Dynamics of the information society

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Abstract

A new economy and new lifestyles emerge which are based on richness in information and extensive use of computer networks, in particular the Internet. This development offers new opportunities for regional wealth, for ecological sustainability and it brings new jobs. A dynamic systems model was build to allow a thorough analysis of this situation and its development. This model allows to test policies on how to use these opportunities, to decrease risks and to avoid conflicts. The model is a result of several large research projects which included consulting and collaboration with regional planning. The model is now applied on a wider scale to develop and help in implementation of innovation policies.

Key Words: Information society, new economy, environmental policies, land use, dynamic models, innovation systems

1 The present situation

The present transition to an information society is multifaceted, it is economic, social, and political. A new economy emerges which is information-rich and network-based. Typical products are media content, cellular phones, Internet, genome sequencing (for example Celera Genomics, Enriquez and Goldberg 2000), biochips (for example Affymetrix, Alexander 2000) and intelligent forestry and agriculture (Forbes 1997a, b). This transition is wider than the so-called “New Economy” of the Dot.coms and part of this transition is the rebuilding of the present “mature economy” into an information-rich form. The new economy (new in this meaning of being based on richness in information) creates jobs at a high rate. For most developed countries the job creation rate is above the loss of jobs in the mature economy most of the times, see also 2.2. Loss of jobs is due to restructuring and rationalization of mostly mature industry. In parallel new lifestyles are emerging. The speed of this transformation is very different in the countries of the developed world, and it is also regionally different. Policies, traditions, education and other factors influence successes and failures in this transition. (For the new economy, see Kelly 1998, Tapscott 1998, Hagel et al. 1997, Margherio et al. 1998, Pine and Gilmore 1999, Dent 1999, Evans and Wurster 1999).

This transition offers new possibilities for regional and urban development in the areas of economy, society and environmental sustainability. We have developed an integrated systems model to analyze this situation, to devise and evaluate new policies and to help actors to benefit from this major transition. Clients are economic top management, urban management and leaders in education for underemployed people.

Although there are vast opportunities there are also numerous difficulties for integrated policies:

- The transformation is poorly understood, causing a lack of orientation and of perspective
- Unemployment
- Anxiety
- Hostility towards change, defense, hopelessness.

An important task in allowing the development of the full potential is to help with a better understanding of the present transformation, to provide a frame for orientation and to show the favorable perspectives. The model allows to investigate the interplay of the emerging new economy with ecological issues, as the new economy has the potential to be resource- and energy-efficient and to avoid pollution, both of which will increase the regional attractiveness for further growth of the new economy. However, an environmentally friendly course of action does not happen by itself and has to be encouraged through insightful policies. A frame for orientation helps to decrease anxieties which is important as anxiety can paralyze. Better understanding enables people and economy to grasp the new opportunities for regional wealth, for ecological sustainability and new jobs.

2 Tasks of a model for the information society

2.1 Opportunity for wealth, ecological sustainability and new jobs

The basic idea behind the ISIS model ("Information Society Integrated System") is to have a tool for elaboration on how to use the present transformation for a multitude of goals. These goals are both passive and active. Passive goals are in better, less costly adaptation to change and, active goals mean influencing the development so that it provides additional desirable results. For example, society may have to adapt to risks from climate change such as flooding of low-lying areas. Climate science is now developing tools to provide timely knowledge on the nature and spatial distribution of emerging risks. This would be a base to enable actors in economy and urban affairs to influence the present ongoing restructuring so that it additionally decreases climate related risks. Using an ongoing restructuring which is proceeding anyway could allow to minimize such risks at little additional costs. More generally, the present broad and deep economic and societal innovation and transformation could become a vehicle to achieve a multitude of other objectives which are not directly related to the emergence of the information society. This approach would also answer the complaint from environmentalists that it would be best to build an entirely new economy which is sustainable. Now an entirely new economy is emerging but few environmentalists seem to be aware and interested in using this unique opportunity for their objectives.

The ISIS-model depicts the interrelationships underlying the development of the information society. It is becoming a family of models which can be adapted to a multitude of objectives.

2.2 Change and job creation

Since 1980 the economic transformation has been creating about 4.5 million new jobs per year in the U.S., whereas about 2.5 million jobs are getting lost per year in the mature industry (data from U.S. Census, OECD, EU). Since 1980 this process of industrial transformation has created 90 million new jobs, whereas 50 million old jobs got lost. This results in a net increase of jobs in the U.S. from 89 million in 1980 to 139 in year 2000. Almost 70% of new jobs are in the two highest job categories, managerial-professional and technical. Simultaneously, based on the "New Information and Communication Technologies" (new ICTs), most of the mature industry is being rebuilt and known products are enhanced with information content and networking capabilities. This rebuilding eliminates jobs in the mature industry. Qualitative changes in the economy were so dramatic that in 1997 the US adopted the new "North America Industry Classification System" (NAICS). Its authors state: "Unlike previous SIC [Standard Industry Classification] revisions, the NAICS changes are fundamental". Two thirds of the now 1200 industry classifications are new or have been revised, only one third has remained unchanged (www.census.gov/naics).

A model on these processes must portray mature industry and new economy, their interactions, mutual benefits and antagonisms. Also, the new ICTs must be present in the model as a driver, because they continue to develop very rapidly. The quantitative development of the new ICT's is well predictable; industrial empires have been founded on the operation of those "laws" that describe the development of components of the new ICTs (Moore's Law of a doubling in speed of microprocessors every 18 months, Gilder's Law of an increase in volume of data transmission by a factor of 3 per year, Metcalfe's Law on how the components of the new ICTs mutually enhance each other, see below).

As a result of the vast transformation in the U.S., unemployment rate is down to about 5%. In Germany, job creation is much lower and unemployment is at about 12% (the German data are mirrored by most Western European countries, although in year 2001 Germany has been the worst European performer). The unemployment rate is high in Germany although the workforce grows much slower than in the U.S.

Which factors explain this difference between the U.S. and Germany? We need such factors in the model to be able to support an analysis of new policies for jobs, their potential and their negative side effects.

Job creation by large companies is about the same in both countries, but job creation through small companies is much higher in the U.S. Which factors explain job creation by small companies? ISIS contains about 25 factors which allow a comprehensive policy analysis and construction of new policies. One major factor that explains the different performance of the U.S. vs. Western Europe is the attitude towards change and innovation; Spectrum Consultants give a very favorable judgement on the "innovation culture" of the U.S. Another major difference is the ease with which companies can be started and operated in the U.S. The energy needed by a small entrepreneur to start and run a business in Europe is much higher than in the U.S. And small entrepreneurs are very limited in their time and energy (i.e. money). Therefore, it is much more difficult for them to succeed in Europe. Recent reforms in Denmark and in the Netherlands have removed quite a number of obstacles for small entrepreneurs. Although the reforms in both countries do not have much in common, they both kind of succeeded; the job creation rate is up.

2.3 Provide orientation

For many people this situation of rapid change, of "churn" (Kelly 1998), is new and frightening. Globalization has become a term that represents some of those feelings. ISIS was used in training of managers of companies to explain the driving forces to them. The model describes new elements in the network-based economy, the social networks behind success and mutually beneficial interactions. In the new economy, competition becomes "coopetition", the new interrelatedness between cooperation and competition. The ISIS-model uses cross-catalytic networks to portray such interactions, see 3.1. The configuration of a CCN is little known but is extremely important to explain success or failure.

2.4 Develop and test policies to use these opportunities and to decrease risks.

The development of integrated policies benefits from a systemic understanding of the present transformation, its major driving forces, its key elements and its dynamics. This is what an integrated systems model can provide. Decision makers often think they know which actions are promising and are amazed that their policies fail. Analysis with the ISIS-model showed how isolated actions tend to fail; they need a bundle of complementary actions. The model even showed that there is a threshold beyond which actions do not change much, see 3.3. Also, there is some counterintuitive behavior in the system. The ISIS-model allows to elaborate bundles of complementary actions. With a new optimization approach it is also

possible to elaborate the most cost-effective policies (see the contribution by Bjoern Grossmann 2002, this volume).

3 Description of the ISIS-model

3.1 General description of model

Major economic changes such as the transition to the information society happen through so-called basic innovations, e.g. the steam engine which has made coal-mining much easier and thus has helped to overcome the scarcity of energy; the transition from the agricultural to the industrial society began. Energy had been used before (mainly wood), but coal has overcome a bottleneck in availability of energy. Basic innovations in the 20th century were the car, air traffic, telephone, radio and TV. Most of these became powerful in the 1930s. Basic innovations emerge and decline in patterns of about 60 years (two generations). They increase human reach, change people's perception of what they can do and cause a far reaching transformation of the environment. The present group of new basic innovations involves the information potential. The ISIS-model shows links between new know-how (the basic innovation), people with the new know-how ("knowledgeable people", "new key people", "key personell", Fuchs 2000), economy and land use (or location).

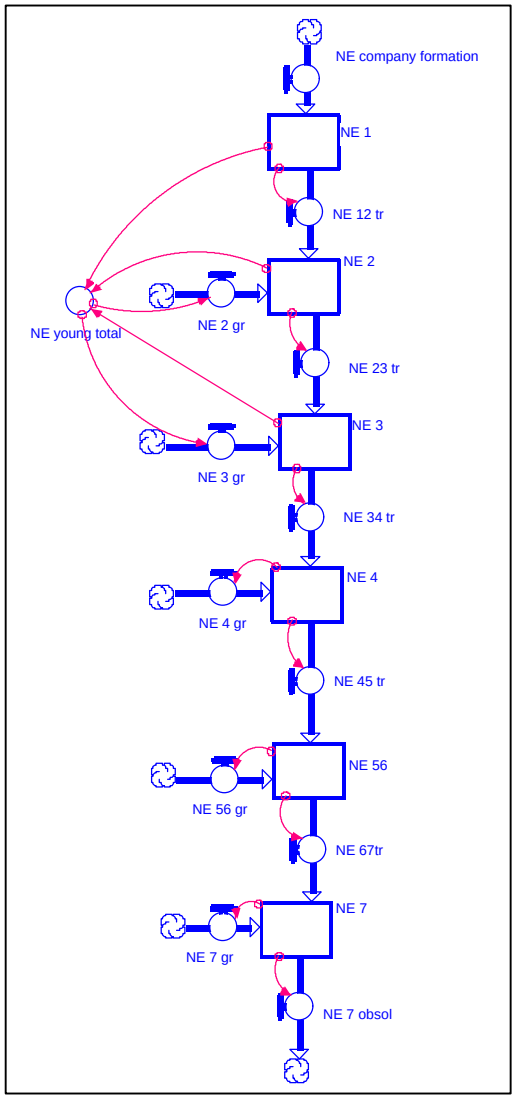


Figure 1. Seven evolutionary phases of a new economy (NE1 to NE7) enabled by a new basic innovation.

