THE TOWER OF BABEL? THE INNOVATION SYSTEM APPROACH VERSUS MAINSTREAM ECONOMICS.

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Summary

The Innovation systems (IS) approach and the system failures it identifies, play an important role in the design and legitimization of innovation policy. This paper analyses the usefulness of this concept. We conclude that the IS-approach can be useful to visualize the complexity of the innovation processes. However, for policy design this approach is less suited, because system failures aim at symptoms in stead of underlying incentive structures. In our view, policy design should be based on standard economic framework of market- and government failures. Theoretically, an exception is the system failure path dependency. However, the empirical evidence for the existence of this phenomenon is mixed. Furthermore, policy initiatives to tackle path dependence are likely to be subject to severe government failure.

JEL: B52, 038

Key words: Innovation policy, Innovation systems, market failure.

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1. Introduction

In the legitimization and design of innovation policy there seems to be a sort of Babel-like confusion. On the one hand, mainstream economics point to a mix of market and government (regulation) failures, whereas the innovation system (SI) approach, mainly used by innovation policy makers, emphasize system failures as an additional reason to intervene. The distinction between market and system failures is confusing, especially if one considers the system as the sum of market and government. We try to clarify this confusion by anatomizing both concepts and analyzing the differences. The goal of this exercise is to explore to what extent the innovation system approach and mainstream economics are complements or substitutes. Firstly, we shortly describe the toolkit of mainstream economics. Next, we describe the SI approach. Then, we evaluate whether the system approach and its policy recommendations are complementary to the analyses and policy conclusions of mainstream economics. Finally, we draw conclusions.

2. Mainstream economics

Mainstream economics starts by analyzing the function of markets through identifying *market failures*, which lead to suboptimal outcomes for the society as a whole (Stiglitz, 2000). External effects, information failures, market power and incomplete markets may cause too less (knowledge) or too much production (pollution). These market failures could justify government intervention with instruments like subsidies, taxes, regulation or public production of goods. However, the effectiveness of these instruments depends on the occurrence of *government failure*. Limited information, limited control over private responses, limited control over bureaucracy and the influence of lobbying, can reduce the effectiveness of policy intervention. Further, policymakers have to take into account that the financing of policy initiatives require distortionary taxation.

As a short illustration of the economic approach we take public support to R&D. Theoretical and empirical literature point to both negative and positive external effects of R&D (Jacobs et al, 2001). Firstly, insufficient market power may limit the ability of a firm to internalize all benefits of innovation or knowledge accumulation (rent spillovers). Furthermore, the mobility of researchers and the inability to keep innovations in new products a secret for competitors create knowledge spillovers (Jaffe, 1996). Also, negative spillovers might occur because an innovation may reduce the profits of competitors. On average, empirical evidence points to positive spillovers. Policy aimed at closing the gap between social and private returns could increase welfare. In addition to external effects, imperfect information, network effects and market power of incumbent firms may justify policy intervention as well. These market failures may decelerate the diffusion of knowledge, although this is (partly) offset by the monopoly rents of early adopters of new technologies (CPB, 2002a).

However, *government failure* reduces the effectiveness of public policy. The effectiveness of public support for specific technologies or sectors in particular is doubtful, because the government usually has limited information about social and private returns, future technological developments and comparative advantages. Also, rent seeking and high transaction costs increase the risks of government failure. CPB (2002a) concludes that the government should interfere when market failures are most severe and when the risk of government failure is small. Moreover, a strong policy focus on technology is not completely clear from a welfare point of view. For example, the present comparative advantages of the Netherlands probably lie in other sectors (Boone et al, 2002). Trying to influence these comparative advantages in the direction of new technology is a risky business. Baldwin and Robert-Nicoud (2002) argue that the government will generally pick losers, because losers need to lobby to survive, whereas winners do not.

To conclude, policy solutions to address market failures are not without risk due to government failure. Unfortunately, the empirical evidence of the effectiveness of public programs is rare. This pleads for building evaluation mechanism into program designs. Jaffe (2002) suggests that this requires either partial randomization of the grant process or recording the rankings used in the grant evaluation.

3. The Innovation System Approach

In the design of innovation policy is the key concept the Dynamic Innovation System approach. Innovation is not seen as a step-by-step process in which R&D activities automatically lead to innovation and commercialization of new products (linear system), but as a complex, interactive, and interdependent process of all organizations and subjects (dynamic system). The output of the system depends on the complex set of relationships among actors producing, distributing and applying various kinds of knowledge (OECD, 1997). The concept of innovation systems is related to Evolutionary Economics. In both theories, individual and organizational behavior result not only from relative prices changes, but from routines and habits as well (Nelson and Winter, 2002).

