Available online at www.sciencedirect.com
SCIENCE DIRECT
Structural Change and Economic Dynamics
14 (2003) 385–404
STRUCTURAL CHANGE AND ECONOMIC DYNAMICS
www.elsevier.com/locate/econbase

# Learning innovation policy based on historical experience

Joachim Schwerin, Claudia Werker *

*Eindhoven University of Technology, ECIS, P.O. Box 513 (DG 1.23), 5600 MB Eindhoven, The Netherlands*

Received 1 March 2002; received in revised form 1 February 2003; accepted 1 March 2003

**Abstract**

Innovation fosters structural change and growth and drives socio-economic change. The generation and diffusion of innovation is a dynamic process, which cannot adequately be guided by static policy conceptions. In this paper we will explore the possibility of devising and implementing a 'learning' innovation policy. As organisational and technological change is not completely haphazard, we argue that innovation policy can make use of structural regularities in socio-economic change whilst, at the same time, be open to advances in scientific knowledge. We devise a method that achieves these two aims and apply it to a concrete example (knowledge systems). We conclude with practical implications originating from such a 'learning' innovation policy.


*JEL classification:* D83; L19; O14; O38

*Keywords:* Innovation policy; Socio-economic change; Historical experience; Knowledge; Learning

## 1. Introduction[1]

Most countries in the Western world have achieved a significant rise of their economic growth rate from less than 1% to more than 2% on average since the beginning of the Industrial Revolution. Since then, innovation has been at the core

* Corresponding author. Tel.: +31-40-247-4479; fax: +31-40-247-4646.
*E-mail address:* c.werker@tm.tue.nl (C. Werker).
[1] We are grateful for helpful comments by Friedrich Breyer, Uwe Cantner, Stan Metcalfe, Wilhelm Ruprecht, and Eddy Szirmai on earlier versions of this paper. The usual disclaimer applies.

0954-349X/03/$ - see front matter 
doi:10.1016/S0954-349X(03)00031-6

of economic development and growth, and the question how innovation policy could contribute to increasing the positive effects originating from innovation and growth has moved centre stage. Under innovation policy we subsume all actions of policy makers that intend to influence the processes connected with the generation and diffusion of innovation. These processes are characterised by novelty and hence contain elements of uncertainty and chance.

For this reason, it is particularly difficult to give advice for innovation policy, as the latter is addressing processes that seem unpredictable—or are they not? It indeed proves necessary and fruitful to distinguish between the observation of each individual innovation and the analysis of innovation on a more aggregate level, because.

> '... although, the emergence of novelty is unpredictable, the processes which translate novelty into coherent patterns of change are not, and it is on this distinction that the role of technology policy hinges.' (Metcalfe, 1997, p. 272)

Consequently, the identification of invariant patterns that translate novelty into innovation and economic change and that underlie the generation and diffusion of innovation is crucial for a successful innovation policy. But is it methodologically and practically feasible? Deterministic and stochastic elements are closely entwined in socio-economic processes. In the following, we try to find out whether these elements can be sufficiently distinguished to identify structural regularities of socio-economic change and to use them as a guideline for innovation policy. If this turns out to be feasible, innovation policy could learn from historical experience, in particular from identifiable patterns of socio-economic change.

In this paper, we can show that in principle it is indeed possible to observe structural regularities of socio-economic change that can serve as a guide to innovation policy. With the help of an example we will demonstrate how this can work in practice. However, it has to be clearly stated that the chance element in socio-economic change still leaves margin for errors. Policy decisions will remain subject to failures, but improving the knowledge base on which they are built helps to increase the chances of successes.

In the following, we first introduce the concept of learning innovation policy in changing socio-economic systems (Section 2). Then, we show that it is possible to cope with the complexity and uncertainty inherent in these dynamics either by applying man-made rules or by making use of historical contingency (Section 3). Based on these insights we conceptualise a learning innovation policy that is based on these mechanisms (Section 4). The outcome is a practically applicable concept of such a policy that depends on the identification of structural regularities within the recorded experience of the past and that is systematically adapted to newly arising scientific insights. In this context the question of how open the set of identified structural regularities is towards a changing environment—i.e. what 'learning' really means—merits special attention. After these conceptual considerations, we demonstrate by way of example how learning innovation policy would look like in the context of knowledge networks (Section 5). We use this example and its political consequences to again demonstrate why we think that our approach constitutes an improvement compared with traditional ways to conduct economic policy. In Section 6, we discuss the chances and problems connected with our approach, before we conclude by pinpointing aspects for which we still see the need for further research (Section 7).

## 2. A learning perspective on innovation policy

Looking at innovation policy as a dynamic learning process facilitates the understanding of how policy can cope with the complexity and uncertainty inherent in changing socio-economic systems. Innovation policy addresses all actions of policy makers that are intended to influence the processes connected with the generation and diffusion of innovation. Innovation emerges when economic agents, for instance firms, individual researchers, R&D institutes or universities, implement novel combinations. In this wide sense innovation includes product, process and organisational innovations as well as the new access to markets of suppliers or consumers.[2] Here we only talk of innovation if the inherent novelty is so high that it contributes to technological change and growth, i.e. that it partly alters the shape of the socio-economic system.

The processes connected with innovation, technological change and growth have been widely analysed, and these analyses can of course provide a sound foundation for innovation policy. Traditionally, innovations were considered as the central part of the so-called linear innovation model, which describes a sequence that starts with an invention in basic research. This invention serves as an input to applied research, which in turn results in the marketisation of an idea (usually called innovation in a narrow sense). This idea is finally diffused within the whole system.[3] This linear innovation model is based on the assumption that technological change and growth are purely supply driven, which runs counter to empirical evidence.[4] First of all, simplifications of the linear model neglect feedback effects between the different stages of innovation processes, which are in fact crucial elements in bringing forward innovation. Second, the demand side needs to be integrated into the analysis, as it considerably contributes to the emergence of technological and organisational progress.[5] Third, many economic agents simultaneously undertake innovative efforts, the outcomes of which overlap. As a consequence, different innovation processes are linked with one another.

[2] Cf. Schumpeter (1911)/(1987), pp. 100f.

[3] See, for example, Steinmueller (1994) or Kline and Rosenberg (1986).

[4] Cf. e.g. Grupp (1997), pp. 17–20.