The evolution of basic innovations happens in very different phases; consultation describes between four to eight. The ISIS-model describes seven phases; Figure 1 depicts these for the economy. The duration of each of the phases 2 to 7 is between 5 to 9 years whereas the duration of phase 1 (invention) is not predictable.

The ISIS-model describes both, the mature and the new economy, in their phases of development. Historically, there is an overlap between both economies. The mature industry has been in phases 2 to 3 in the 1930s and is now in phases 6, 7 and beyond; the new economy is at present cycling between phases 2 to 4, a few new companies are already in phases 5, 6 or later. The model run starts at 1980 to show the early beginning of the new economy and this overlap of mature and new.

1. Invention (phase economy 1, e1). There are always numerous inventions. Most are useless, but sometimes one changes human life. Some inventions are dormant for a long time.

2. Innovation (phase e2). Innovation is converting an invention into something marketable, desirable and useful. This is a magical process. (Senge 1990 emphasizes the difference between invention and innovation, a differentiation which goes back to Schumpeter).
3. Pioneering adaptation (phase e3). A promising innovation can grow to its potential only if the outside world is adapted to it and if it is adapted to the world. The microcomputer needs software, experts and courses. The car needs roads, gas stations and driving schools. Each basic innovation needs lots of other inventions and innovations. Therefore, basic innovations come in bundles. This causes a cycling between phases e1, e2 and e3.
4. Dramatic expansion (phase e4). Phase 3 fulfils all preconditions for a wide expansion of the basic innovation. Afterwards it can expand dramatically, phase 4, because people and companies have got to know this new invention, demand grows in parallel with increasing the usefulness of this invention. Growth in turnover in each of the phases 2, 3 and 4 can be by a factor of 100. Thus, a highly successful company can grow from a turnover of a few 100,000 $ in phase 2 to, say, 10 or 20 million $ in phase 3 to, say, 1 or 2 billion $ in phase 4. This growth in phase 4 seems dramatic. New inventions are usually also necessary for the wide expansion. Therefore, on this phase there is an ongoing mutual support between know how in phase 4 and companies in phase 4. Companies finance development and successful development in turn allows to improve profitability and profits.
5. Convenient life (phase e5): After the new goods became globally visible in phase 4, the logistic slowdown of the expansion is strong; expansion usually slows down to a factor of 5 in those 7 years of this phase. Due to solid but no longer breathtaking growth, life is very convenient in phase 5. Products are well known, production is smooth, jobs are plenty, staff members are well trained. Costs for marketing and advertising are increasing to find new markets and keep established ones. Regions which supported the upswing of a new basic innovation usually enjoy a very high regional income. This income allows successful regions to become even more attractive, for example by spending in arts, culture and regional amenities such as sport facilities. Economy phase 5 becomes very good at producing those goods that base on the new basic innovation. New inventions in phases 1 and 2 have no longer much possibility to succeed, the so-called “vertical competition” becomes very strong, preventing new breakthroughs.
6. Tough global competition (phase e6). Know-how about the basic innovation becomes globally available, and as a consequence production begins everywhere. This increase in supply starts wide competition; prizes go down as a reaction to competition. Companies can only survive if they rationalize for cheaper production. Companies are merged and become very big, most companies disappear, many people loose their job and overall qualification can be lower. Average salaries decline, regional income shrinks. Defense against all disturbing factors is strong. One threatening factor is new innovations. They are suppressed in the way which most of us can easily recall from the last few years, e.g. the fight against the Internet by Microsoft, Time Magazine or many states (Microsoft established its own MS Network; Time Magazine printed a falsification on sex in the Internet and many states still prevent their citizens from use of the Internet or censor it). This defense is strongest in regions which want to preserve their mature economy. This defense has economic consequences but is difficult to model. This defense is dependent, in the ISIS model, on the ratio of invested capital in the first four phases divided by the last three phases. If this ratio is low, defense is strong. Additionally, a parameter allows to specify regional peculiarities, in particular strong aversion towards new or good support for new developments. Moreover, parameters depict capability for successful start-ups, depending on the effects of administration, availability of capital and so on. Due to this defense, usually, really new things do not develop well in regions which are good and strong in the mature basic innovation. There are exceptions; Berlin managed twice to go

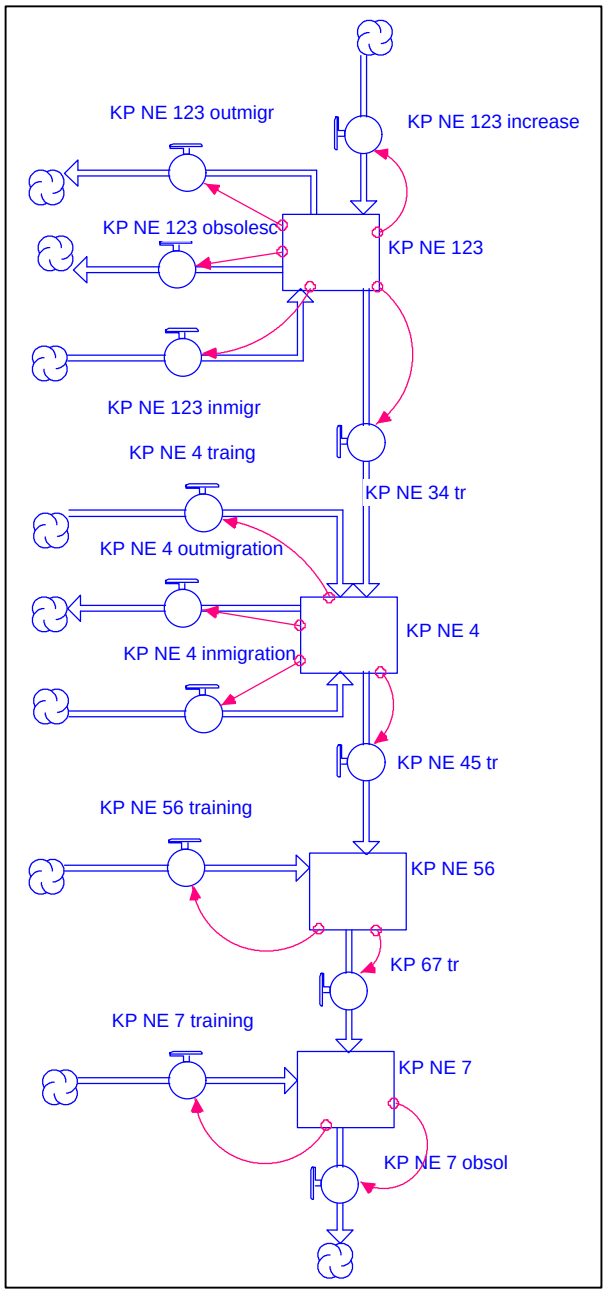
with a new basic innovation, the Boston area succeeded three times (Hall and Preston 1988).

7. Sclerotic saturated phase e7: Regions which used to prosper from the basic innovation get poorer as general income in such regions declines. Their basic innovation may disappear almost entirely, like Atlantic passenger ships due to airplanes. The innovation may become economically unimportant, like electrical motors which are nearly omnipresent but generate very little regional wealth as they are cheap and competition persists. Laepple (TU Hamburg-Harburg) named this and later phases the “sclerotic milieu”. Later phases often live through subsidies. This development is partially driven by internal factors, such as increasing capability to rationalize. It is partially driven by increasing global competition. A factor that brings the development to an end is the external factor of another, fresh basic innovation succeeding increasingly big. As was said before, a new innovation usually comes from somewhere else and is taking away buying power from this mature basic innovation. There is increasing market competition between two very different types of products: the mature basic innovation and a new one. In the model, the existing demand is shared by a modal split between these two types of offers. With the ongoing continued growth of the information potential, the modal split shifts demand towards the information rich offers.

As the present transition seems very much to be driven by the new basic innovation of the new Information and Communication Technologies (new ICTs), a model on this transition must properly describe the factors listed for these seven phases. In particular this description must include people who have to have very different capabilities depending on the phase of economic development of the basic innovation. Therefore, ISIS contains a sequence of people, of phases of development of people, Figure 2, which correspond to the phases of economy. For each phase the economy needs those people who have the particular new knowledge to grow the new economy for this phase. Without these people, for example those who started the Internet in the 1980s, no economic growth of a new economy would have been possible. These people are a key to the emergence of this new economy; and therefore we name them “new key people”, Figure 2. Key people are very different for the different phases. Inventors are different from innovators, innovators are different from the “bridge-builders” who are, in turn different from the expansionists and so on. Therefore, the transition of key people is low from one phase to the next. In reality we often read about people who started a company, and with the first big success get removed from their own company. Very few survive the development in their company. Training and psychological support can increase it in the model.

Many regions in the world have learned how important these people are and therefore try to attract them. International migration of these knowledgeable people has become common. Western Europe offers them Green Cards; and immigrants come from Eastern Europe and Asia, in particular India. The U.S. has a very long tradition in offering Green Cards to these knowledgeable people; the U.S. attracts them from all over the world, including Western Europe.

Politicians and managers are grabbling with correctly naming them; another name for them is "highly qualified people". The funny thing is, that often they are highly qualified just for a very small piece of the whole new world. For example they may be very young, without the chance to have learnt much, but make headlines like the founder of Napster, who at age 18 developed his new software which started the Peer-to-peer revolution in networking. There does not yet seem to be an awareness how different the people are, depending on the phase, who are needed.