In an innovation system different types of system failures occur. Bemer et al (2001) identify seven sources of market failures and three additional system failures. In this section we focus on the latter type of failure: too much or too little interaction, path dependency and lock-in, missing or inadequate institutions.[1]

The first system failure is a suboptimal degree of interaction. Bemer et al (2001) mention insufficient interaction between firms and public knowledge institutes as an example. Firms do not innovate in isolation, but innovation is an outcome of interactions among firms and between firms and public knowledge institutes (Nelson, 1994; Lundvall, 1988). In an innovation system learning processes are crucial for the innovative performance of the system (Edquist, 2001).

[1] Somewhat confusing is that the description of system failures differs in the literature. For example Smith (1996) distinguish three system failures (provision of infrastructure, transition and lock-in). Malerba (1996) points to five system failures (learning failure, exploitation-exploration trade off, variety-selection trade-off, appropriability traps, complementarities failures). Edquist (2001) suggests that market failures are irrelevant in a system approach. He

Hence, insufficient interaction leads to suboptimal learning and too little transfer of knowledge in the system. Bemer et al (2001) argue that the government should stimulate interaction by acting as a knowledge broker, distributing information (cluster studies, technology roadmaps) and stimulating joint research projects and networks. Too much interaction can also occur if too frequent contacts between private agents lead to habit formation (collusion) which delays innovative efforts.[2] More intensive competition policy and another design of contracting out methods could address this failure.

A second system failure is missing or inadequate institutions. Institutions are supposed to influence the development and diffusion of new technologies and knowledge. Therefore missing or inadequate institutions break the chain of interactions in the innovation system. The literature gives examples like the absence of certain knowledge institutions or insufficient demand for new innovative products. The IS-approach points to the creating these institutions and stimulating (high-tech) starters (creating demand) as policy solutions for these problems.

The third category of system failures are path dependency and lock-in. Path dependence is adopted from evolutionary economics, which states that agents decide on the basis of past experience because of high transaction costs or lack of information (Metcalfe, 1995; Nelson and Winter, 2002). These rules of thumbs are relatively insensitive to small changes in relative prices. Since firms find it difficult to evolve beyond a particular scientific and technological paradigm, they get locked-in in existing technologies. As a consequence, production specialization patterns adjust slowly (Edquist, 2001). Edquist argues that policy should intervene in an early stage of the emergence of new technological systems by stimulating shifts into new technologies.

4. Innovation system and mainstream economics: complements or substitutes?

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recognizes four system failures; missing functions, organizations and institutions and a lack of interaction in the innovation system.

[2] This problem is less often mentioned in the literature and policy documents. For example, in the ministry of Economic Affairs (2003) the focus is on too little interaction in the assessment of bottlenecks in the innovation system and not on too much interaction.

In this section, we analyze the system failures described above with the mainstream economic toolkit. Our main aim is to establish whether the system approach and the corresponding problems are additional to or overlapping with the market failures of mainstream economics.

Interaction

The first system failure, too little interaction, causes suboptimal knowledge transfer and diffusion. Two remarks need to be made. In the first place, it is not clear what would be the optimal level of interaction; is more interaction always better? And if one accepts that interaction is “too” low, then why is it too low? Economics provide more understanding of this kind of problems. Market failures such as imperfect information, high transaction costs and market power can cause a suboptimal level of interaction (transactions), and hence slow diffusion of knowledge. A first potential candidate to explain the lack of interaction is information problem. High transaction costs, search costs or uncertainty about future development can prevent (rational) firms from investing in profitable innovations or from investigating or adopting alternative technologies. This implies that low interaction is the result of a cost-benefit analysis by the firm, which indicates that transaction costs are larger than the potential gains of adopting new technologies. Secondly, market power diminishes the need for firms to adopt new knowledge. Hence, if the need to stay ahead of competitors is absent, firms will make insufficient use of available (public) knowledge (Bartelsman & Hinloopen, 2002).

Bemer et al (2001) point to the inadequate interaction between public research institutes and the private sector as a system failure. Again, our first question is: what is the optimal degree of interaction? Then, from an economic point of view, two responses are possible. First, it depends on the aim of government whether this is a problem. If the aim is to stimulate fundamental research in universities because of the positive external effects, interaction with firms may give researchers incentives to avoid fundamental research. Interaction may then even be undesirable

(CPB, 2002a). Hence, in the case of universities, incentives should be directed towards scientific quality. Second, if the aim is to enhance the applicability of fundamental research by intermediary institutes for applied research, the question remains why existing firms and institutes for applied research do not interact. In the case of firms, this may be due to insufficient incentives as a result of market power, as explained above. On the supply side, there might be a principal-agent problem if government does not succeed in giving applied research institutes (the agent) sufficiently high-powered incentives to interact with its customers. To conclude, it seems that in these cases, the system failure of too little interaction is a symptom of underlying market or government failures.