[5] Schmookler (1966) put forward his famous criticism of this supply dominated approach. More recently Lundvall (1992) pointed to the fact that the problems encountered by first-fast adopters can lead to renewed questions for basic or applied research.

This critique of the linear innovation model has led to a more detailed view of innovation processes that emphasised its systemic nature.[6] Feedback effects within individual processes, interaction between the demand and supply sides and overlaps between a multitude of innovations all augment complexity and uncertainty. In practice, economic agents have to cope with this complexity and uncertainty in an ordered fashion. For policy makers the complexity is even higher, as they are faced with many overlapping innovation processes within the socio-economic system they try to influence. Therefore, in a first step it is useful to have a closer look at the socio-economic systems that are constituted by the activities of its agents.[7] These agents, who are mostly sub-systems in themselves (firms, non-profit organisations), try to achieve their individual goals in the best possible way while competing with others for scarce resources. They—as well as the socio-economic systems as a whole—possess specific characteristics, depending on their main activities.[8] Their attempts at innovation, on whatever systemic level (individuals, firms, industries, regions or the economy as a whole), result in changes of the socio-economic system. It follows that any analysis of economic entities has to take into account that decentral economic agents are the drivers of systemic change. Still, as individual cognitive capacity is limited, it is not possible to connect every agent with all others at every point in time in such complex and uncertain situations as those emerging from innovative activities.[9]

A similar observation applies to policy makers. From an evolutionary point of view, they operate under constraints of imperfect information and bounded rationality, just as firms and consumers do.[10] Especially in fields that are characterised by continuous change and where this dynamics is influenced by a multitude of overlapping causal factors, it becomes crucial for the conduct of sound policy to enable policy makers to learn. They need to adjust their measures to the current state of the evolving socio-economic system at each point in time. As continuous learning is in fact a vital demand for the sensible conduct of any activity, it should come as no surprise that the existence of dynamically evolving socio-economic systems also gives rise to manifold learning processes in the realm of policy making. And yet, the particular complexity and uncertainty associated with innovation raises the question of how policy makers can practically cope with this situation.

In principle, there exist two kinds of mechanisms that reduce complexity and uncertainty to a manageable extent (see Section 3.). First, there is a closely related group of activities that can be interpreted as purposefully designed by economic agents, e.g. encoded rules, routines and social norms. Second, there is a property of socio-economic change that serves—beyond any individual calculus—as a more or

[6] E.g. cf. Lipsey and Carlaw (1996) and Metcalfe (1995), or Hanusch and Cantner (1993).

[7] Cf. Schwerin (2001), p. 17.

[8] Cf. Willke (1991), pp. 128–145.

[9] Luhmann (1995), p. 24.

[10] Cf. Metcalfe and Georghiou (1997), Metcalfe (1995) and Hanusch and Cantner (1993).

less automatic counterbalance to complexity: the contingency of man-made change. As we will explain in the following sections, learning innovation policy in the sense that we suggest can and should use both mechanisms by applying rule-driven policy decisions based on identifiable structural regularities of socio-economic change.

From a policy perspective, the crucial aspect here is that we suggest a form of learning through experience—i.e. a form of learning that purposefully uses the complexity-reducing function of socio-economic contingency. Policy, in this sense, aims at stimulation to systematically exploit known as well as newly arising knowledge on economic change and growth. It thus contains a forward-looking perspective. Furthermore, as any policy which tries to stimulate innovation is connected with the uncertainty which is always inherent in the generation of innovation—the random element of change, so to say—policy in itself is a process of trial and error.[11] However, the component of error can be minimised if learning, as we suggest in the following, is based on scientific progress in economics. This means that changes of rules only occur if the economic experts' understanding of the underlying mechanisms improves. Thus, 'learning' refers to improved knowledge about the nature of change triggered off by innovation, which is more than just the passive observation of change as such without developing an understanding of what is its underlying principles.

## 3. The role of rules and historical contingency in learning innovation policy

In general, two different mechanisms exist to reduce the complexity and uncertainty connected with innovation to a level that is manageable for economic and political agents: man-made rules and historical contingency. While both serve the same purpose, they work in different ways. Moreover, while the first can be actively influenced by individual or collective actions, the second is a property of system dynamics outside human control (though not independent of human actions). In the following, we first investigate how man-made rules can reduce complexity and uncertainty. Then, we explore the nature of contingency. In a later step, we integrate both into the concept of learning innovation policy.

To begin with *man-made rules*, it is a well established insight of evolutionary economics that routines can be interpreted as powerful filters which reduce complexity: actions do not need to be planned totally anew if former actions of the same kind have proven relatively successful in similar circumstances.[12] Thus, routines serve as a framework that stabilises expectations. In a much broader sense, institutions of any kind produce the same result. They are rules that can normally be relied upon by economic agents, so that the set of possible outcomes is limited.[13] In

---

[11] There are a few approaches which draw conclusions of this systemic view for policy; cf. Lipsey and Carlaw (1996), Metcalfe and Georghiou (1997), Metcalfe (1995) and Teubal (1997).

[12] Nelson and Winter, (1982) pp. 99–107.

[13] North (1990), pp. 25 and 50.

this context it is less important whether these rules are formal (e.g. laws encoded in writing) or informal (e.g. social norms, traditions or most routines, which cannot be enforced in a legal sense). Taken together they considerably reduce the information one has to gather if a certain decision is to be taken.

In order to demonstrate how rules can best be applied within our concept of learning innovation policy, we now try to identify the kind of rules that best fit to the nature of the processes to be influenced by policy measures. This choice of rules takes into account the problem of incomplete information and changes in a society's knowledge stock. At the same time, it has to address the problem that the object of innovation policy—i.e. subsystems of a broad socio-economic system—changes continuously. The theory of economic policy generally conceives that the conduct of economic policy can either be based on per se-rules or on rules of reason.[14] After a brief discussion of the two concepts we will suggest a compromise that best reflects the changes occurring in dynamic socio-economic systems.