In the model the number of these people changes through training, learning with the phases, and obsolescence - they do not learn with the phases but drop out, but also through immigration and outmigration.

Regional immigration and outmigration depend on the regional quality of life and on job offers. Immigration programs are possible, but if the other factors are not right, these people will leave again quite rapidly.

Figure 2: Developmental phases of new key people

Some, but not all, of these people learn new skills as their basic innovation matures. Therefore, we also need an internal flow from one phase to the next (flow variables KP NE ij tr where i and j are the respective phase numbers). In reality this flow often simply does not happen. Some inventors always remain inventors, even when their "baby" evolves into a grown up multinational (could happen in phase NE 4). This is the factor of obsolescence. We included this flow variable for the early phases 1, 2 and 3 (KP NE 123 obsolescence).

The relationship between new key people and their respective economic phase is of a very special nature which is of utmost importance. It is a so-called "Cross Catalytic Network" or CCN, Clarke 1980. A CCN is a more complicated "Hypercycle", Eigen and Schuster 1978 (these authors provide the detailed mathematics). The hypercycle was developed by Manfred Eigen to explain the emergence of life and extended by Clarke to a wider class of phenomena.

A CCN consists of two or more autocatalytic cycles A and B which mutually help each other, Figure 4. An autocatalytic cycle is, in the language of System Dynamics, the smallest possible positive feedback loop, i.e. a state variable that directly controls a flow variable for exponential growth, Figure 3. A CCN can produce growth which is dramatically different from exponential growth: hyperbolic growth, that is, it can grow to infinite within a finite time, whereas an exponential function can grow to infinite values only in infinite time.

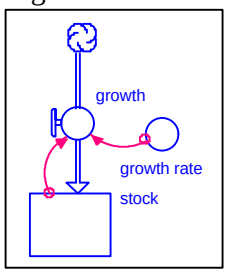


Figure 3: Autocatalytic system

We have analyzed about 60 highly successful companies, regions and inventions: they all were organized as or within CCNs (Fränzle and Grossmann 1999). They could not have succeeded as isolated competitors, because an isolated competitor, even if it exhibits superior qualities, cannot conquer an occupied niche, whereas a CCN can do this.

Figure 4 shows the systems diagram of the CCN that exists between new key people and the respective phase of the economy. A relationship with this structure exists within each phase.

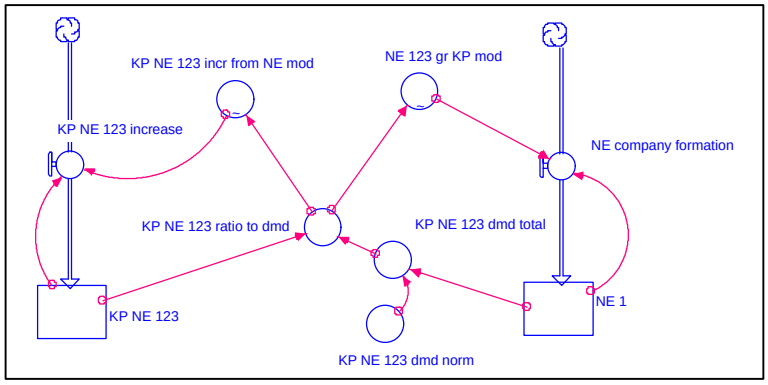


Figure 4. Systems diagram of the CCN between new key people and economy

Explanation of Figure 4: KP is the abbreviation for key people; NE for new economy; NE1 is phase 1 of the new economy. "KP NE 123 increase" increases the number of new key people for phases 1, 2 and 3 (KP NE 123 in the figure), who for simplification are lumped together. For planning of training it would be necessary to keep them apart. "KP NE 123 increase from NE modifier" is a nonlinear relationship between, on the one hand, the ratio of availability of new key people to demand and the effect on increase of new key people, Figure 5. If this ratio is very low – few key people compared to demand – then incentives will be high for people to get trained to become new key people.

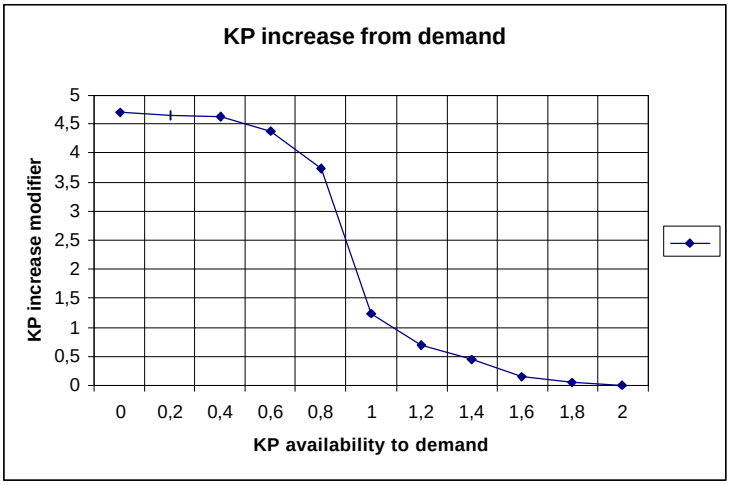


Figure 5: Function that controls increase of new key people depending on ratio of KP availability to demand

If this ratio is significantly higher than 1, then new key people will look for other jobs or leave this region.

The same type of mechanism works to increase the new economy, where this ratio controls the “NE 123 growth from KP modifier” which, in turn, controls “NE company formation”. Company formation is much easier if the availability of new key people is good, that is the ratio is higher than 1. If the ratio is below 1, company formation (and growth) become difficult. The demand for new key people depends on the invested capital in NE1; it is NE1/(average cost of a job in the new economy, phase 1).

Why is this relationship in Figure 4 a CCN? Autocatalytic growth of new key people (NKP): Their group can grow autocatalytically when members of this group train other people with their knowledge and these in turn can train more new people. The number of NKP can thus grow proportional to the size of the group. Companies, if they grow by some percentage per year, also grow exponentially. Mutual support between new key people and economy: If there are more companies the demand for NKP grows and the NKP are better off; the companies support NKP. Support for new economy by NKP: Companies are better off if there are more NKP. As all conditions for a CCN are met, this structure is a CCN.

This CCN is highly important in the model, although there are several more CCNs, for example between new know how and new key people, and new know how and new companies. CCN-nature of these latter CCNs: Autocatalytic growth of know how: it can grow autocatalytically because if more know how is available, this additional know how can help in producing even more know how. For example, more (and usually better) software allows to produce even more software. The other conditions for a CCN are as obvious: KNP produce new know-how, and more new know-how makes NKP more effective. Companies from the new economy finance production of this new know-how, and this new know-how makes these companies more competitive.

A CCN would allow unrestricted growth. Unrestricted growth is true for the initial phase, but afterwards slows down from limits of the human environment, whether these are psychological, or depending on availability of time, money and other limited resources. This slowing down is done by a number of mechanisms such as market saturation, forbidding increase of wages for new key people if growth is too fast, and also by some none-market mechanisms, e.g. “psychological saturation”: People are slow to pick up innovations, to understand them, to learn them. In economic theory such psychological factors translate into slow growth of demand. In management theory it is important to know the origin of this slowing down to use appropriate management tools to deal with it.

As a summary: three CCNs are behind the present growth of the complex which is composed from new key people, new companies and new know how: the one between NKP and NE, the one between NKP and new know how and the third one between new companies and new know how.

It was stated before that model evaluations show a great importance of the availability of new key people, compared with the other factors. Is this result correct? First, there are reports from all over the world that this is true. But why is it? Why are people so important for the development of a region? Why is not the new know-how more important? Without new know-how, there would be no new economy, no Internet, little of the present economy (including well known, established companies, as they also have to make the best use of these new technologies and processes and so on). But this limitation in know-how is less restrictive than low availability of NKP, because a large amount of new know how is nowadays available wherever a company wants to operate. Experience from successful regions and from successful companies is that people with the new know-how are of very limited usefulness if they are not physically present in the region but can only be asked through communication networks. The funny thing is that real people need real meetings. Although use of the Internet

is an indispensable tool, it cannot replace the “real thing”, the actual meeting, but it can complement actual meetings and help to make them more effective. We need both, Internet and face-to-face meetings. Other preconditions for regional success can be much more easily fulfilled for example also availability of venture capital, the establishment of a supportive administration, or the installation of excellent information infrastructure. All of this costs money, but it can be done quite rapidly. To find or train good new key people is taking much longer.

Combination of phases of development and of crosscatalytic interactions

In reality we have CCNs acting in each phase and the development in phases over time. Thus, the development moves from the CCN in the first phase to the CCN in the second phase and so on. Figure 6 shows the development of the phases of CCNs over time, the phases of the CCNs between new key people, economy and know how. This figure is an excerpt from the ISIS model as it does not show all seven phases.