Missing or inadequate institutions.

This system failure seems to be a somewhat broad set of different problems. Both the nature and the solutions to these problems differ. Bemer et al (2001) mention, among others, the following examples: insufficient supply of venture capital, inadequate resources for (high-tech) starters, insufficient demand for new innovations and the absence of certain knowledge institutions. Once more, we ask ourselves how the IS-approach determines if something is insufficient or inadequate operational from a welfare point of view. Despite this main critique, we will shortly discuss the above mentioned examples in order to asses the similarities or differences between the IS-approach an the economic approach.

Insufficient supply of venture capital and missing or inadequate facilities for starters is supposed to reduce the adoption of innovations. Hall (2002) argues that starters can theoretically face higher financing costs. Starters have to search for external financing, whereas established firms can rely on internal financing. In the case of financing R&D, standard market failures (asymmetric information, moral hazard) and government failure (tax considerations) could drive a wedge between internal and external financing favoring existing large firms. However, the market also provides solutions to these market failures. Venture capitalists are normally well-informed and monitor their investment quite intensively, which reduces information asymmetries and the risk of moral hazard. Furthermore, a low degree of supply of venture capital can also be an efficient market outcome if there are no profitable investment opportunities. In retrospect, the amount of (venture) capital supplied to dot-com firms at the end of the 90's was probably higher than socially optimal. Hence, an apparently insufficient supply of capital does not always indicate a failure in the innovation system.

According to the IS-approach, suboptimal diffusion of knowledge can also be caused by *insufficient innovative demanders*. However, it is difficult to imagine why agents in existing organizations and firms have no incentives to adopt new technologies. Again, a market failure explaining "insufficient" innovative demand is market power. For example, Baily (2001) suggests that in the U.S., competition has been a major reason for the existence of high demand for innovations. However, slow adoption of new technologies can also be the result of market forces. For example, Manuelli and Seshadri (2003) conclude that the slow transformation from horses to tractors in U.S. agriculture in the 1940s can simply be explained by the fact that a more intensive use of tractors was not cost effective. Instead of purchasing a new expensive tractor, farmers bought a (cheaper) conversion kit to transform their car into a "tractor", despite attempts of Ford to forbid the sale of these conversion kits by Ford dealers (Kline and Pinch, 1996). Another market failure which might explain apparently insufficient innovative demand is network externality; the resulting coordination problem induces prohibitively high switching costs for the individual firm (see path dependency).

Missing research institutes are supposed to hamper the transfer of scientific research to the market. However, the relevant question is; if profitable opportunities exist for applied research or for the conversion of the outcome of fundamental research to marketable products and processes, then why are those not seized by public or private research organizations? Again, market failures point to insufficient incentives on the demand side (competition) or – in the case of public institutes for applied research – to government failure on the supply side (principal agent problem).

Hence, in most cases, the system failure of missing or inadequate institutions is no more than a symptom of underlying incentive problems caused by market failure.

Path dependence and lock-in.

Path dependence and lock-in, as interpreted by Edquist (2001), differ most fundamentally from mainstream economics. Liebowitz and Margolis (1995) distinguish three types of path dependence. First-degree path dependence occurs if initial actions lead to a path that cannot be left without some costs, but given the transaction costs, this path is efficient and agents are rational. Second-degree path dependence implies that decisions are based on imperfect information. As a result, ex-post a different path is superior to the chosen one, but ex ante, given the information constraint, agents act rational. Both first-degree and second-degree path dependence are commonplace in mainstream economics. Third-degree path dependence, the relevant one in the innovation literature, states that ex-ante the chosen path is suboptimal. This means that given the available information more efficient paths are available. This implies that irremediable errors occur, so third-degree path dependence conflicts with neo classical economics. However, Liebowitz and Margolis (1995) show this form of failure requires important restrictions on prices, institutions and foresight. This makes it very difficult to establish the theoretical case. Furthermore, the evidence of the empirical relevance of third-degree path dependence is not very strong.3 Bemer et al (2001) also mention lock-in as a systemic failure. We follow Margolis and Liebowitz (1995), who show that lock-in is the outcome of path dependence.

The general conclusion of the analysis of the system approach from the point of view of mainstream economics is that system failures are not complementary to market and government

[3] The SI-literature as well as the economic literature (David, 1985) document some well known examples of path dependence such as QWERTY and VHS. However, Liebowitz and Margolis (1995) claim that most examples are in fact first degree or second-degree path dependence. Convincing examples of sustainable remediable errors of market activities (third-degree path dependence) is rare. For example, they argue that in the case of the QWERTY-keyboard alternative keyboards are not really superior (Liebowitz and Margolis, 1990).

failure. Rather, system failures are caused by underlying incentive problems, which can be traced back to market or government failures. From an analytic point of view the system approach has little added value.

