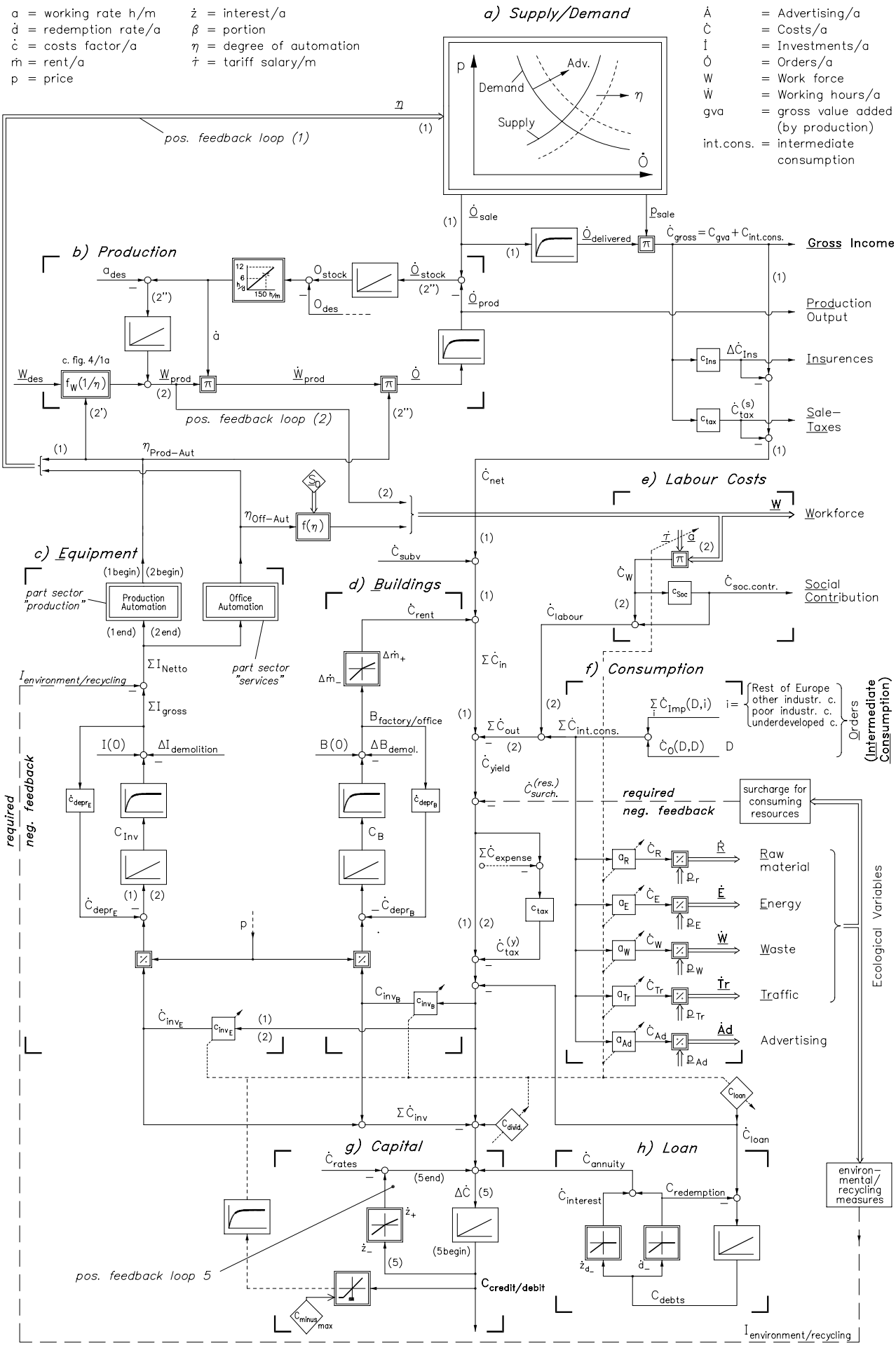


Fig. 2/3: Sector “Enterprises”