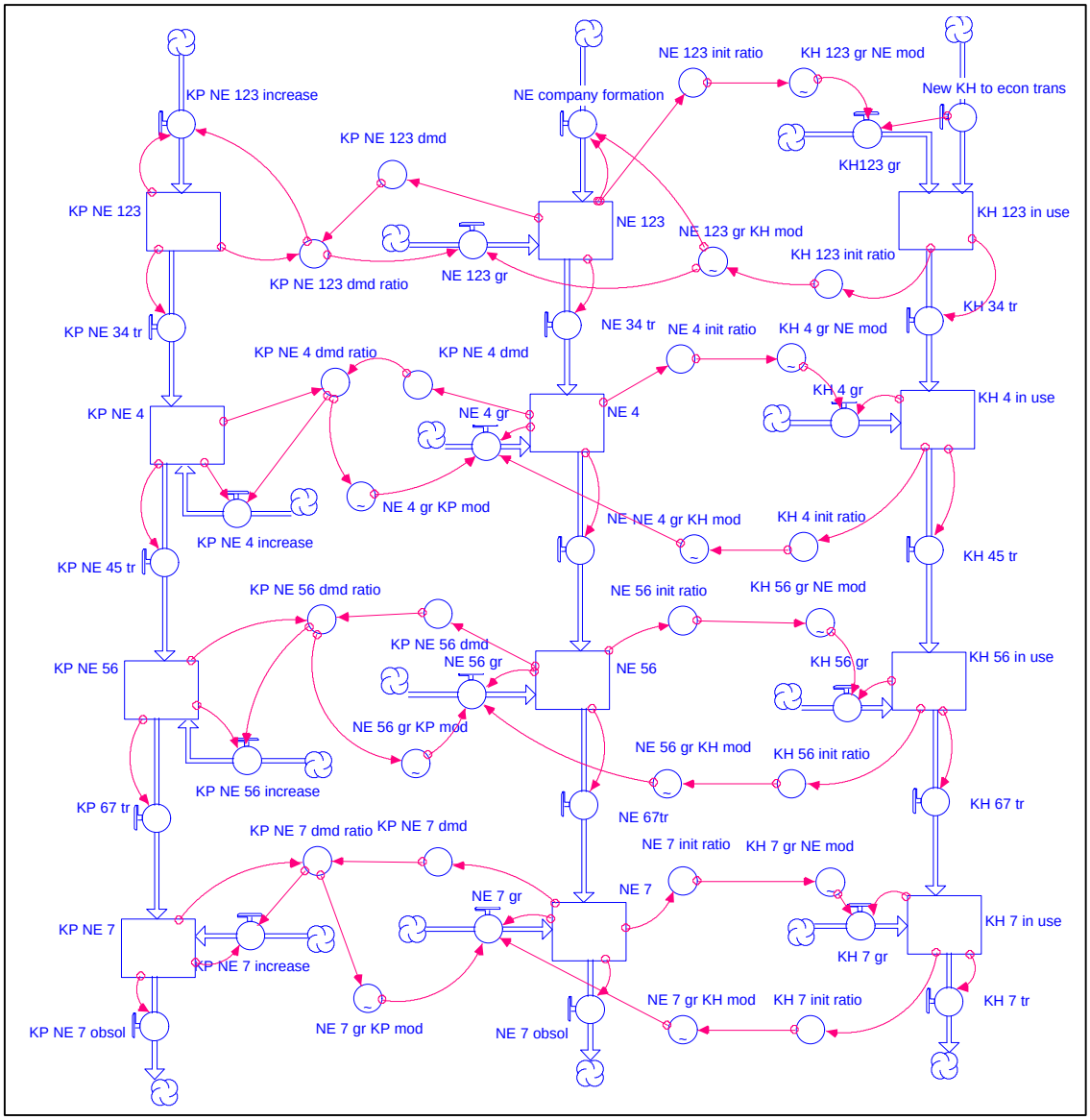


Figure 6. The core of interactions between “new key people”, economy and know how in the ISIS model

These phases of CCNs are embedded in the overall structure as shown in Figure 7. More details of this structure will be explained in the next paragraphs. One word to explain the "New Economy Dwarfs": There are many young companies that in an early phase stop to grow. They stay at 5, 10, or 12 people. These companies often live for the lifetime of their founder and disappear with his or her death.

Validity of model: the ISIS-model seems to be fairly generally valid, see below. This conclusion is based on extensive groundwork. In the EU-Project MOSES we evaluated six very different regions in Israel, Spain, United Kingdom, Switzerland, Germany and Austria. We worked with scientists from Mendoza, Argentina, on their region and with scientists and planners in several Asian countries in seminars in Thailand and Indonesia and on a variety of Mediterranean countries in seminars at the IHEAM in Zaragoza, Spain.

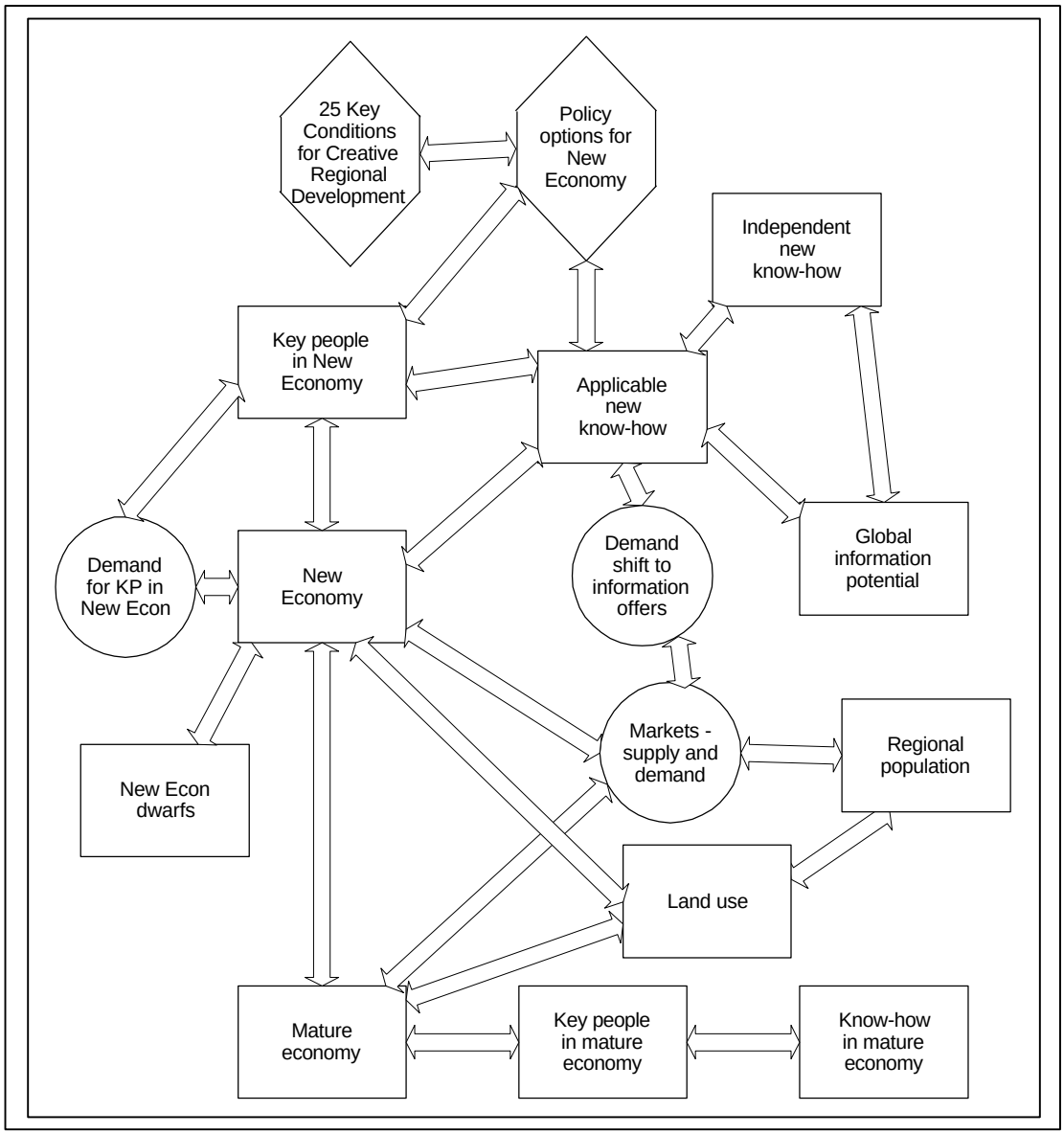


Figure 7: Overall structure of ISIS as a block diagram

Now we are extending the ISIS-model to cooperate with a national econometric model (of Germany, together with the Hamburg Institute of International Economics, HWWA). The ISIS-model will depict the transformation; the econometric model shows the relationships between wages, prices, supply and demand and other macro-economic variables. Another extension deals with possible impact of climate change and how to use the present economic innovation and transformation to avoid risks at much lower costs than would be possible without such an ongoing transformation (together with the GKSS Research Center Geesthacht and the IPRC of the University of Hawaii).

3.2 Information Potential

A major driving force, the information potential, is the aggregate of all capabilities of the new ICT in combination with vast amounts of digital information and an ever increasing number of digital types of data. Examples of such types of digital data are numbers, text, data banks, images, sounds, music, digital video, geographical data, and as a new form for personal or group interaction through the Internet, MUDs and MOOs.

Many so-called laws are well known that describe aspects of the development of the information potential. Economic empires could be established by farsighted use of such laws. For instance, the initial and ongoing success of Intel has been and is based on Moore's Law (one of the two founders of Intel). From laboratory prototypes and early breakthroughs we can be certain for most of these laws that they will be valid for another ten to twelve years.

Moore's Law: Speed of computers (microchips) doubles every 18 months at the same price. Corollary: Every 18 months the same speed for half the price. Validity: another 12 years.

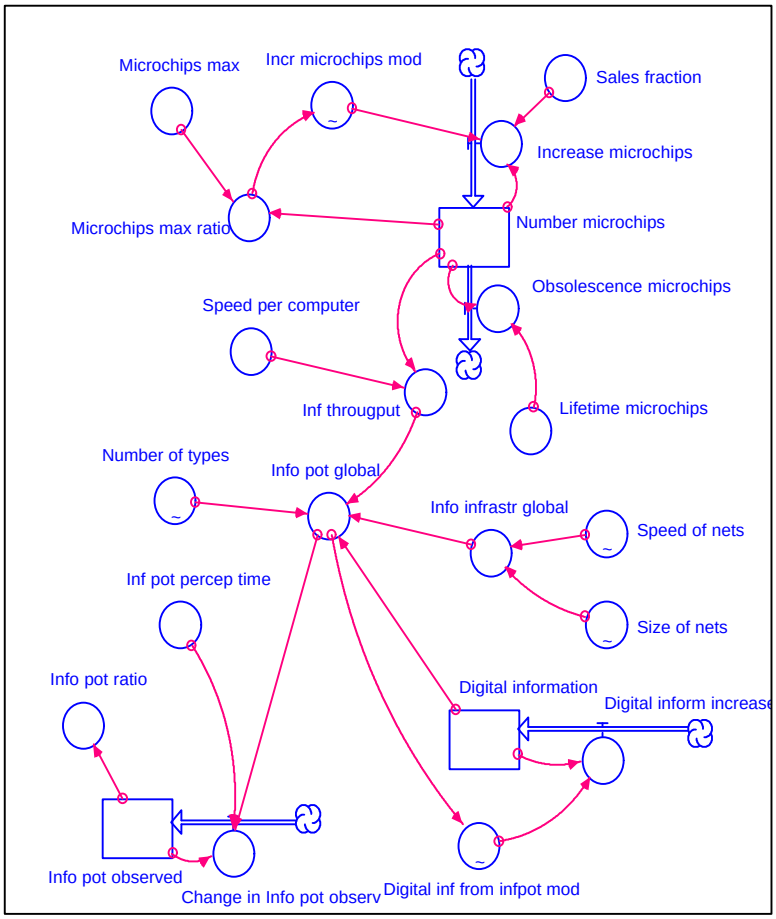


Figure 8: The technological components of the information potential.