Per se-rules specify causal if-then-relations ex-ante, so that all economic agents know the political reactions towards the outcomes of their economic activities in advance. Per se-rules consequently create a stable expectation-stabilising institutional framework by reducing uncertainty. Such rules allocate economic control in favour of private agents. They largely reduce the discretionary power of political boards by denying these the opportunity to decide on market results ex-post in an unpredictable manner. For these reasons, per se-rules are often considered as being superior to rules of reason. This particularly holds true if long-term economic activities are involved, such as investment decisions. However, a general disadvantage of per se-rules consists of their inflexibility. The rules are specified at one moment in time and are then left unaltered for a prolonged period. During this time, however, the economic environment changes in manifold ways, due to the dynamic nature of the socio-economic process.[15] Another disadvantage of inflexible rules can be seen in the complexity of socio-economic relations, which might render the ex-ante specification of all possible outcomes and thus the formulation of government responses to these results impossible.

As a consequence, a policy based on discretionary rules of reason might look like an advantageous alternative. Rules of reason offer politicians or bureaucracies the opportunity to decide for every single and different case anew which market result is 'useful' and thus 'allowed' (given a set of political goals). And yet, the substitution of inflexible per se-rules, which put decentralised behaviour centre stage, by discretionary rules of reason, which open the door for state intervention ex-post, loses its appeal if we think of the information problem. Von Hayek pointed out that it is the people who are best informed under uncertainty that should take the decisions.

[14] Cf. Schmidt (1996), pp. 148ff

[15] Here, a good example is the German antitrust law, which is altered (normally extended) every 3 to 9 years, but nevertheless hardly keeps pace with the alterations of competitive behaviour in the economy; cf. Schmidt (1996), pp. 155ff.

These are the people on the decentralised level.[16] Still, even if one acknowledges the fact that the individual agents are best informed about their specific circumstances, there remains a role for a learning innovation policy. The knowledge needed for such a policy is on a different level than that needed and accumulated by individual agents: it is specifically about patterns which can only be identified on a larger scale by using a lot of resources. This identification of invariant patterns is too costly for decentral agents when compared to the potential individual gains for them.

The discussion so far proves that per se-rules as well as rules of reason have comparative advantages and disadvantages. Nevertheless, the last considerations have demonstrated that—from a system perspective—the deficiencies of rules of reason seem especially severe. We will thus now focus on a solution which encompasses a compromise, but which gives greater relative weight to a specific kind of ex-ante specified per se-rules. In addition, we enrich the use of these rules by integrating a dynamic element: in order to avoid the above described increasing imbalances in time between unchanging, rigid per se-rules and the continuously evolving economic process, policy makers permanently have to learn. They can do so by basing their decisions on the latest available, regularly updated scientific information—not once, but instead in regular intervals—about the parts of socio-economic life they intend to influence with their measures.

The existence of ex ante per-se rules implies that several cases can be treated under the same framework. In order to specify such rules we therefore suggest to derive invariant patterns of socio-economic change from the state-of-the-art of scientific results. The basic idea of our approach is that economic policy should be based on the best available information on the structure of the economic process at every point in time. We will outline the concept in great detail in Section 4. In a nutshell, what we are saying is that this information should be collected by a panel of experts who continuously evaluate scientific research on processes for which data exist (i.e. historical processes) and condense their findings into a set of structural regularities, or patterns, of socio-economic change.

But still—do such regularities exist at all? We argue that they do, and we explain this by exploring the second mechanism introduced above to reduce complexity: *historical contingency*.[17] The mechanism, which is very powerful in its consequences, is an integral part of any socio-economic change. Contingency expresses the basic fact that selection mechanisms exist in reality, i.e. although many actions are theoretically conceivable, only few actions will in fact be taken by economic actors, simply because they have to survive in their ever changing environments. As a consequence, human beings behave similarly in similar situations, although in principle they would have many more options to their avail.

[16] von Hayek(1945), p. 524.

[17] The word ‘contingency’ originates from the Latin word ‘contingentia’, which is a translation from the Greek expression ‘endechómenon’ used by Aristotle to describe ‘possible and feasible’ outcomes; cf. in detail Fulda et al. (1998), pp. 340ff.

Powerful as system theory is in other areas, it is possibly its biggest flaw that its standard definition of ‘contingency’ fails to recognise the difference between ‘possible’ and ‘possible and viable’ actions.[18] Without this insight, the dynamics of socio-economic systems looks much more complex and unstructured than it actually is. Of course, this does not imply that behaviour and its consequences are deterministic. Actions of economic agents are the result of two sets of factors. One set of factors gives structure to the process of change: as economic agents try to be successful in their ever changing environment, they apply rules when taking decisions. Still, their actions are also influenced by a second set of factors, i.e. stochastic elements.

Contingency of socio-economic processes thus reflects the fact that change neither fully consists of structural elements that obey to general rules nor is purely driven by random effects. It rather is a mixture of both. On the individual level, this means that there is more than one feasible option of action for every economic agent at each point in time, but not a limitless spectrum. On the aggregate level, contingency emerges as a systemic phenomenon that channels all individual behaviour into observable patterns. In other words, contingency is defined as the phenomenon that, at each point in time of a system’s evolution, the number of future paths is greater than one, but not infinitely large, because each path must obey to the causal logic of socio-economic dynamics.[19]

For the concept of learning innovation policy it is essential to understand that the structural elements of socio-economic change, i.e. the regular patterns, can be identified by repeated observations. These structural regularities provide a basis for rule-driven (and thus non-stochastic) innovation policy, as they allow predictions about the way in which the socio-economic system evolves that policy makers try to influence. However, in reality predictions about any *single* historical process remain prone to errors, since the element of chance interferes with the regular element. Consequently, policy might still fail because of the stochastic elements in socio-economic change that unavoidably exist in every concrete historical situation. And yet, insights into the regular part of socio-economic change allow for policies that are built on a better understanding of their object than traditional approaches to policy making.

## 4. Learning innovation policy: the identification of structural regularities

We will now demonstrate how a learning innovation policy, which tries to cope with complex and uncertain socio-economic systems, can be conceptualised and

[18] See for examples the definitions of ‘contingency’ by Luhmann (1975), p. 171 and Willke (1991), p. 192f: both neglect the importance of selection mechanisms for the outcome of contingent processes. For a much more detailed discussion see Schwerin (2001), pp. 71–85.