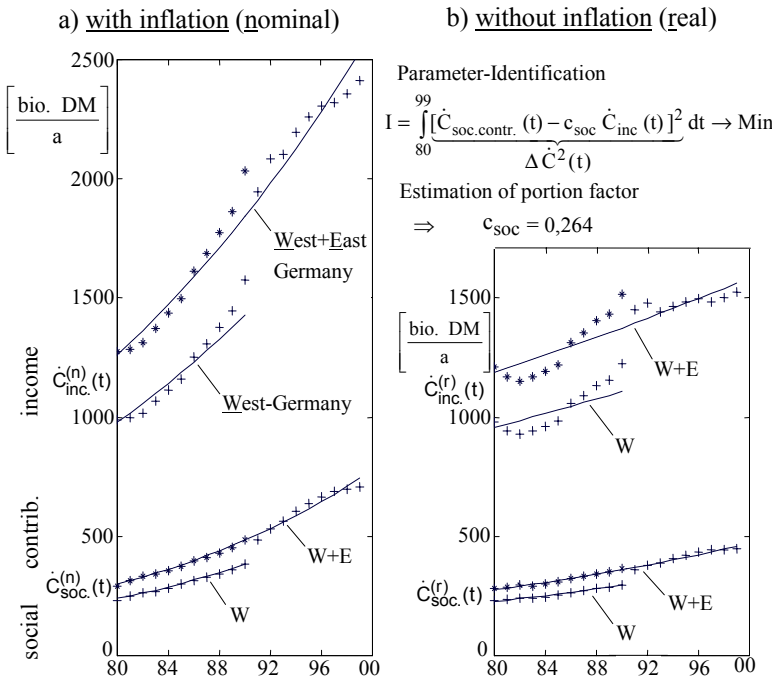


Fig. 3/1: Evaluation of data series
=> elimination of structure changes

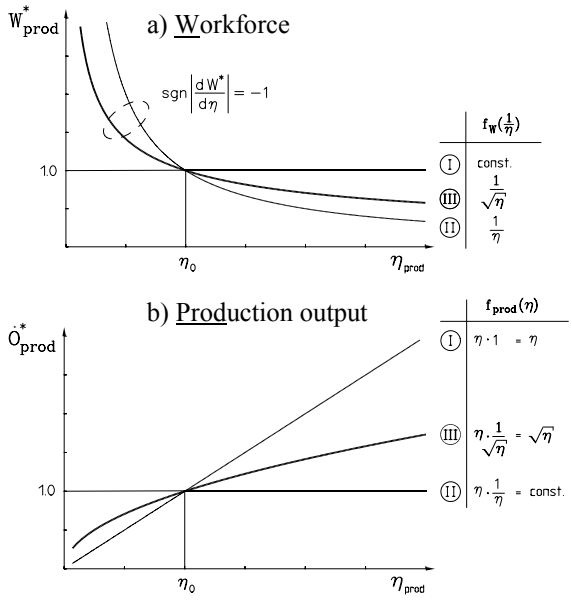


Fig. 4/1: Dependence on the automation degree

4.1 Technical reasons for the momentum

In the following section the momentum caused by technology is investigated by means of the increasing rationalization in the sector "Enterprises". All multi-faceted influencing factors of rationalization are summarized – in the sense of a global consideration – by the mechanization and automation degree $\eta_{mech/aut}$ separately for production as well as for services.

a.) Qualitative considerations

As illustrated by the part model production within the sector "Enterprises", referring to Fig. 2/3, most of the profit $\dot{C}_{yield}$ is reinvested in new manufacturing and office buildings and especially in more effective industrial equipment. The resulting increase of the automation degree η leads on the one hand to an increasing order flow $\dot{O}$ and therefore to an increasing gross income $\dot{C}_{gross}$, s. **=> positive feedback loop (1)** in Fig. 2/3, and on the other hand the increasing automation degree η leads to a reduced workforce W and therefore to a reduction of the compensation of employees $\dot{C}_W$, s. **=> positive feedback loop (2)** in Fig. 2/3. Both positive feedbacks result in climbing profits in spite of increasing capital expenditures to improve η.

Referring to /7/ the interaction of the two feedback loops is qualitatively illustrated again in Fig. 4/1 for

- border case I: Workforce $W^* = const.$[1], $\dot{O}^* \sim \eta$
- border case II: Prod. output $\dot{O}^* = const.$, $W^* \sim 1/\eta$

as well as for

- realistic case III: $\dot{O}^* \sim \sqrt{\eta}$, $W^* \sim 1/\sqrt{\eta}$

Which of the two feedback loops:

1) the "production increase" $\dot{O}^*_{prod}$ or
2) the "workforce decrease" W^*

will be more influenced by the automation degree η is depending on the market demand as well as on the tax burden and wages. The different impacts are issued below.

b) Quantitative consideration

Fig. $4/2_I$ shows the increase of the production-automation degree η_{aut} concerning the part sector "production"[2] within the sector "Enterprises" in "Germany" between 1980 and 1999.

As to be seen the automation degree η has increased quadratically with time. This corresponds to the equation $\eta = \dot{O}^* / \dot{W}^*$. The production output $\dot{O}^*_{prod}$ increases in Germany linearly whereas the total annual working hours $\dot{W}$ decrease reciprocally to time, starting from $W_0(1980) = 10{,}2$ billion hours, s. Fig. $4/2b_I$ and c_I.

The real system behaviour is determined by time series published in the statistical year books /9,15/ and afterwards approximated by regression curves. As financial value for the production the "gross value added" by production $\dot{C}_{gva}$ has been chosen in real terms, which is directly proportional to the production orders $\dot{O}_{prod}$. In the per-unit-system $\dot{C}^*_{gva}$ is even equal to $\dot{O}^*_{prod}$.

Solving equation $4/2a_I$ with respect to t a transformation of the coordinate system can be implemented by equation $4/2a_{II}$. It can be seen in Fig. $4/2b_{II}$ and c_{II}, that the production output $\dot{O}^*_{prod}$ increases, as predicted in /7/, in reality by the factor $\sqrt{\eta}$ and the entire annual working hours $\dot{W}^*$ decreased by the factor $1/\sqrt{\eta}$, comp. Fig. 4/1, characteristics III.

The reasons for this η-dependent behaviour of the part sector "production" in Germany are considered in Appendix A1-A3 by comparison with the η-dependent production-sector behaviour in the USA and the η-dependent services-sector behaviour in Germany.

[1] $X^* = X/X_0$ [%] referred values in the per-unit-system

[2] each time area "manufacturing"