Gilder's Law: Capacity (size and speed) of networks triples every year. Corollary: Price for transmission falls to 1/3 every year. Validity: Gilder says until 2020. From literature we see 10 years.

Metcalfe's Law in Grossmann's generalization: Overall information potential grows with the product of its components.

Increase of digitally available information: Factor of 2.5 per year, because number of servers almost doubles every year, and new servers have double the disk capacity of last year's models. This gives less than an increase of a factor of 3 per year because old servers are shut down.

The number of microprocessors is difficult to guess, because they are applied in ever more sizes and in ever more applications. We assume an increase by a factor of 20% per year which may be much too small. In the model the increase stops at a number of 8e12 which may be too low but takes into account that the globe is limited.

Data on the information potential show that the present rate of increase should continue for more than 10 years. The information potential has grown from a value of 1 in 1970 (base value, at that time several 100,000 mainframe computers existed) to 10^{37} in year 2000, which means incredible hyperbolic growth to astronomical dimensions. Due to this incredible speed of development very little of this potential is actually applied. Lorenz Magaard from IPRC, University Hawaii, who also is an investor and consultant, says: "We have overtaken ourselves".

In spite of the importance and obvious effectiveness for economic strategies of these laws, little effort has been made to find out what can be learned with respect to societal and political implications. ISIS fills this gap a little bit.

3.3 Development of a "New Economy"

While regions in phase 6 and later fight new basic innovations, the potential from a new basic innovation (since the 1970s the Information Potential) grows ever faster due to research and contributions from ever more enthusiasts. During the 1980s the size of the Internet grew by factors between two and four per year with ever more people adding ever more software and servers and involving ever more people (this is another CCN, with the three subsystems of people, computers, and software). Eventually this potential became so big that it could no longer be ignored for applications. This happened in the early 1990s. In 1990 the Internet had about 300,000 servers; this number increased to 6 million in 1995 and to 300 million in year 2001. (For good data on the Internet see the Network Wizards, http://www.isc.org/ds/new-survey.html).

In the ISIS-model, there is one subsystem on new economy and a second one on mature economy. In both subsystems we have the phases of CCNs between economy, key people and know-how. In the subsystem on the mature economy, all of the components are for the mature subsystem: know-how for mature economy, key people for mature economy. And in the subsystem for the new, everything is new.

There are manifold interactions between the new and the old. The new economy develops within these interactions. The suppression of the new economy by the mature was mentioned before. There is a competition for capital, for markets, for people and for land. Later on there is a transformation of the mature economy by the new one (not yet part of the model).

Know-how in the ISIS-model is modeled separately for "New" and for "Mature" economy. Both forms of know-how evolve in phases parallel to the phases in the economy. The characteristics of know-how are very different for each phase. For example, know-how in phase 6 is widely available, mature, voluminous and generally appreciated. It is the income base for society and the boredom of whiz-kids, whereas new know-how in phase 2 is comparatively small, strange, little-known, but for some people utmostly fascinating (the coming new key people). Development of know-how always proceeds within **and** outside of

the economy. Know-how for the successive waves of new basic innovations seems to have developed always outside of the ruling economy.

This new independent know-how can only become effective in economic respect if it has surpassed some critical volume. The model compares the volume of know-how in mature economy with the volume of independent know-how (measured in bits, according to Shannon. Although this measurement has many shortcomings it is better to use this than to have no idea how much information grows). Once the volume of independent know-how has surpassed twice the volume of know-how in the mature economy, the independent know-how is released for application in a "new" economy; a new basic innovation gets started. At around 1995 the independent know-how for example in the Internet had grown so big that it began to become effective in economy. This ignited a fast new economic development.

Growth of a new economy is not automatic once the new know how has its breakthrough in globally the first region. Instead, manifold new regional requirements must be met to allow and support emergence of a new economy. Examples are: good availability of venture capital, existence of fast information infrastructure and of new key people. These requirements are policy options in the ISIS-model; underlying the model is a set of 25 key issues for creative regional development. Regions begin to understand that they must fulfill new requirements, although understanding is still poor for most regions and learning often is slow. Learning and understanding are topics of relevance for use of ISIS for consultancy. In the application to a specific region, the ISIS model is based on an analysis of regional strength and weaknesses. We will demonstrate below such evaluations.

3.4 Market-shift to information products

In the last century we have seen an emergence of information products in ever more sectors. Electronic mass media started in the 1920s, the phone became globally widely used since the 1930s – development which has not yet come to its end – and at 2000 you could get dozens of TV-programs in all locations of this planet.

This implies that consumers spend ever more for products of this sector and that there is a competition for the buying power of consumers with the mature industry. Increasing attractiveness of products from the new economy shifts demand to these products, away from products of the mature economy, Figure 9.

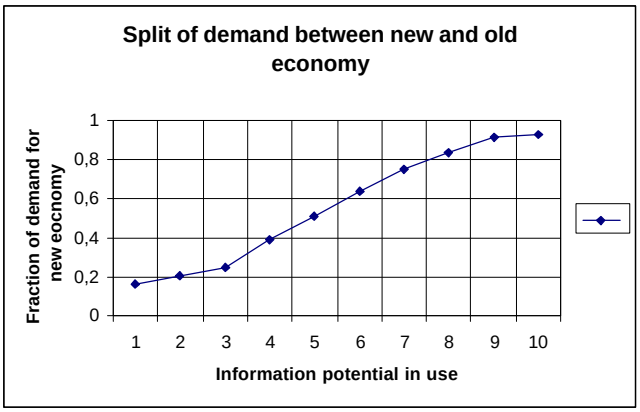


Figure 9, split of demand for new vs. mature economy, see text

This statement is an idealization; in reality products of the mature industry also get charged with information products; e.g. the about 50 microprocessors in many new cars. The most unlikely sectors of the mature industry get transformed by information products, for example logistics are enhanced with extensive use of information. Experts forecast that within 10 years 90% of profits in logistics will come from use of information, only 10% from the physical transport of goods.

The curve in Figure 9 is an expression of this consideration: If we look at the fraction of buying power remaining today for agriculture and at the rapid decline of market share of the service industry compared to new products, the development could well be like this figure.

In a model on the transition to the information society we need a market mechanism that does this shift. Demand is generated depending on number of people ("Urban population total) and their average income ("Material standard of living ratio"), mature industry ("Demand from MI"), new economy ("Demand from NE") and a demand increasing term depending on the size of the information potential ("Information potential demand modifier"). This demand is distributed between mature and new economy by a split variable ("comparative attractiveness of information offers). This split variable is also controlled by the size of the information potential, Figure 10.

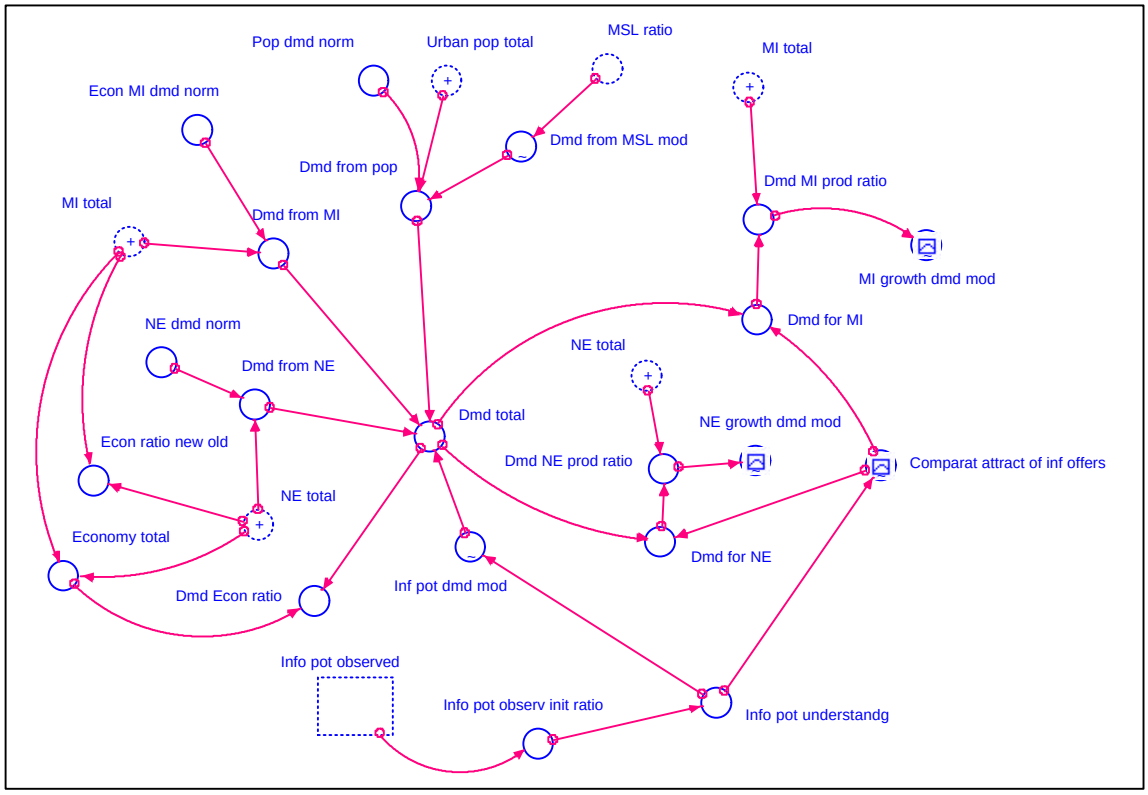


Figure 10: Market with supply and demand, controlled by the size of the information potential

The variable "comparative attractiveness of information offers" (with the effect of the split in Figure 9) is one of the few variables in the model where we see a very sensitive reaction of model results on input by the modeling group. This is as it should be: if there were no demand for those new products, we would never see a new economy. If this demand grows very fast (as it does for quite a number of product categories, e.g. mobile phones which now multiply even in the slum belts around Third-World countries) we will see a very fast growth of the corresponding sectors of the new economy. Growth seems to be very fast for some products and very slow for others; the development over time needs closer examination in new projects.