[19] Cf. Schwerin (2001), p. 79. The contingency that emerges on the aggregate level can constrain individual choices if economic agents are aware of its existence and form expectations about the limited numbers of paths within the system. We thank an anonymous referee for this comment.

practically implemented. The approach will combine and use the complexity- and uncertainty-reducing characteristics of man-made rules and historical contingency. The first pillar of such a policy is scientific knowledge about innovation processes, which provides insights into the structural regularities resulting from historical contingency. The second pillar is rule-driven policy, which is based on these insights but, at the same time, remains open to change, as it is reasonable to assume that the invariant patterns themselves might change with the evolution of the socio-economic system.

Learning innovation policy requires the interplay between policy makers, a board of scientific advisors, a scientific community, and voters. All of these have different roles to play. To start with the policy makers, they are of course responsible for the innovation policy in the context of overall policy making. They are legitimised and controlled by their voters, for whom they are implementing policy measures in the first place. The scientific community carries out research on innovation processes. The board of scientific advisors transforms the results of these studies into information that can be used by the policy makers. Moreover, it publishes its findings. Thus, this information can also serve as a yardstick for the voters to judge the performance of the policy makers they elected.

As the concrete concept we suggest needs to be transparent and open for control, it is crucial to apply a clearly defined concept, so that the way in which suggestions for innovation policy are derived can be fully reproduced and understood by outside observers. As a side effect, this whole procedure keeps the experts' findings and the possible objections of critics in continuous and open debate, which in itself helps to spread new knowledge within the community of all who take an interest in the issues discussed. This procedure also serves to strengthen the communication between political advisors, scientific organisations and economic agents, so that it in itself constitutes a network in which knowledge is diffused and accumulated.

Apart from these advantages, the concept contributes to avoiding a major problem in practical economic policy making. Normally, experts sufficiently disagree to leave politicians enough arguments to decide in one direction or to do the exact opposite. Yet, here, the board of advisors provides a filter, in the sense that the current state of knowledge in the relevant field of economics is defined as the set of structural regularities on which a sufficient consensus[20] exists. However, this consensus is not a *political*, but a *scientific* one within the broad community of researchers. The reason to apply this filter is to take the element of discretion out of economic policy and, as a side effect, to minimise the welfare-reducing effects of lobbyism: as in science, learning means 'gathering new knowledge', and current knowledge consists of those insights on which *scientific experts* agree.

[20] For the respective roles that consensus and dissensus play in our concept, cf. below.

In practice, the concept to identify structural regularities within socio-economic change that we will now specify and on which we will base our approach towards learning innovation policy originates from a critique and modification of Kaldor's concept of stylised facts.[21] In contrast to Kaldor's original—and still widely used—approach, the concept used here is based on strict guidelines for the identification of these regularities. First of all, the identification of structural regularities should be based on the broadest available amount of experts' knowledge. Moreover, a practical method has to be derived that explains how diverging opinions can be checked for a sufficient consensus—a consensus which would allow the aggregation of these opinions into a set of structural regularities. This set has to be open for scientific progress, which means that it must be open to changes in time that reflect the latest scientific evidence. Last but not least, it has to be guaranteed that the regularities are not solely based on a single theory, but on empirical evidence derived by heterogeneous methods. Given that several mutually exclusive and contradicting theories compete for the explanation of any topic and that no meta-criterion exists which states ex-ante what theory is 'true', such a consensus is the only way to base practical actions on a sound scientific foundation. The absence of such a meta-criterion in science is obvious; thus, the use of structural regularities, i.e. stylised facts, as a reference system for theory and policy evaluation serves as a second-best mechanism.

The process of identifying structural regularities of socio-economic change, which meets the aforementioned requirements, is summarised in Fig. 1. It is important to note that panels of scientific advisors can directly apply this method, because identified regularities allow for a thorough understanding of real-world economic processes in a condensed yet detailed way. Thus, they directly provide a foundation for economic policy.

How should a board of advisors proceed on the basis of this concept? The observation of a practical problem for which policy measures are to be derived marks the starting point. The problem has to be formulated in the form of a clear and concise scientific question, which can then be examined by using empirical evidence. However, most questions can be tested in various ways and based on conflicting theories. Any ex ante choice of a single testing method would imply the implicit use of normative statements and immediately render the analysis open to political dispute, because alternative procedures (and ultimately alternative results) would be easily obtainable. We therefore take a different route. The board of advisors from the very beginning uses the broadest available amount of experts' knowledge on the relevant question: After the formulation of the scientific question,

[21] Cf. a critique of Kaldor's concept of stylised facts and a discussion of the modified concept of stylised facts Schwerin (2001), pp. 92–117, where the concept was originally devised. In order to simplify the discussion, we speak in the following of structural regularities and use this term as a synonym for stylised facts derived by applying the modified concept.