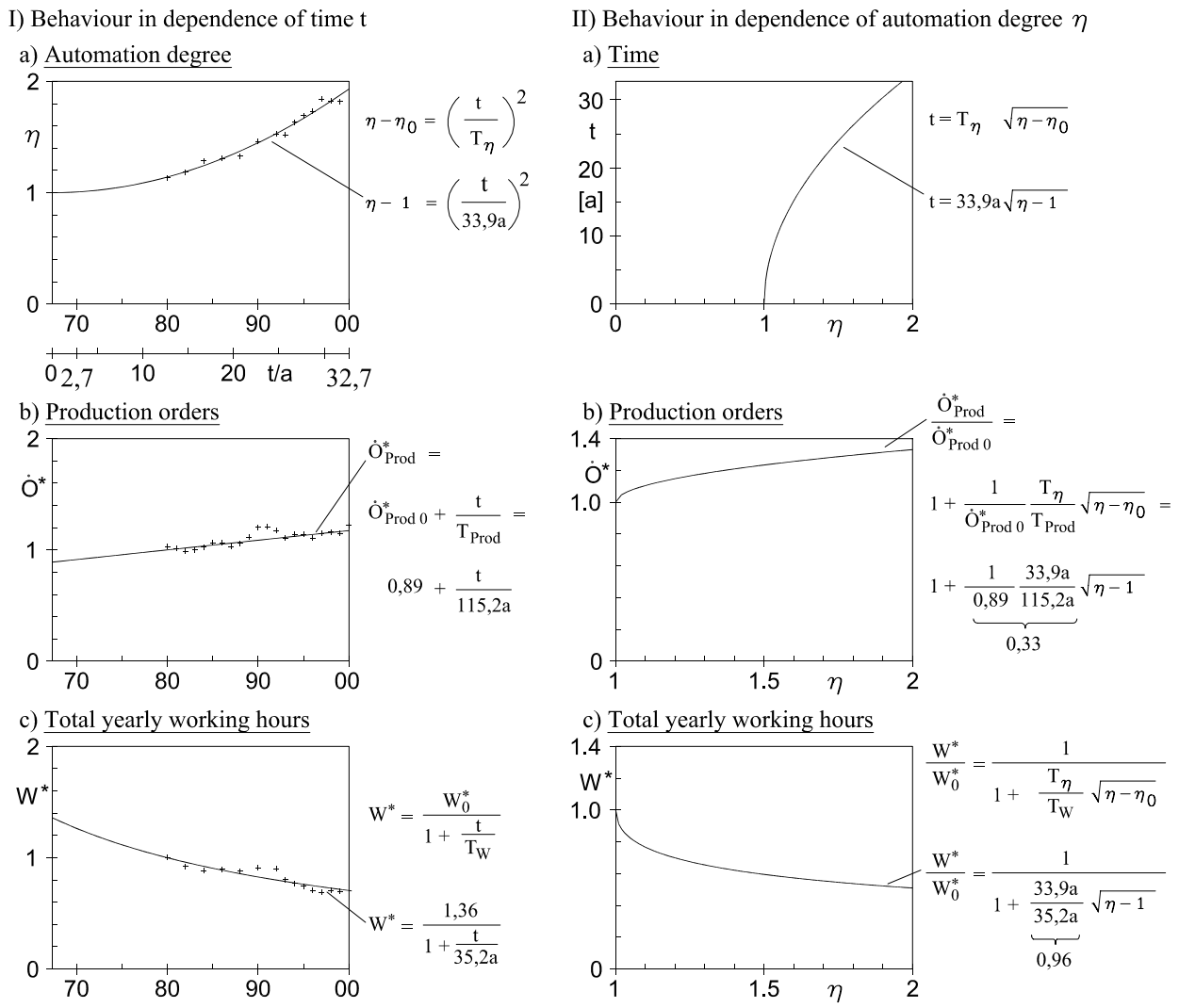


Fig. 4/2: Quantitative evaluation of the production behaviour in Germany in dependence of time and η

c) Additional simulation results

After adjusting the referring time constants the deviations of the considered variables could also be simulated with the help of the production model. Therein the partial model, shown in Fig. 4/3a, has been considered as an autonomous system with trend curves as input variables, that are determined by regression method in chapter 3. Looking at Fig. 4/3b it is remarkable that the weekly working time $a^*(t)$ and the magnitude of workforce $W^*(t)$ oscillate against each other.

4.2 Business and national economic reasons for the momentum

a) Price increase and use of inflation

The prior explained technical reasons of the momentum caused by the automation degree η are summarized in Fig. 4/4a, by => **positive feedback loops 1 and 2**.

Raising prices are another possibility for companies to increase the yearly profit. This business scheme is represented in the Fig. 4/4a by => **positive feedback loop (3)**. However this action mostly leads only to short

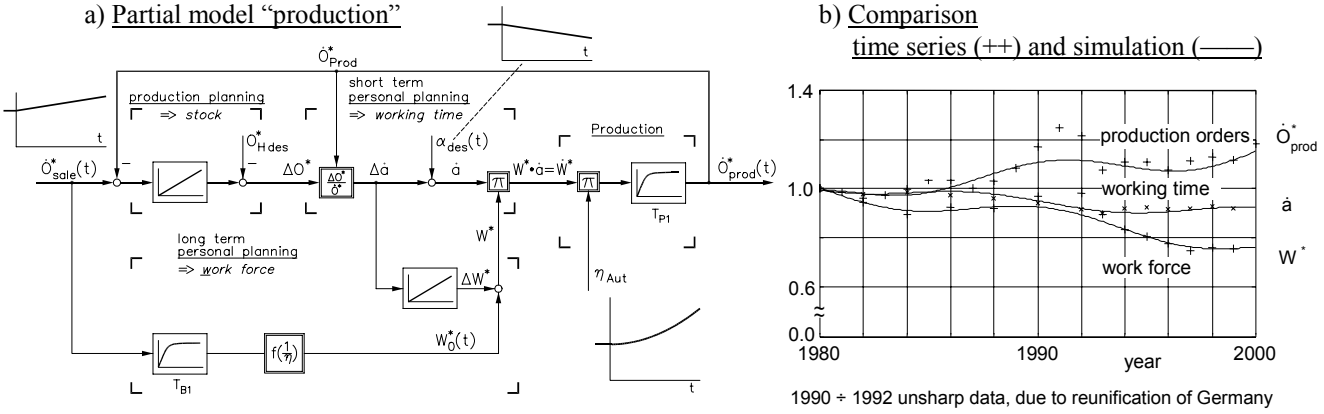
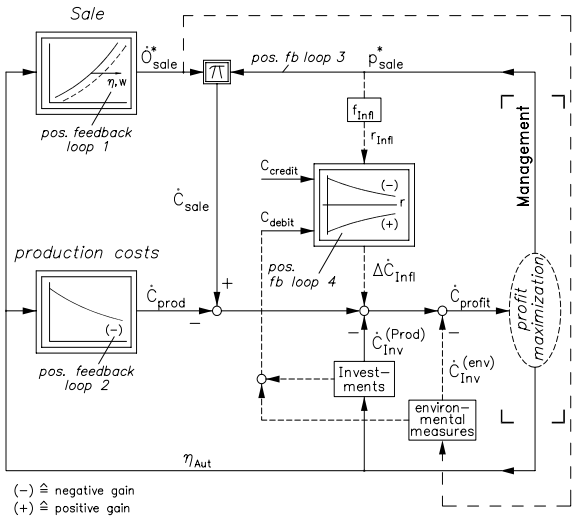