3.5 New Key People

The model shows the people who build and use this information potential and who are behind the new economy. There is a severe lack of such people as these new skills are usually not yet well taught at universities; most teachers in school do not know much about such things. There is now an effort in many countries to train the teachers, professors and directors. This needs training of the trainers of teachers and lecturers (the author trains leaders in education and management). There is a global competition to hire people who are knowledgeable in the new field. Even Germany, which used to be restrictive with immigration, is now offering Green Cards to such people.

The ISIS-model uses the number of new key people in the different phases to calculate employment. In each phase there is a different ratio of people who are leading others and those who have superiors. In phase 2 there may be one additional staff member person for three key people. In phase 3 there may be 3 people per new key people. In phase 4 we have about 7 people per new key people. In this way the number of new key people per average staff member decreases through the phases. Multiplication of the number of new key people per phase times this ratio gave surprisingly correct occupation numbers for the city of Hamburg. With this approach, the ISIS-model projects numbers of employment and unemployed based on its economic submodel and a regional population model.

3.6 Policy section

Figure 11 shows policies that influence regional economic success, or, to a degree, attractiveness of a region for new economy. For optimization of the model we added one auxiliary variable to the term “Economy hard locational factors” which allowed to change all the effect of all policies that are lumped in this one variable.

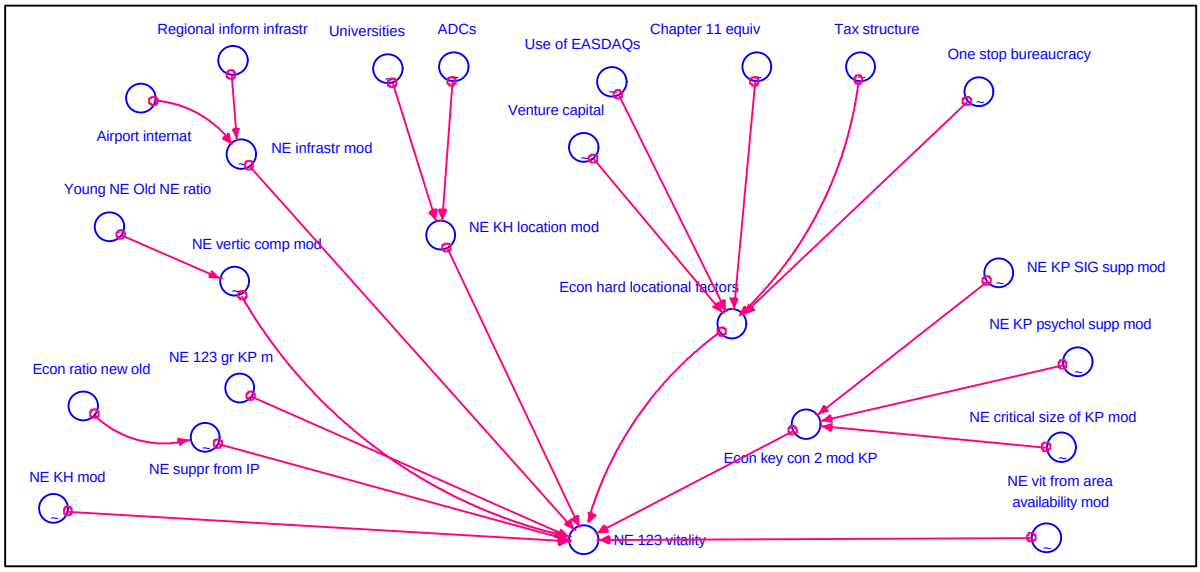


Figure 11. Policy options in ISIS which influence emergence and growth of the new economy

Figure 11 is only a summary of policy parameters and of locational factors. Regions try to improve their attractiveness for young companies and for key people. This can be modelled by changing a few of these parameters. Evaluations with the ISIS showed that it is effective for the well-being of the region to improve these locational factors. An improvement of

economic growth by changing these factors is not easy. Why is this so? We will look at model evaluations to see which policies are the most effective.

3.7 Model evaluations

Figure 12 shows a typical pattern of development of new economy, mature industry and total economy (sum of new and mature economy) for the years from 1980 to 2020. The period prior to year 2002 is used to show people patterns of development which they know – the past two decades, with a slow beginning of the new economy and a sudden boom since the 1990s. It also shows, what people know anyway, a slowing down in growth of the mature industry. So, we can use this figure for discussion, but people tend to take it as a prediction. It is true that this looks like a prediction, but as every Systems Dynamics modeler knows, we are not good at predicting - nobody is -. We want to understand interactions within our system to became able to device good policies that use the systems characteristics and try to avoid counterintuitive reaction. Since the mid 1990s a number of well-known experts predict a long boom that should last until about the year 2020, similar to the development in Figure 12, e.g. Schwartz et al. 1999, Schwartz and Leyden 1997.

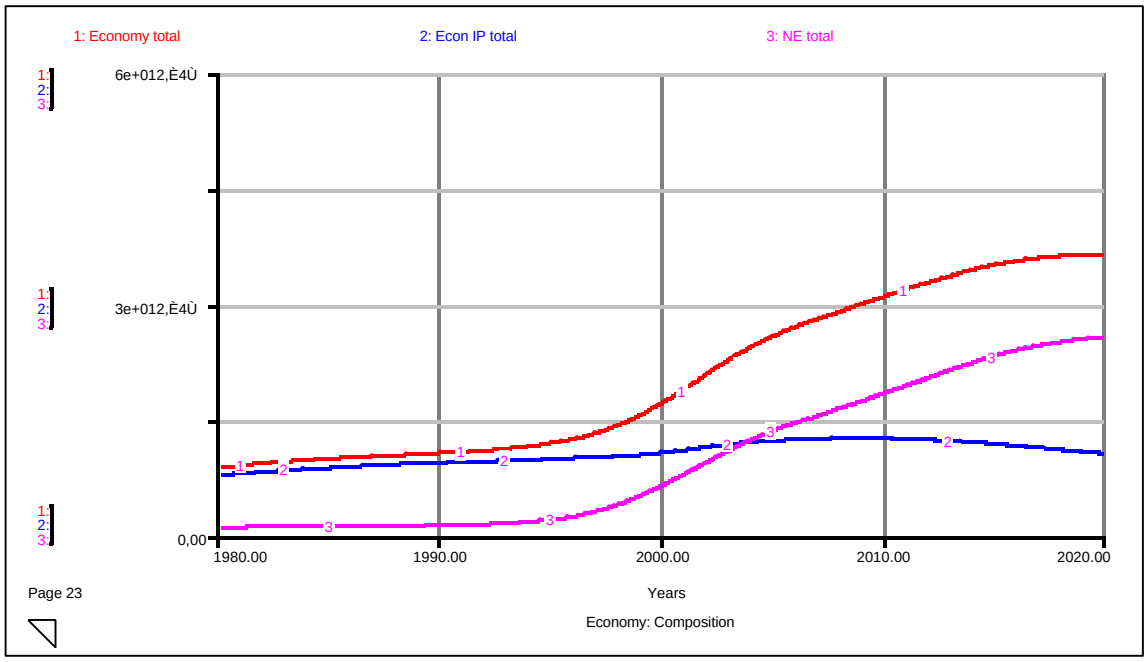


Figure 12: Development of the total economy (curve 1), mature economy (curve 2) and new economy (curve 3)

Dynamics in a specific region can be very different from this optimistic development if the region fails to provide the key elements for successful development of the new. Not only regions fail; we see nation states that do not get their act together.

How realistic are the curves from the model, given all these obstacles towards effective modelling? The curves are realistic if a region is good at supporting the development of the new economy. Industrial goods, according to a major consulting company, will be produced somewhere in the world, where it is most suitable or where the production happens to stay by some random events. Most money will be earned with information intensive products. In the

U.S., 80% of all new jobs are created in small innovative companies that start from scratch. Figure 12 shows some growth for mature industry (in the model mainly due to growth of the new economy which creates demand for more products of the mature industry, e.g. metal for computer casings, electricity, additional transport and so on).

The information potential is globally available. But whether a region benefits from this new potential depends on regional factors. They include information infrastructure, one-stop-bureaucracies, education etc. Land use is an important issue, because shortage of land in metropolitan regions for new economy can inhibit their growth. ISIS allows to evaluate effects of land use planning, and land use change due to economic and social developments. It has seven land use categories: settlements, infrastructure land, agriculture, forestry, parks and gardens, protected nature areas and "Urban Nature Sanctuaries", a new concept in urban planning to reconcile man and nature and to make the city attractive for the "new wilds", the new key people. In the new Malaysian Cybercity Cyberjaya it means rainforest in the city for these new wilds. The key factors are summarized into the variable "new economy 1,2,3 vitality", curve 1 in Figure 13. High viability triggers extensive company formation, curve 2 leading to an increase of young companies in phases 1, 2 and 3 (curves 3, 4 and 5, respectively). Moreover, these companies grow and support each other, an auto- and crosscatalytic process.