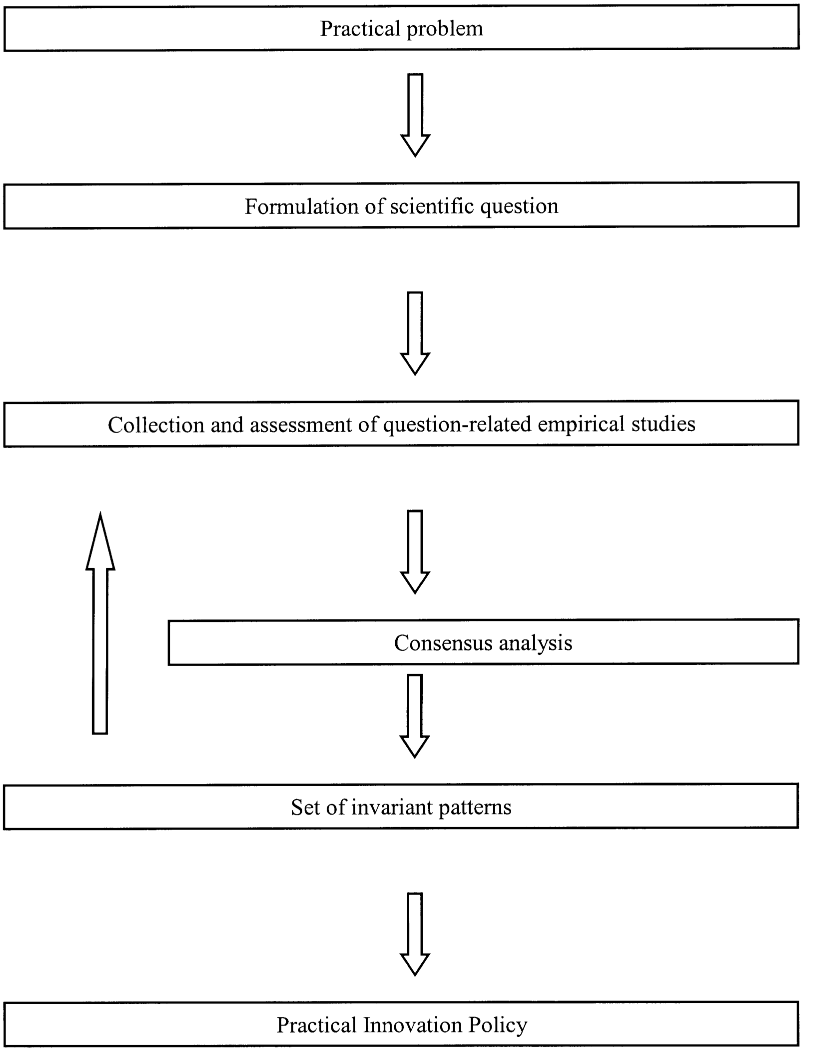


Fig. 1. Identification of invariant patters for learning innovation policy. Cf. Schwerin (2001), p. 114.

a panel of scientists systematically collects and assesses all empirical studies which currently exist for a given topic, deliberately including varying approaches.[22] As a result, a set of studies will become available, which contains all recently discussed hypotheses for causal structures underlying the question in debate.

[22] It has proven to be useful to include quality filters and restrict the studies to those which have been put forward in a period of e.g. the last 10 years. A quality filter could consist in the exclusive use of publications in top-ranked scientific journals; cf. Schwerin (2001), p. 121.

In this context, it has to be stressed that the past processes examined need to be sufficiently similar to those for which political measures are to be found. If, for example, policy strives to find instruments that can increase the success of knowledge networks, the panel of experts should look at analyses of those networks that have proven to be successful or unsuccessful in the past. As stated before, this should not be done in a purely reactive way by just collecting a set of all potential variables that might be possible causes for success or failure. Instead, they should aim at gathering insights that improve the theoretical understanding of the processes under consideration, i.e. they should try to identify causal relationships or investigate the strengths of correlations.

The next procedural step marks the core of the concept, namely the consensus analysis. For all hypotheses explored in the empirical studies, the percentage of experts who agree to them will be identified. The group of these experts is confined to the authors of the existing empirical studies. Furthermore, only hypotheses that contain topic-related statements in already published material will be considered. This latter requirement serves as a quality filter—taking into account any statement brought forward in an ad hoc fashion would increase the knowledge base, but at the same time make render any quality control impossible. Correctly applied, this method can minimise observation effects and any direct influence between policy advisors and scientists. It is then possible to define a consensus if, as Robert Whaples has suggested,[23] at least two thirds of all scientists agree on a certain statement. All statements for which a such sufficient consensus exists and which have been tested in several studies by using different methods constitute the set of structural regularities for the topic in question. This set then forms the basis for the guidance of economic policy, as it makes it possible to derive concrete policy measures.

From an evolutionary perspective, this focus on consensus might seem surprising. Is it not diversity that enables complex systems to adapt and survive over time? Can conformity of views therefore be of merit after all? These questions, appropriate as they are, are misleading. Firstly, we observed above that socio-economic change results from the *interplay* of rule-driven actions and stochastic elements. The identification of structural regularities only serves to explore the first, not the latter. Secondly, consensus and dissensus are of equal importance. In fact, the element of 'learning' is integrated into our concept by giving an important role to dissensus: While consensus refers to a sufficiently high agreement among scientists on a statement *at a specific point in time*, dissensus means that diverging views exist that might lead to a reassessment of the agreement *over time*. If, for instance, new insights emerge that will drive the number of consenting scientists below the two thirds mark, we cannot speak any more of a structural regularity. Vice versa, new regularities might be identified if a new consensus emerges. This mechanism is open to change. It thus reflects learning in the very sense of the word.

In Fig. 1, the upward arrow reflects the aforementioned remarks. It forms the crucial aspect for a *learning* policy: The concept of structural regularities is

[23] Cf. Whaples (1995), p. 139.

dynamically open in the sense that the facts—and thus the justification for certain policy measures—have to be regularly checked against the latest empirical studies. This means that always if new studies emerge, the question whether a scientific consensus exists or not has to be raised anew. As a result, 'knowledge' becomes a variable entity: 'Facts' which have been considered secure knowledge in the past might be rendered unreliable if new pieces of information emerge, and new knowledge can be identified which has not been available so far. Given that the process of the generation of stylised facts is institutionalised and will be performed in regular intervals, politicians' learning about the topics they have to decide upon will thus be institutionalised as well.

Of course, at the end politicians will still decide on the final actions, for which they have to take full responsibility. They are elected to do so. Indeed, politicians have to take into account more aspects than just the narrow perspective that scientific experts have on a certain topic. And yet, the openness of the process described above guarantees that it becomes publicly visible when politicians' actions run against an existing consensus among experts or when measures are taken without a sound scientific base. Hypotheses on which no sufficient scientific consensus emerges are not well suited to guide economic policy, and if politicians do take actions on dubious premises without having proper reasons, the costs of bad decision-making would become plainly visible.

## 5. Learning innovation policy based on the invariant pattern on knowledge networks

We will now illustrate our concept of learning innovation policy by giving an example of a structural regularity that has been identified in the way described above.[24] This example describes a pattern of innovation and technological change from which policy implications can be derived. We chose this particular example as it hints at the way a socio-economic system could contribute to the growth-enhancing processes that include innovation and technological change. It is thus particularly closely related to the analysis of socio-economic systems above (especially in Sections 3 and 4):

> 'The maintenance of already existing growth paths by many small innovations is favoured by knowledge networks. No general statement can be derived for the optimal spatial size of these networks.' (Schwerin, 2001, p. 174, own translation)

Here, knowledge networks means systems of information exchange between economic, political and social agents in a sector-specific context. 'Maintenance' implies that a sector has already emerged by means of one or a few basic

[24] This structural regularity was identified in the context of an analysis of general patterns of innovation and growth; cf. Schwerin (2001), pp. 266ff.

innovations, and the focus is now on the growth path in later stages in the industry's life cycle.