Fig. 4/3: Dynamic behaviour of production

a) Block diagram



b) Gross domestic products

b$_1$) "USA" b$_2$) "Germany"

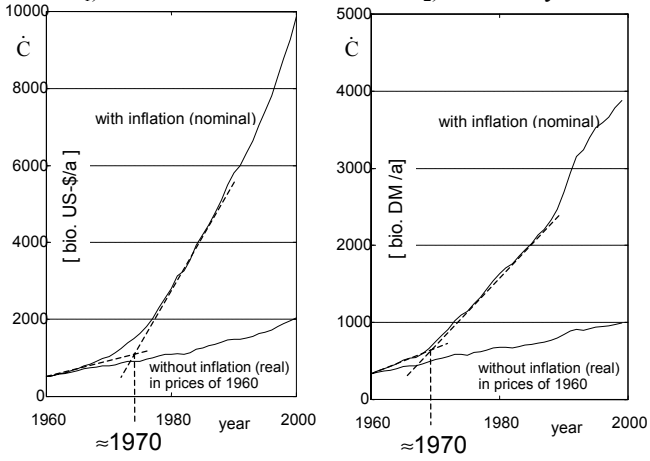


Fig. 4/4: Profit maximization and inflation

term profit. Because looking from the national economic point of view, all companies will act in the same way and instead of individual business profits there will be inflation. The significant impact of this yearly sneaky influence is shown in Fig. 4/4b on the example of the gross domestic products in "Germany" /9/ and in "USA" /16/. In both cases, the increase of the gross domestic product in real prices of 1960 was, within the considered four decades, 4 times smaller than the domestic product in nominal prices.

This sneaky inflation rate r_{infl} causes a yearly decrease of the utilized capital in real prices and due to this a negative feedback loop with regard to the credit capital, but a positive feedback loop with regard to the debit capital. Since companies normally finance investments only partly with own capital and stocks (long term loaned capital) but mainly with bank credits, they do systematically take advantage of this **positive feedback loop (4)**.

As to be seen by Fig. 4/4b the industrialized countries make strongly use of this hidden positive feedback since 1970.

b) Positive feedback loop of capital and debit interest rates

The yearly interest to be paid or received for credits represent a further positive feedback loop. As illustrated at the bottom of Fig. 2/3 this **positive feedback loop (5)** causes the ever increasing poverty of poor households/nations and the ever increasing wealth of rich households/nations.

This widely known social effect accounts mainly for the big gap between the developing and underdeveloped countries, see chapter 5, and is also responsible for the fact, that developing countries are not able to pay back their debits.

4.3 Existing and necessary countermeasures

Due to general competitive struggle the companies have nearly no stability insuring possibilities to lessen the momentum of the technical/economic development. Only social contributions and the option of donations are certain ones to overtake social responsibility.

Also the government has only limited possibilities to reduce the momentum taking monetary measures.

These are mainly the collection of taxes as well as of social contributions. Therein the government has the task to redistribute the social contributions and part of the tax receipts with regard to social needs.
To such social outlays there are also belonging subventions to the developing and underdeveloped countries in form of developing aid as well as by lengthening or canceling of credits.
However, the finally decisive and effective possibilities for lessening the momentum of the technical economic development are of global nature, as pointed out in the following.

5. HOLISTIC AND GLOBAL VIEWPOINT

The focus of the previous chapters was the analysis of the momentum of the technical and economical development. This "**integral acting influence I**" can clearly be seen in Fig. 4/4b by the real growth of the "gross domestic product in constant prices" in the United States and Germany, i.e. two of the main industrialized nations.
In opposite to this proper growing behaviour Fig. 5/1 shows, that only 1/6 of the worlds population earns 4/5 of the worlds gross domestic product. These numbers are equal to a difference in standard of living of 16:1 between the industrialized countries and the developing/underdeveloped countries.