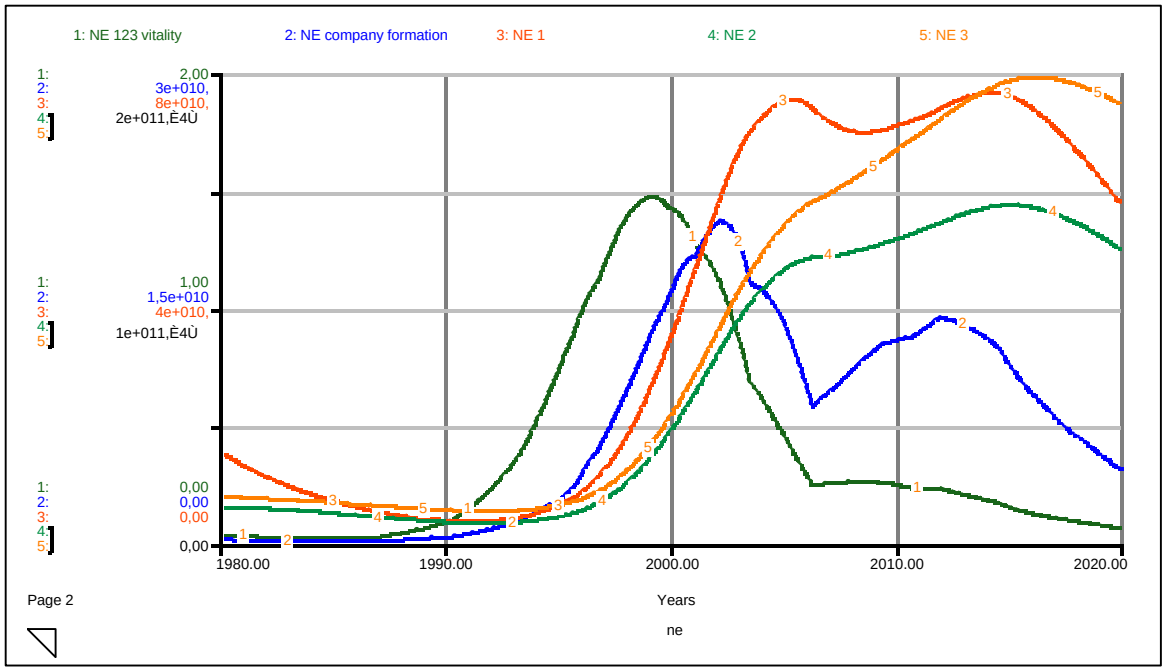


Figure 13: Conditions for company formation (curve 1), company formation (curve 2), phases 1, 2 and 3 (curves 3, 4 and 5)

The next model run evaluates the importance of new key people. *Figure 14* depicts two model runs for the city of Hamburg, Germany. The first model run, curve 1, is for the present situation. In the second model run, curve 2, the assumption is that 50,000 new key people will immigrate or be trained beginning in 2001 within one year.

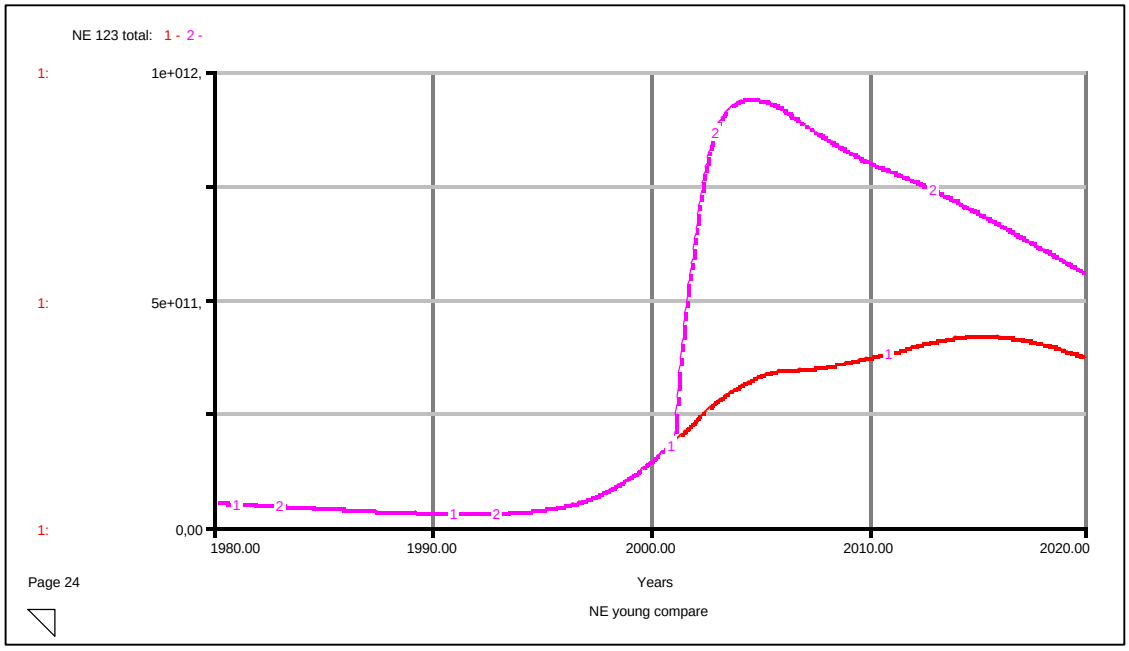


Figure 14: Young companies, phase 1, at present availability of new key people (curve 1) and with an increase of new key people by 50,000 (5% of workforce), curve 2.

50,000 is 5% of the total workforce. The effect is dramatic growth in company formation which after year 2003 levels of. Many new key people leave, because in the first years they do not have a good income as founders of young companies and therefore cannot get adequate housing. Their quality of life declines rapidly from 10 to 0.1, *Figure 15*. An average city has a quality of life of 1 which implies that immigration is equal to outmigration. Due to the high attractiveness of the city of Hamburg with respect to quality of life the figure is close to 10 in the beginning.

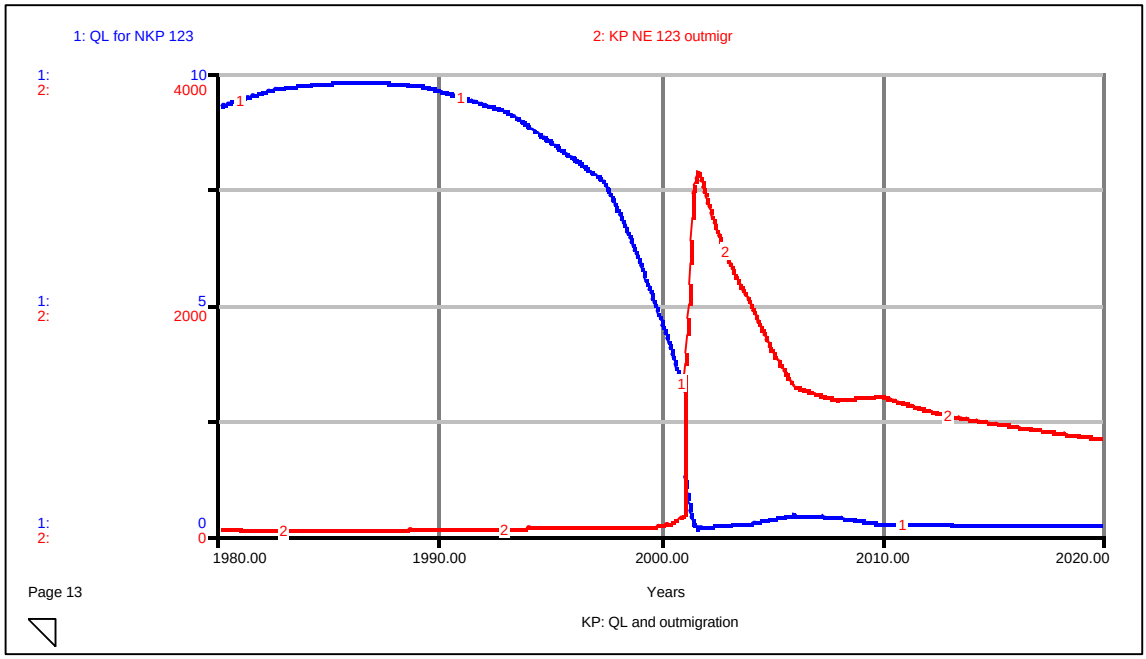


Figure 15: Dramatic decrease of quality of life for new key people due to lack of housing

Growth of the new economy can be hyperbolic if availability of these new key people is high, like in Silicon Valley or in Seattle. This high importance of new key people is emphasized by almost all leading managers in this new economy. For example, John Doerr, who speaks for this economy in the U.S, said: “The biggest limitation on new economy growth is finding talented, knowledgeable workers....”. Another author says: “People are the crown jewels of this new economy and they know it.” Lack of new key people has considerable repercussions for availability of jobs in general: in the early phases each key person creates about 5 additional jobs, which is an outcome of the normal span of 1 : 5 of leading people to general staff. Therefore it is important to look more closely at this group: what are their regional preferences, which region is more attractive for this group of people? Such evaluations have been done with the ISIS-model.

The dramatic decline in quality of life for new key people, if immigration of more new key people is encouraged, are due to a severe shortage in housing. This result on the dramatic impact of availability of housing was not what we expected before. We thought, and this was correct until the 1980s, that new key people earn enough money so that they can easily pay high rents. Nowadays this is usually, but not always, true if they are employees. It is wrong when they are forming their own companies because in that stage they need their money for their company and cannot spend it for themselves. As now, other than in the 1970s, the economic development comes from the formation of many small new companies, this lack of cheap housing is a severe problem. Indeed, the reports which we evaluated to check this result confirmed that this model result is valid. As the new economy comes due to a high degree from formation of new companies, this bottleneck is severe. Therefore, one possibility to overcome the lack of new key people would be to offer them adequate cheap housing subject to the condition that they start businesses.