As a consequence, this structural regularity addresses an important aspect with regard to innovation and change: the mechanisms of knowledge diffusion.[25] All fifteen experts[26] who analyse these kinds of diffusion mechanisms within the assessed period support the hypothesis that networks are a main reason for the continuation of an already existing higher growth rate on the aggregate level, because the accumulation of knowledge and the interaction between agents within these networks induces a series of incremental innovations, which raises the rate of technological and organisational progress on the sectoral level.

The experts especially highlight that these networks consist not only of highly qualified staff but also of all persons that are involved in the production processes.[27] They only differ with regard to the geographical delineation. Five researchers[28] stress the importance of regional networks, whereas eight researchers[29] regard international connections as crucial (two experts[30] consider networks to be generally growth-enhancing). As a general consensus with regard to the importance of knowledge networks according to the Whaples criterion has been reached, the criterion of whether this fact is generated by different methods of analysis must be checked. As the hypothesis is tested not only by growth accounting but also by patent analyses and case studies of different industries and regions, this criterion is fulfilled.

It is intriguing that only knowledge networks but not other kinds of networks are considered as important. For example, Kim concludes that traffic networks have no significant impact on economic growth.[31] Moreover, it is apparent that knowledge networks are analysed much more often in the actual literature than traditional input–output-relationships, so-called linkages. Although the two experts[32] who say something about linkages conclude that these kinds of interactions between leading sectors and other sectors are growth enhancing, these two studies are not enough to formulate a stylised fact. While this result is in part due to the fact that the only recent research was used as a basis for the analysis, whereas most research on linkages dates from earlier decades, this demonstrates that the criteria to gain a stylised fact are very strict. It follows that the knowledge basis on which learning policy would rely is gained in a very cautious and conservative way. Moreover, it is

---

[25] See also Mokyr (1992), p. 327.

[26] Berg and Hudson (1992), Chuang (1996), Collins and Bosworth (1996), Cookson (1994), Crafts (1995), Griffiths et al. (1992), Khan and Sokoloff (1993), Lall (1992), Langlois (1992) and MacLeod (1992). The structural regularity was based on all cliometric (i.e. quantitative historical) studies published between 1988 and 1997; cf. Schwerin (2001), pp. 133ff, for a detailed justification.

[27] Cf. Sokoloff and Khan (1990), as well as Cookson (1994).

[28] Berg and Hudson (1992) and Cookson (1994) as well as Khan and Sokoloff (1993).

[29] Chuang (1996), Collins and Bosworth (1996), Griffiths et al. (1992) and Lall (1992) as well as Langlois (1992).

[30] Crafts (1995) and MacLeod 1992).

[31] See Kim (1995), p. 885.

[32] Altman (1988) and Cookson (1994).

historically open in the sense that new scientific evidence can be integrated at once: if new studies emerge, they are immediately accessible to bibliometric analysis and will be included into the process of generating the structural regularities. Therefore, all requirements we have formulated above for enabling the emergence of a learning economic policy are fulfilled.

The regularity on knowledge networks provides a basis for a learning innovation policy. The knowledge diffusion via knowledge networks can be supported by a number of policy measures. Especially measures that lead to a better connection between highly qualified and all other persons involved in production processes, together with a better integration of firms into the knowledge networks, look promising. An important feature of learning innovation policy in this context is that it should not be selective by e.g. only supporting networks in biotechnology. This non-selectivity is important, because the invariant pattern of knowledge networks does not remove the fact that there is still a stochastic element in socio-economic change. The requirement for non-selectivity does not only hold with respect to the sectoral but also the spatial dimension, as the regularity on knowledge networks does not give a clear hint on the spatial scope of successful networks. Generally speaking, learning innovation policy that targets knowledge networks has the best overall chance of success if it is not selective with respect to sectoral or spatial dimensions.

Concrete measures to support the emergence and functioning of knowledge networks can be built on the existing ones, but need to be adapted. The major difference is that they would be non-selective. For example, the provision of information on research and production of technology oriented firms in publicly funded databases leads to better networking.[33] The characteristics of databases make it easy for the users to exclude sectors or regions as well as technological and organisational solutions they are not interested in. This means that if the firms knew well how to search in databases, it is not a problem that the databases contain a great amount of information, a large share of which would not be relevant to the individual user. Moreover, the organisation and financing of workshops for entrepreneurs or conferences on specific topics opens new information channels. Here, intersectoral knowledge networks with contributions from practitioners, scientists and policy makers are usually especially productive. This is also indicated by historical analyses of extremely fast growing industries that point out the importance of intersectoral knowledge networks with participants from different backgrounds.[34]

## 6. Chances and limits of learning innovation policy

As observed before, a number of critical points are often raised in the context of devising a framework for policy making. While Hayek's statement that knowledge is

[33] Cf. Werker (2000), p. 164f.

[34] See Schwerin (1998),especially pp. 14ff.

gained in markets and that individual agents have better knowledge than policy makers to a large extent holds (cf. Section 3), we also need to acknowledge that knowledge is also accumulated within other relationships, such as co-operative or corporate relationships. This especially holds true if the exchange between the agents is carried out during a long period of time and the uncertainty involved leads to an inability to sufficiently specify the contracts in advance. Both of this is usually the case in the context of innovation and technological change. As innovation can lead to surprises by being advantageous for one partner and disadvantageous for another, the future reward of the exchange can be at stake for one party.[35] What is even more important is that the storage, transfer, and use of knowledge often crucially depend on the functioning of specific relationships.[36] A policy that stimulates a variety of relationships between individuals—as the one suggested here, which is a result of the structural regularity on knowledge networks—will in general improve this storage, transfer, and use of knowledge.

A second critique of policy that is closely connected with the first one is that private investment in R&D is better than public investment, because the more advantageous incentive structure.[37] Whereas private investors have to take their risks themselves, public investment may lead to a waste of taxpayers' money. One can object against this that, due to the high private risks of investing in R&D without having always the possibility to appropriate the profits, R&D should at least partly be financed publicly, because otherwise there would not be enough R&D from the point of view of social welfare. Moreover, it can be sensible for the government to finance costly and risky projects if the taxpayer is rewarded appropriately in case of success.