5.1 Qualitative Considerations

Looking from the holistic point of view concerning a "reasonable further development of the global society", two additional factors with also **integral** or in the long-term even exponential behaviour have to be taken into account, s. Fig. 5/2a and b. These are:

			Economically rich countries		Economically poor countries	
			Rest-OECD	EU	Develop. C.	Underdev.C.
Gross Domestic Income	$\dot{C}^*$	[-]	ca. 4/5		1/5	
	$\dot{C}$	$\left[\frac{10^{12}\ \text{US-\$}}{a}\right]$	14,8	8,1	5,2	0,76
Population	P	$\left[10^9\ \text{Pers.}\right]$	0,73	0,37	2,7	2,0
	P^*	[-]	ca. 1/6		5/6	
Standard GDI	$\frac{\dot{C}}{P}$	$\left[\frac{10^3\ \text{US-\$}}{\text{Pers.}*a}\right]$	20,3	21,8	1,9	0,38
			20,8		1,27	
		≙	16	:	1	

Fig. 5/1: Distribution of gross domestic product and population 1997

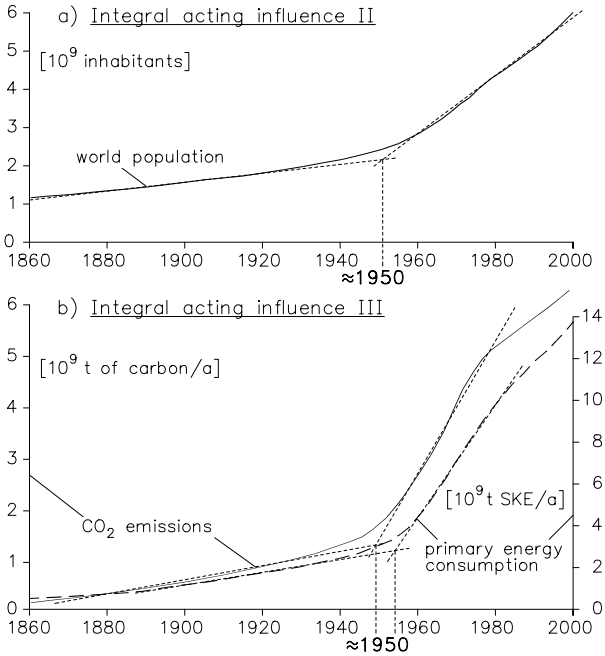


Fig. 5/2: Increasing long-term development 1860 - 2000 [3)]

- the increase of population as a consequence of economical poverty of underdeveloped countries, => **integral acting influence II**, origin see Fig. 5/3, and
- the increasing cutback of resources and the increasing environmental pollution, both as consequence of the technical development => **integral acting influence III**, origin see Fig. 2/2.

As to be seen by Fig. 5/2 both integral acting influences have strongly increased since **1950**, i.e. since the beginning of the industrial process automation.

a) Lessening of integral acting influence II

To solve the problem of a fast growing population or at least to weaken this fact an intensive encouragement and further evolution of the developing and underdeveloped countries is urgently necessary. Then based on past experience, a voluntary reduction of

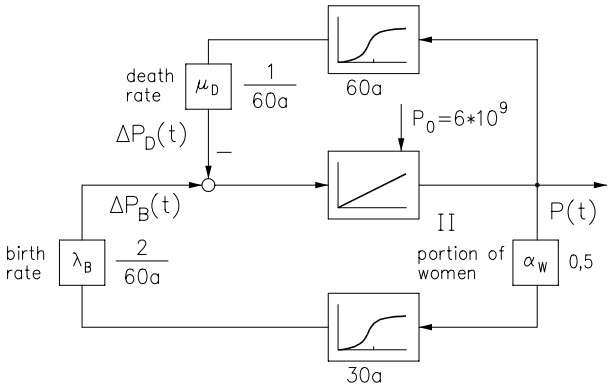


Fig. 5/3: Simplified population model with rough data => positive feedback for $\alpha_W \cdot \lambda_B > \mu_D$

birthrates only seems to be possible with the people's hope in mind to have a realistic chance to escape from the persistent poverty and dreaming to achieve better education and more economic wealth /18/, or pointed out more simply:

In the poor countries a change in parents mind is needed

- from their old fashioned naturalistic supply statement: "The more children we have the less difficult our old age feed and lodging supply should be."
- to the more modern monetary supply statement: "As the children's supply costs money, the less children parents have as more money they can spare for their own old age support."

The required increase of subsidies, which will be the precondition for such a change in mind, can easily be paid by the industrialized countries, when regarding the following global statement. The conflict between poor and rich countries can't be solved by weapons, at least not in the mid-term.

Therefore one concrete proposal is, that the industrialized countries should reduce their military production from at present 2% /14/ of the global gross domestic product as far as possible and should increase their subsidies correspondingly from at present 0,2% /14/. Furtheron they should stop to transfer older weapons to the poor countries – up to now partly masked as subsidies too !

Therein it has to be regarded, that such a hopeful development – if at all possible – will only have a long-term effect, as to be seen by the simplified population model[4)] in Fig. 5/3. Furtheron, an increase of the production output by the up to now poor countries without qualified redistributive measures will lead to a dramatic increase of resources consumption and environmental pollution /7/.

b) Lessening of integral acting influence III

Therefore well directed ecological support is necessary to control the third integral acting influence. To reach this goal, a better conciousness by the population, by

3) Background concentration of CO_2: 1860-1960 obtained through an analysis of air bubbles in the arctic ice, from 1960 onward direct measurements /17/.

4) The simulation of the population development will be done by a detailed discrete model /20/.

the managers as well as by the politicians is necessary, comp. the up to now limited results of the world climate conferences /19/. Such an urgently required understanding is only achievable by holistic thinking having all three integral acting influences in mind. Corresponding ecology protection measures are exemplarily described in Fig. 5/4.

The cost of the environmental protection measures, which could e.g. be coordinated by the United Nations Organization (UNO), should mainly be covered at present and in the near future by the industrialized countries for they have mainly caused the already existing environmental problems.