5. Policy implications

From the point of view of the policy maker analytical differences between the innovation system approach and mainstream economics is not a problem as long as policy recommendations do not differ. However, policy recommendations do differ. First and foremost, this is caused by the fact that the system approach does not analyze the underlying causes of problems. Secondly, the possibility of government failure is neglected. We illustrate this by comparing some policy recommendations.

Policy measures to increase interaction and innovative demand by stimulating networks, information brokerage, public consultancy and cluster studies directed at solving information problems stem from the system approach. However, if the problem is caused by market power of firms these measures are not likely to be very effective. For example, if the government stimulates cooperation between firms the market failure is even enlarged if market power is the problem. In addition, the scope for the government to solve information problems is limited as government agencies suffer from information problems themselves. As a result, efforts aiming to create formal knowledge networks are ineffective (CPB, 2002b). Moreover, the market addresses these problems by cooperation between firms and commercial knowledge brokers. Hence, government intervention in the form of public consultancy might even replace more efficient private initiatives.

The present policy to address inadequate interaction between research institutes and private sector is often to use specific subsidies to correct and stimulate the behavior of institutes.

However, the AWT (1999) doubts the effectiveness of this instrument, because institutions will spend time in rent-seeking. In addition, if the problem is caused by agency problems in the financing of these public research institutes, the solution lies in rethinking incentives in the financing rules of these institutes.

Insufficient supply of venture capital and missing or inadequate facilities for starters is tackled by supplying starters with public venture capital and public consultancy. As discussed above, an apparent lack of (venture) capital can be efficient; stimulating venture capital supply will then result in welfare loss, because relative prices are disturbed which leads to sub-optimal allocation of production factors. In this case, the superior policy is ‘hands-off’. Moreover, it is not clear why public supply of venture capital is superior to private supply.

The creation of new public-private research institutes is supposed to stimulate the transfer of scientific research to the market. However, as discussed before, it is likely that if a problem exists, it is caused by lack of competitive pressure and/or government failure in the financing schemes of existing public institutes for applied research. In addition, the AWT (1999) states that the private sector has enough incentives to perform applied research. The government should focus on fundamental research, especially since firms increasingly shift their R&D activities from fundamental to applied research (CPB, 2002a). Introducing new public-private research institutes, given the supply of researchers, has the risk of crowding out present (fundamental) research activities.

Finally, the existence of third-degree path dependence might justify government intervention aiming at technological transition. However, the evidence for the existence of third-degree path dependence is mixed. In addition, policies aiming to address this failure are likely to be subject to severe government failure. Firstly, the government should be able to forecast the developments of new technologies and future comparative advantages, since relative productivity levels rather than absolute productivity levels matter in an open economy. Secondly, Baldwin en Robert-Nicoud (2002) point to the risk of lobbying. They argue that the risk of picking losers is substantial, because losers need to lobby to survive, whereas winners do not. Thirdly, a switch to another technology will be accompanied by severe international coordination problems.4 High transaction costs increase the risks of government failure and the ineffectiveness of specific innovation policy. To conclude, it is very doubtful whether public policy is able to address (third-degree) path dependence in an effective manner.

6. Conclusions.

The system innovation approach has contributed in two ways to the policy debate. Firstly, this approach can be a useful concept to visualize the complexity of the innovation process. Secondly, the IS-approach points deservedly to path dependency as a potential source for government intervention. However, with the possible exception of third-degree path dependency, we do not see any additional insights of the system approach to guide innovation policy. This approach primarily serves to detect bottlenecks in this process. Yet, a clear analytical framework to analyze the behavior of agents is missing in this theory. Hence, to what extent these problems are the result of the incentives of different agents is less clear. Policy design on the outcomes of the system approach leads to recommendations aimed at symptoms rather than underlying incentive structures (examples are public consultancy, information brokerage, the creation of new research institutes and formal networks). These recommendations are likely to be ineffective and risk replacing more efficient private initiatives. In our view, innovation policy should use the standard mainstream economics toolkit for designing effective innovation policy solutions. As mentioned previously, the possible exception might be (third-degree) path dependence. However, the empirical evidence for the

[4] For example, a switch from gasoline to hydrogen driven cars requires severe international coordination, because a simultaneous transformation of filling station at the international level is necessary (one should also be able to refuel

existence of this phenomenon is mixed. Furthermore, policy initiatives to tackle path dependence are likely to be subject to severe government failure.

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