One example particularly well shows how this could work. One-third of the private profits made in projects financed by the German Research Society[38] has to be paid back and the remaining two thirds have to be used for further research up to the sum that was originally received.[39] If the two thirds cannot be used for research purposes they have to be paid back as well. One could even go a step further and ask for a share of the private profits that go beyond this publicly financed sum to compensate for the projects that are not successful or that do not make any private profits. If one follows our suggestions above, it becomes very unlikely that taxpayers' money is wasted, because technological and organisational solutions are not chosen ex ante. Although policy supports network creation, the participants in these networks still have to spend their own resources and have to take some of the risks involved.

Still, every policy can fail as well as any individual action. Consequently, the above suggested measures taken within the framework of learning innovation policy can fail, too.[40] And yet, these failures have the advantage that they are in themselves an

[35] Cf. Chesbrough and Teece (1996) p. 66.
[36] Cf. Werker (2001).
[37] Cf. Hanusch and Cantner (1993).
[38] The German Research Society is called ''Deutsche Forschungsgemeinschaft' (DFG).
[39] See for this and the following sentence DFG (2001), IV.3.
[40] See Metcalfe and Georghiou (1997), p. 25.

element of learning policy, because they contribute to the stock of historical experience. However, this only holds if every policy measure is evaluated independently. The aim of the evaluation is to find out whether the policy measure influences the right group of economic actors according to the aims of the policy, e.g. to identify intended and unintended effects of the measure.[41] Moreover, the evaluation contains an efficiency control as regards the implementation of the policy measures. Evaluation may accompany each measure or may be executed ex post. In order to learn about policy failures as soon as possible, an accompanying evaluation would be advisable.

In any case, structural regularities—as the one described in greater detail above—can only give hints in which areas policy measures could be promising. Therefore, evaluation is indispensable. Unfortunately, today only some policy measures are evaluated. In order to gain an exact information basis whether and how concrete measures function, it would be necessary to evaluate every single one independently. The results of policy evaluation could then provide a powerful basis for future decisions. If innovation policy is performed as a learning policy, even failures may be a part of its success. In this case, the main requirement of successful innovation policy is not to be without any failures, but to identify these failures as soon as possible, to avoid them in the future, and to store them into the policy knowledge stock.[42]

## 7. Conclusions

As innovation is a crucial driving force of change in socio-economic systems, we focussed our attention on this issue and tried to develop a framework for a learning innovation policy that is in line with the dynamics of its object. However, our proposed concept can easily be generalised, as became clear from the discussion of the sequence of steps in Fig. 1. Therefore, it can be applied to many other fields as well—in fact all fields for which a sufficiently large set of relevant scientific studies exists. Moreover, these topics need not be confined to very rapidly evolving parts of economic life. Learning innovation policy addresses very fast changing parts of socio-economic systems, but it would also be possible to apply our approach to more slowly evolving parts as well.

In any of these contexts, a practical application of the concept of learning policy raises important question that merit further discussion. For instance, what would boards of advisors exactly look like, i.e. who would participate, chosen by whom, responsible to whom? How often would new scientific findings have to be assessed by checking the new literature and then revising the set of structural regularities? While there is no ex ante valid answer to these questions, we primarily aimed at

[41] Cf. Kuhlmann (1992), p. 125.
[42] Cf. Lipsey and Carlaw (1996), p. 269.

demonstrating that the concept as such would already constitute progress in itself. This seems to be confirmed by the above analysis.

As regards the field of innovation policy, we have tried to derive an approach towards a learning policy that reflects the dynamically changing nature of socio-economic systems and that is based on a critique of so far existing reactive and interventionist policies. It is of utmost importance that such a conduct of policy is active and not merely reactive. Moreover, learning innovation policy differs from standard innovation policy in the sense that it is not concerned with specific single measures. Rather, it uses insights into the general functioning of socio-economic systems as a guideline for policy making. In addition, a part of learning innovation policy is its likelihood of failure. Policy failures as such are not problematic in the context of learning policy. However, it is important to detect policy failures as soon as possible and to learn from them for future measures.

To achieve this objective, the performance of economic policy has to be evaluated according to whether this policy is intelligent in the sense that learning from past experience takes place. It is a question still to be investigated in greater detail which meta-mechanisms might be introduced to make ‘unintelligent’ political behaviour, i.e. the neglect of learning, costly for political agents and thus avoidable. In this context, the incentives for the policy makers and their supporting scientific boards—as well as any effects resulting thereof—have to be analysed very carefully. The reason for this is that a suitable incentive structure should be provided, which could lead to behaviour of policy makers that is consistent with the tasks of policy.

We are fully aware of the fact that boards of advisors already exist in many fields of policy. However, we feel that the working mechanisms of these boards usually leave too much room for discretionary political decisions, in the sense that the advice given by these boards can be interpreted in whatever sense politicians currently want when they take their decisions. Consequently, already existing boards may use the concept of invariant patterns, but the crucial aspect is that we see the necessity to tighten the procedures within these boards, so that it can be checked whether unambiguous results can emerge or not. If not, there can be no scientifically accepted guideline for policy. Our approach especially aims at such a consensus, but at the same time respects the role of dissensus as the driver of scientific progress and, subsequently, improvements in the conduct of policy.

## References

M. Altman, 1988. Railways as an Engine of Economic Growth? Who Benefited from the Canadian Railway Boom, 1870–1910?, Histoire Sociale—Social History. 21: 269–281.

Berg, M., Hudson, P., 1992. Rehabilitating the industrial revolution. Economic History Review 45, 24–50.

Chesbrough, H.W., Teece, D.J., 1996. When is virtual virtuous? Harvard Business Review 74, 65–73.

Chuang, Y.-C., 1996. Identifying the sources of growth in Taiwan’s manufacturing industry. Journal of Development Studies 32, 445–463.

Collins, S.M., Bosworth, B.P., 1996. Economic Growth in East Asia: Accumulation versus Assimilation, Brookings Papers on Economic Activity. 135–203.

Cookson, G., 1994. Innovation, diffusion, and mechanical engineers in Britain, 1780–1850. Economic History Review 47, 749–753.

Crafts, N.F.R., 1995. Exogenous or endogenous growth? The industrial revolution reconsidered. Journal of Economic History 55, 745–772.

DFG (Deutsche Forschungsgemeinschaft), 2001. Sachbeihilfen. Merkblatt und Leitfaden für die Antragstellung, available from http//:www.dfg.de/foerder/formulare/1_02.htm.