With the ongoing development the previously poor countries should also participate in the worldwide costs for environmental measures

$$\dot{C}_{Env}^{(WW)} = c_{Env} \sum_i \alpha^n(i)\, \dot{C}_{GDI}(i)$$

which amounts at present to a very small portion c_{Env} of the worldwide gross domestic income $\sum_i \dot{C}_{GDI}(i)$. Therein the sliding participation of the still poor countries can be achieved by a linear or quadratic weighting function

$$\alpha^n(i) = \left(\frac{\dot{C}_{SGDI}(i)}{\dot{C}_{SGDI}(OECD)} \right)^n \quad \text{with } n = 1 \text{ or } 2$$

in dependence of the individual standard gross domestic income $\dot{C}_{SGDI}(i)$ referred to that of the industrialized OECD countries $\dot{C}_{SGDI}(OECD)$.
Taking the data from Fig. 5/1 the linear and quadratic weighting function amounts to the following values:

	i / n	EU	Rest OECD	Devel. countries	Underd. countries
$\alpha^n(i)$	1	1,05	0,98	0,091	0,018
	2	1,10	0,95	0,008	0,00033

As to be seen by these weighting data the participation of the developing and underdeveloped countries will be small or even very small at present.

c) Lessening of integral acting influence I

Under such circumstances enterprises within the industrialized countries would have to transfer a fraction of their investments intended for production improvements to environmental protection measures, see left part in Fig. 2/3.
In the same way the enterprises and private households should pay high rates when exhausting non-renewable resources furtheron. The resulting income of rates can be used for a higher portion of regenerative energy production as well as for an improvement and a wider application of material recycling measures.

As a consequence of this, the investment and production expense for both measures concerning the environmental and resource protection would result in a reduction of the further increase of the automation degree η and therefore also lessen the integral acting influence I, i.e. the momentum of the technical and economical development. These stabilizing influences based on

a) Governmental regulation

- Environmental protection measures
  - governmental immission protection regulations $\{CO_2 \quad NO_x \quad SO_2 \quad \cdots\} = \hat{\underline{x}}^T \downarrow$
  - insulation regulations for buildings etc. $\dot{Q}_{loss} \downarrow$

b) Conciousness of industry

- Development of resources economizing and environment preserving methods and products
  - long-term products $\dot{R} \downarrow$
  - regenerative energies $\dot{E} \downarrow$
  - fuel economizing motor cars etc. $\dot{E} \downarrow$
- Quantification and labeling of resources consumption and environmental burdens
  - per production company $\underline{R} \downarrow$
  - per product etc. $\underline{x} \downarrow$

c) Conciousness of citizens

- Ecology based shopping $\dot{M}, \underline{x} \downarrow$
- Reduced consumption of
  - products $\dot{Q}_D \downarrow$
  - energy etc. $\dot{E} \downarrow$
- Reduction of environmental burdens, e.g.
  - less waste $\dot{W} \downarrow$
  - qualified waste disposal $\underline{x} \downarrow$
  - ecological operation of private systems (like motor car, heat and water supply, air conditioning) etc. $\dot{E}, \underline{x} \downarrow$

Fig. 5/4: Ecology supporting measures

environmental and resource protection measures are plotted with dashed lines in Fig. 2/2, 2/3 and 4/4a.
The stabilizing interaction of the described measures are also illustrated qualitatively by Fig. 5/5.

5.2 Necessary quantitative considerations

After final balancing and parameterizing of the holistic model the previously qualitatively discussed interactions are to be reproduced and refined quantitatively. For this, using a sensitivity analysis, possible actions should be examined. Thus, for example:

- effects of government control actions like tighten the environmental restrictions, reducing expenses for the armed forces, etc.
- changing of goals by negotiations between employer and trade union with regard to salary, working time and employees
- attitude change of the people's behaviour concerning birthrates.

To the results of this investigation there will belong:
If all industrialized countries do agree about an increase of environmental subsidies (currently 0,7% of the global gross domestic product /6/) as well as about an increase of subsidies for underdeveloped and developing countries, there would be no essential change in the proportions of economical power between the industrialized countries and due to this no collapse of companies would occur.
To achieve this aim the financial burdens should be shared in such a way that industrialized countries with a higher standard of living pay more than countries with a lower standard of living. This can e.g. be done by linear or quadratic weighting the gross domestic income (GDI) with the belonging standard GDI factors, comp. Fig. 5/1.