4 Optimization of policies in the ISIS-model

This section uses results from the contribution by B. Grossmann, this volume: “Policy Optimisation in Dynamic Models with Genetic Algorithms”. Figure 16 shows an optimization with ISIS of policies to decrease unemployment. As this optimization is done with a Genetic Algorithm (GA) applied to ISIS, we will name such evaluations “ISIS-GA”. These policies start in year 2002. Here, unemployment would decline from its present state of about 12% to 0 within three years (curve without marks). This might be theoretically possible, however, these policies are implemented without consideration of their costs. Unemployment in this figure is much higher than in the official statistics, because the German state provides many benefits to put people into work, but these are no real jobs (“Arbeitsbeschaffungsmassnahmen”). There are more factors which need further elaboration. We will discuss some of these later in more details.

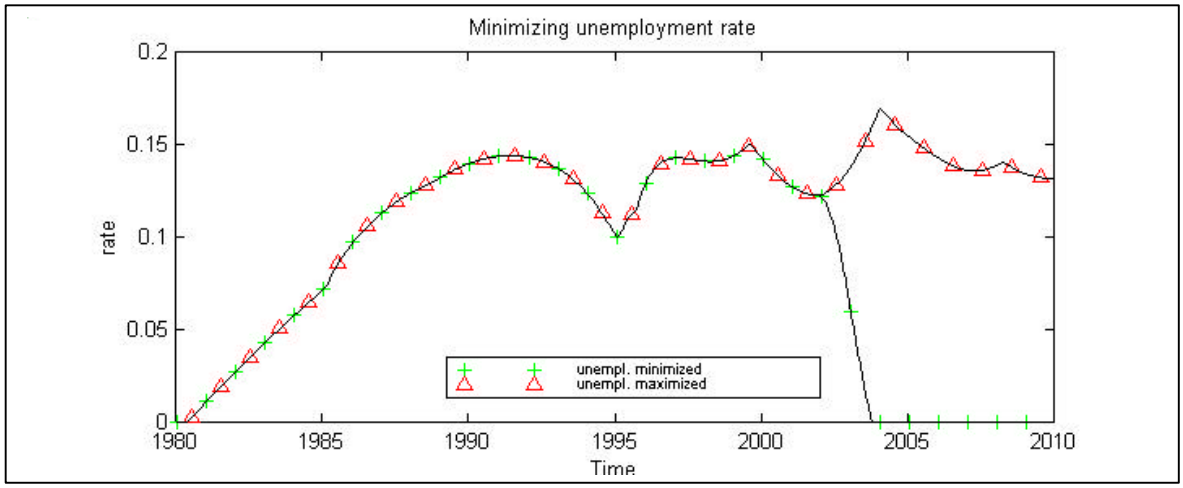


Figure 16. Optimization and "pessimization" of employment, see text

This figure shows a second curve, marked with triangles, which is the "pessimization" of unemployment: using policies so that unemployment is made as bad as possible. Optimal value and worst value together form a triangle in the right side of this figure. The effect of any other policy in the model will be between these two curves. Therefore, if we want to judge the value of any particular policy, we can additionally embed it into this figure. We can repeat these two runs in the STELLA-environment with the respective parameter values that we get from the ISIS-GA and put these two runs in a comparative plot (like in Figure 16). This new graph pad allows to judge any other policy, like in Figure 17. Here we see two additional runs, the second worst would be to continue business as usual (continue present policies) and the much better one would be to increase immigration of new key people to the maximum possible in the model. The effect of immigration would be quite dramatic. In reality, Germany is offering a limited number of Green Cards to people with knowledge in advanced programming and the effects of this program are quite good.

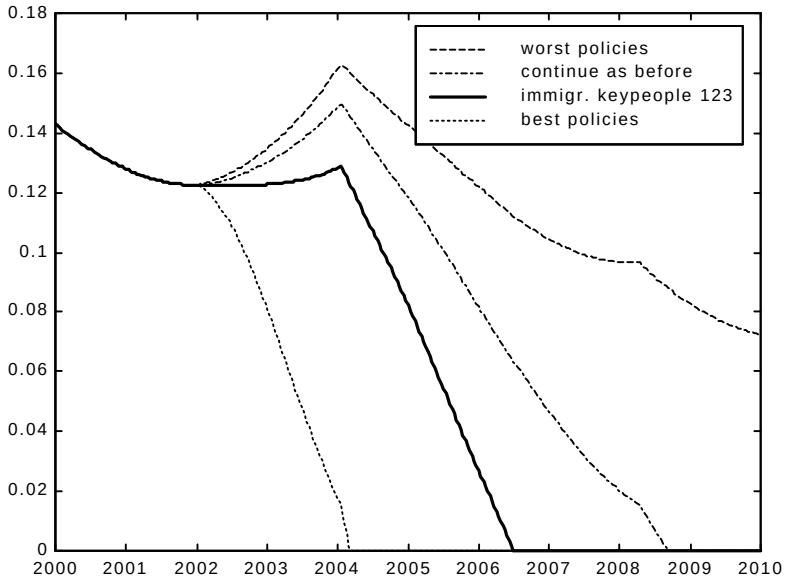


Figure 17: Unemployment decreases if key people for new economy phases 1, 2 and 3 are allowed to immigrate

As was stated above: the availability of new key people is so highly important because they form a CCN with the economy and they must be available in person in that region. The optimization confirms this insight from regional science, Figure 18. Here, the immigration policy is combined with the policy of training new key people and of educating others about the importance of that policy. This brings us close to the optimum.

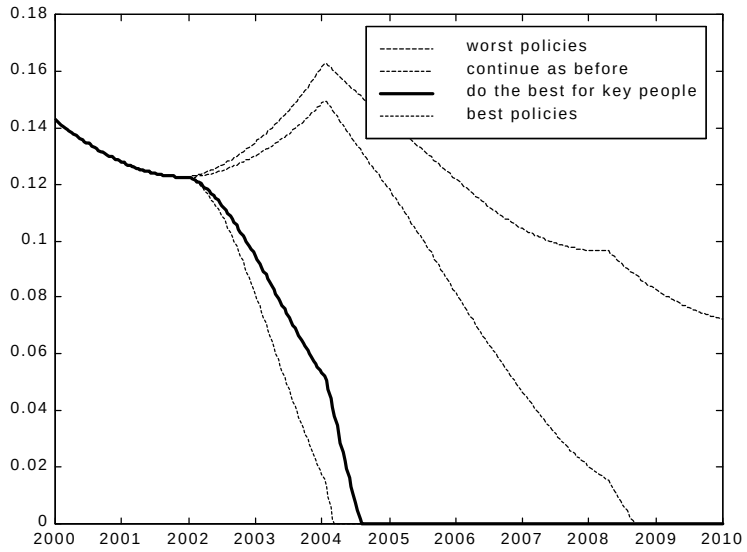


Figure 18 shows effects of combining immigration and training programs for new key people

Now we can also answer the initial question why Europe performs so much worse than the U.S. Large companies have the same job creation rate in the U.S. and in Europe whereas the job creation rate in small businesses is much lower in Europe. What are the reasons? A person who starts a new company has only a very limited amount of money, time and capacity for work. He cannot succeed with his limited resources if there are too many obstacles which he has to overcome. His resources are depleted before he can have success. In many European countries there are by far too many obstacles, for example lack of venture capital, or a public administration that is too slow and too time consuming for an individual who wants to start his company, and has to do many many more things. Also, the mood is not in favor of those who dare to do something different. These obstacles from finance, administration, social environment and politics add up and are by far too heavy. Many regions and governments have started to remove them through policies which, in the ISIS model, would make it easier for companies in NE 1, 2 and 3 to succeed. But the evaluations with ISIS have shown that these policies do not suffice even if two, three, four of them are done. It is the right direction of change, but it takes large changes before small companies of the new economy can succeed. This also explains why the Netherlands had some success with their package of policies and Denmark succeeded with a very different package of policies. Both of these packages remove enough obstacles, although different ones, to allow small entrepreneurs to succeed.

In comparison, spin-offs from large companies can succeed much easier. They have all possible support, there are departments that deal with the public administration, there is capital from the mother company, there is job security for staff in the young company and so

on. Nothing of this exists for the small independent founder. Breeding enough new key people can only bring about the desired results if they are supported by a multitude of systemic policies to remove obstacles and to build up support, because otherwise they would very rapidly migrate to more promising countries.

5 Conclusions

As new key people are of utmost importance – and this is not just the outcome from these model runs, but as well an insight that is widely shared – the question arises: what can a region do to attract them, or once the region has trained its own key people, to keep them in the region? There are many policies to succeed in this endeavor. We have mentioned a few that need to be implemented to allow these people to succeed. Success makes them happy and makes them stay in their region.

These people want and need a very high quality of life. They need places where they can meet like-minded people, which is an important component of their quality of life. An evaluation from Housing and Urban Development (HUD) in the U.S. on the 114 most successful regions of the last 10 years has shown that all of these have a high concentration of such knowledgeable people and a high quality of life. Therefore, successful regions are almost always part of metropolitan regions so that there are enough new key people. These "success-regions" are not in the core of the metropolitan regions but usually at a distance which allows easy connection to the core but allows a remarkable amount of green areas, lakes and so on. This insight on the importance of outdoor nature justifies restoration on a large scale of ecosystems in the region, because rivers, lakes, forests and meadows contribute very much to the specific quality of life needed by these people (and enjoyed by everybody). Never mind that these people are often much to busy to really visit nature, they want to have the possibility.

As there is an economic rebuilding and large-scale emergence of something totally new, we could influence it to become much more environmentally compatible at little additional costs. There are very elaborate policies how to influence this development. In a model evaluation of an ISIS version for research on climate change together with the IPRC in Hawaii and the GKSS Research Center in Geesthacht/Germany we found that policies which speed up modernization instead of subsidizing mature industries would decrease, not increase, unemployment. The reason is that the disappearance of old industry allows a faster success of young companies which afterwards have a much higher growth rate than old industry. Although this "churn" (Kevin Kelly) is inconvenient, it is successful.

Putting it all together, policies seem possible that would improve the economic performance, increase number of good jobs and are highly effective for regional well-being, quality of life and environmental goals. The ISIS-model was made to allow development and analysis of such integrated policies which synergistically combine different areas to benefit from the present wave of large-scale innovation and transformation.

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