Fulda, E., Lehmann-Waffenschmidt, M., Schwerin, J., 1998. Zwischen zufall und notwendigkeit-zur kontingenz ökonomischer prozesse aus theoretischer und historischer sicht. In: Wegner, G., Wieland, J. (Eds.), Formelle und informelle Institutionen-Genese. Interaktion und Wandel, Marburg (Metropolis Verlag), pp. 327–377.

Griffiths, T., Hunt, P.A., O'Brien, P.K., 1992. Inventive activity in the British textile industry, 1700–1800. Journal of Economic History 52, 881–906.

Grupp, H., 1997. Messung und Erklärung des technischen Wandels. Grundzüge Einer Empirischen Innovationsökonomik. Verlag, Berlin, Heidelberg.

Hanusch, H., Cantner, U., 1993. Neuere ansätze in der innovationstheorie und der theorie des technischen Wandels-Konsequenzen für eine industrie- und technologiepolitik. In: Meyer-Krahmer, F. (Ed.), Innovationsökonomie und Technologiepolitik. Forschungsansätze und Politische Konsequenzen. Physica-Verlag, Heidelberg.

Khan, B.Z., Sokoloff, K.L., 1993. Schemes of practical utility: entrepreneurship and innovation among, great inventors in the United States, 1790–1865. Journal of Economic History 53, 289–307.

Kim, S., 1995. Expansion of markets and the geographic distribution of economic activities: the trends in US regional manufacturing structure, 1860–1987. Quarterly Journal of Economics 110, 881–908.

Kline, S.J., Rosenberg, N., 1986. An overview of innovation. In: Ralph, L., Rosenberg, N. (Eds.), The Positive Sum Strategy. Harnessing Technology for Economic Growth. National Academy Press, Washington DC.

Kuhlmann, S., 1992. Evaluation von technologiepolitik: zur analyse der wirksamkeit politischer techniksteuerung. In: Grimmer, K., et al. (Eds.), Politische Techniksteuerung. Schriften des Instituts Arbeit und Technik, Bd. 5. Leske und Budrich, Opladen, pp. 119–135.

Lall, S., 1992. Technological capabilities and industrialization. World Development 20, 165–185.

Langlois, N., 1992. External economies and economic progress: the case of the microcomputer industry. Business History Review 66, 1–50.

Lipsey, R.G., Carlaw, K., 1996. A structuralist view of innovation policy. In: Howitt, P. (Ed.), The Implications of Knowledge-Based Growth for Micro-Economic Policies. University of Calgary Press, Calgary, pp. 255–333.

Luhmann, N., 1975. Soziologische Aufklärung 2. Westdeutscher Verlag, Opladen.

Luhmann, N., 1995. Social Systems. Stanford University Press, Stanford, CA, USA.

Lundvall, B.-A., 1992. User-producer relationships, national systems of innovation and internationalisation. In: Lundvall, B.-A. (Ed.), National Systems of Innovation and Interactive Learning. Pinter Publishers, London, pp. 45–67.

MacLeod, C., 1992. Strategies for innovation: the diffusion of new technology in nineteenth-century British industry. Economic History Review 45, 285–307.

Metcalfe, S.J., 1995. The economic foundations of technology policy: equilibrium and evolutionary perspectives. In: Stoneman, P. (Ed.), Handbook of the Economics of Innovation and Technological Change. Blackwell, Oxford and Cambridge, MA, USA.

Metcalfe, S.J., 1997. Technology systems and technology policy in an evolutionary framework. In: Archibugi, D., Michie, J. (Eds.), Technology, Globalization and Economic Performance. The Syndicate of the University of Cambridge Press, Cambridge (NY), US.

Metcalfe, J.S., Georghiou, L., 1997. Equilibrium and Evolutionary Foundations of Technology Policy. CRIC Discussion Paper No. 3, The University of Manchester, Manchester: mimeo.

Mokyr, J., 1992. Technological inertia in economic history. Journal of Economic History 52, 325–338.

Nelson, R. R.m Winter, S.G., 1982. An Evolutionary Theory of Economic Change, The Belkanp Press of Harvard University, Cambridge MA US and London.

North, D.C., 1990. Institutions, Institutional Change and Economic Performance. Cambridge University Press, Cambridge (MA).

Schmidt, I., 1996. Wettbewerbspolitik und Kartellrecht. Lucius and Lucius, Stuttgart.
Schmookler, J., 1966. Invention and Economic Growth. Harvard University Press, Cambridge MA.
Schumpeter, J.A., 1911/1987. Theorie der wirtschaftlichen Entwicklung: Eine Untersuchung über Unternehmergewinn, Kapital, Kredit, Zins und den Konjunkturzyklus. Berlin: Duncker and Humblot, seventh ed., published first in 1911, unchanged reprint of the fourth ed. of 1934.
Schwerin, J., 1998. Innovation and Growth in Shipbuilding on the Clyde, c. 1860–1900: Some First Evidence. Working Paper, London School of Economics and Political Science, London: mimeo.
Schwerin, J., 2001. Wachstumsdynamik in Transformationsökonomien. Strukturähnlichkeiten seit der Industriellen Revolution und ihre Bedeutung für Theorie und Politik. Köln, Weimar, Wien, Böhlau.
Sokoloff, K.L., Khan, Z.B., 1990. The democratization of invention during early industrialization: evidence from the United States, 1790–1846. Journal of Economic History 50, 363–378.
Steinmueller, W.E., 1994. Basic research and industrial innovation. In: Dogson, M., Rothwell, R. (Eds.), The Handbook of Industrial Innovation. Edward Elgar, Aldershot, Brookfield VT, USA, pp. 54–66.
Teubal, M., 1997. A catalytic and evolutionary approach to horizontal technology policies (HTPs). Research Policy 25, 1161–1188.
von Hayek, F.A., 1945. The use of knowledge in society. American Economic Review 35, 519–530.
Werker, C., 2000. Marktchancen innovativer Unternehmen aus Transformationsländern. Duncker und Humblot, Berlin.
Werker, C., 2001. Knowledge and organization strategies in innovation systems. International Journal of Innovation Management 5 (1), 105–127.
Whaples, R., 1995. Where is there consensus among American economic historians? The results of a survey on forty propositions. Journal of Economic History 55, 139–154.
Willke, H., 1991. Systemtheorie. Gustav Fischer Verlag, Jena and Stuttgart.