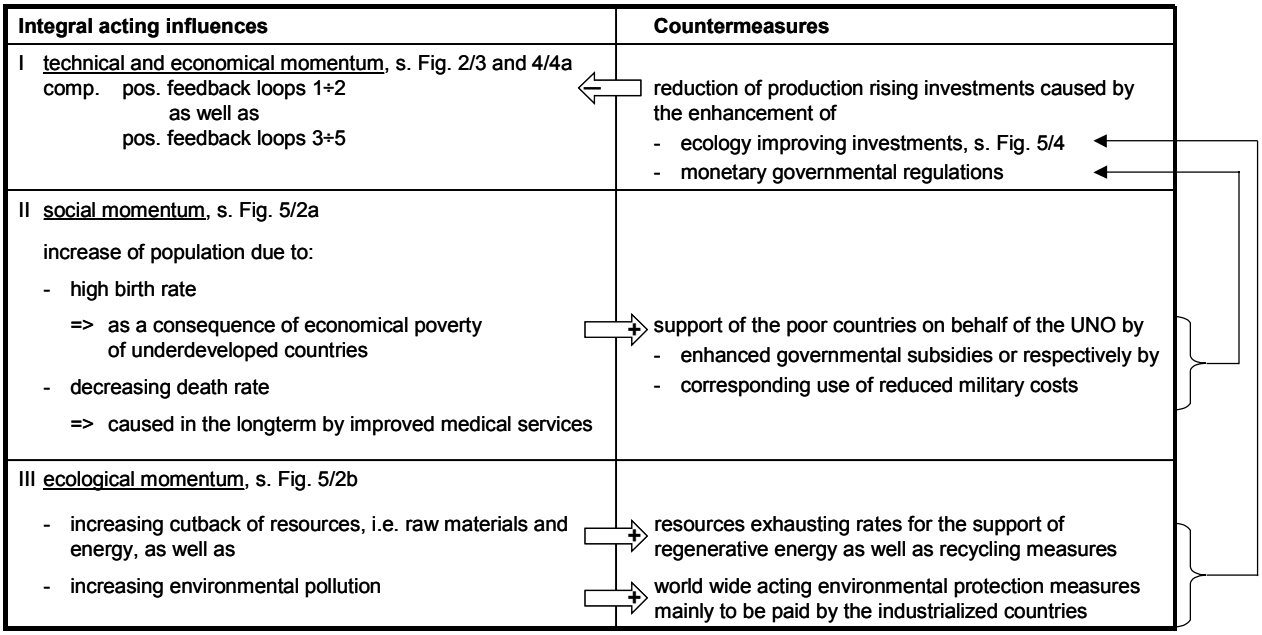


Fig. 5/5 Negative feedback reaction of the countermeasures concerning the social and ecological momentum II and III also to the technical/economical momentum I

However, such a equitable procedure will probably not be feasible from the beginning. Therefore, single states, enterprises or institutions are required to set a good example. But without aimed quantitative investigations it is hard to predict at what extent a single nation or enterprise can go ahead in the sense of "sustainable development of the global society" without loosing significant market share. This will be one of the main tasks of the announced sensitivity analysis.

6. CONCLUSION

A sustainable social economic evolution of the globalized society will only be possible by global consideration, global thinking and corresponding measures, priorly to be activated globally, such as by the UNO. However, the measures should not only be supported regionally by the highly developed nations but by the great majority of all nations.

To achieve this goal, a general change of views towards the world-wide existing social economic and ecological problems is necessary, taking particularly into account the further development of the information and automation technologies as the main motors of progress.
This means that also the engineers have to **broaden** their thinking from the hitherto well known views:
=> **functionality, efficiency and profitability** to a globalized view, regarding additionally
=> the world sociability.

To contribute in this sense a flexible supranational model has been developed. The model is hierarchically structured with different levels of aggregation/detailness from top to bottom permitting an each time global view and a still manageable complexity when investigating different kinds of problem areas.

For reasons of model verification and parameter estimation, the applied investigation is based on time dependent data series taken from the world-wide existing statistic data bases.
The main advantages of the flexible supranational model comprise among others its functional structure and due to this the possibility to carry out not only simulation studies but also aimed analytical investigations. This has been stated by means of the momentum of the technical economical development, the growth of population and due to both the exploitation of the resources and environment.
It has been shown that a further increase of the three integral acting influences inside of the strongly intermeshed social economic society can be lessened mainly by ecology improving global restrictions.

Due to the simple intelligibility of the functional model, it does represent a suitable basis for interdisciplinary discussion as well as for the elaboration of socio-politically acceptable higher aims to obtain an economically and ecologically sustainable evolution of the globalized society.

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8. APPENDIX:
FURTHER INVESTIGATIONS CONCERNING THE INFLUENCE OF THE AUTOMATION DEGREE

To scrutinize in detail the reason of the η-dependent behaviour of the part sector "production" in Germany, regarded in chapter 4/2b, the corresponding behaviour of the part sector "production" in the United States as well as of the part sector "services" in Germany is investigated in the following.
Similar results have been obtained in /21/ where the gross value added $\dot{C}_{gva}$ is regarded in dependence of the yearly working hours $\dot{W}$ and the invested capital $\dot{C}_{Inv}$ as well as especially in dependence of the electrical energy consumption $\dot{E}$. Based on that consideration the gross value added $\dot{C}_{gva}$ has also been used for the determination of the automation degree η_{prod}. This is also in accordance with /8/ where the labour productivity is defined as the ratio of the "gross value added" by production $\dot{C}_{gva}$ to the whole number of workers W.

A1) Production sector behaviour in the United States

Fig. A1a$_I$ illustrates the increase of the automation degree η of the production sector[5)] in the United States determined by time series /11/.

As can be seen, the automation degree η is raising from 1980 to 2000 slightly stronger than in Germany, comp. Fig. 4/2Ia.

Since the production orders in Fig. AI$_{bI}$ increases also quadratically with time, the amount of the yearly working hours of the production sector in the United States remains approximately at the same level. This may also be caused by cheaper working power in the United States than in Germany.

The thereby resulting linear growth of the production orders in dependency of the automation degree η is the typical characteristic of an unlimited growing economic sector.

A2) Services sector behaviour in Germany

Fig. A2 illustrates the corresponding behaviour for the services sector in Germany. As can be seen, the automation degree η is also growing quadratically with time and even faster as shown in the production sectors of Germany and the United States. Also the time constant is herein noticeable smaller.

Since the real production orders increases likewise quadratically with time, a linear coherence is resulting again for the production orders in dependency to the automation degree η with a nearby constant amount of yearly working hours $\dot{W}$.

A3) Comparison of the sectors „production" and "services" in Germany

In the following the reason for the principally different behaviour of the production sector in Germany is investigated.
As shown by Fig. A3 the gross income of the production sector has increased in real terms during the last two decades by the half, whereas the gross value

5) Sector "Manufacturing" in the United States

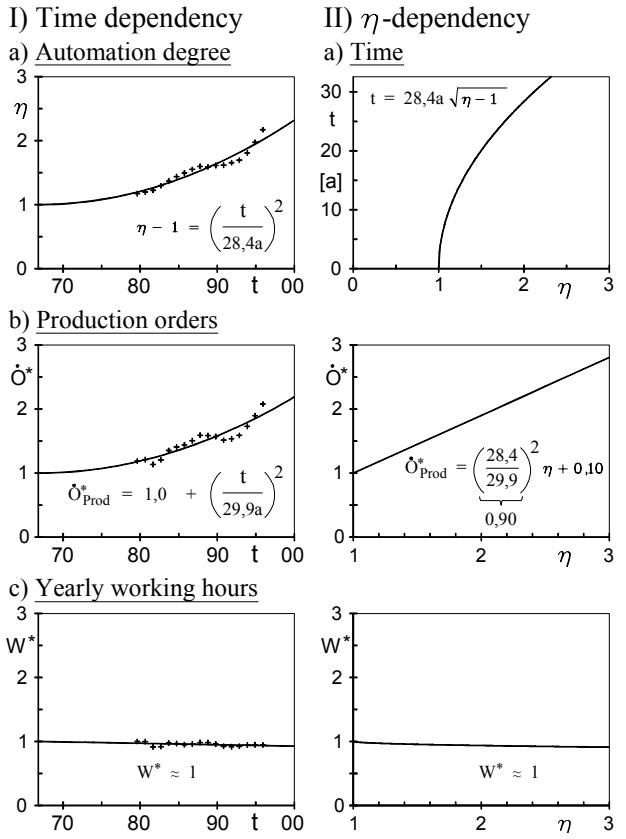

Fig. A1: Production behaviour in the United States in dependence of t and η

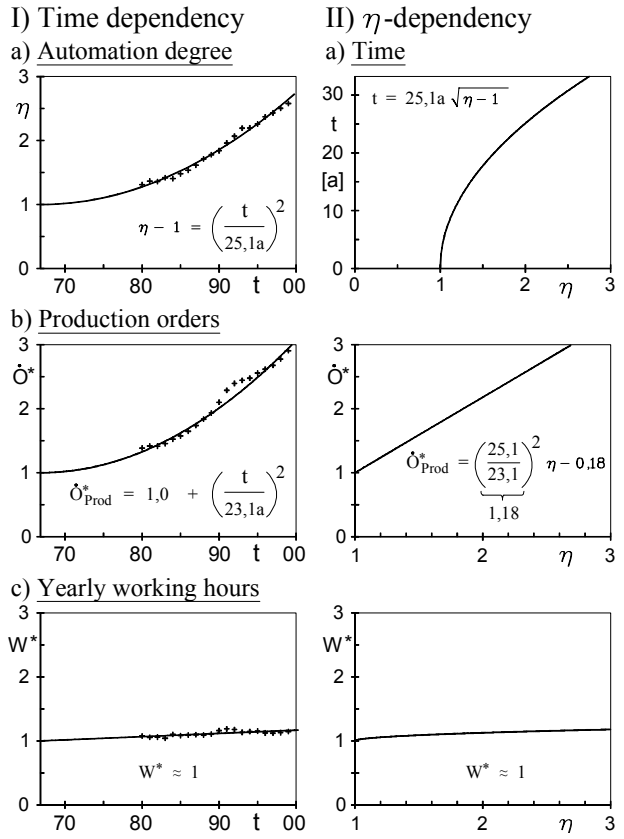

Fig. A2: Quantitative Evaluation of the Services behaviour in Germany in dependence of t and η.

added remains rather at the same level. Considering this percentally, the gross value added as part of the gross income has decreased from 50% in the year 1980 down to 33% in the year 2000.

In contrast the gross value added in the services sector has been growing quadratically with time up to the double value in the year 2000.

Considering percentally the gross value added as part of the gross income has been thereby increased from 50% up to 67% during the same period.

This is based on the continuously accumulating profitability in the services sector combined with an increased inducement to invest in this area.

In the production sector the development has been passed inversely. Caused by the rising automation and high wages the number of employees in the production sector decreases disproportinately. Instead of this the German producers have invested abroad to produce there cheaper due to less expensive workplaces.
Thus the strongly increasing import of abroad produced finished resp. semi-finished goods has caused an only slight growth of the gross value added in the production sector in Germany, see Fig. A3a.

Such an aimed displacement of production for the purpose of profit maximization leads on the one hand to a wanted increase of the gross value added in the developing countries. On the other hand this can result in a rise of the structural unemployment in the industrialized countries /22/, like – as regarded – in Germany.
Within the complete model this displacement process is quantitatively taken into account, too.

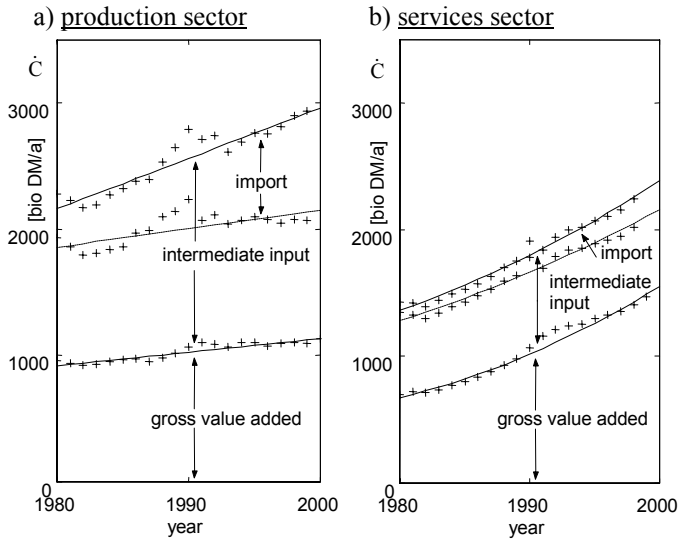

Fig. A3: Sector dependent participation of the gross value added in the gross income within Germany.