A New Look at Innovation Policy: Twelve Recommendations

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1 Stage 1. Traditional Industrial Policy

Although industry as we know it emerged in the late nineteenth century it was only in the early twentieth century that politicians started to see it as a subject that could benefit from state intervention. In contrast, agricultural policy is as old as agriculture itself. Early Greek mathematicians such as Pythagoras were driven by the need to accurately define the borders between the lands of different owners. Charlemagne introduced the 'three-tier system' in which plots of agricultural land were divided in three parts, each of which followed a rotating programme of growing crops. This system raised productivity and was the basis for later improvements. It may be the earliest instance of state intervention in economic activity except for taxes and general legislation.

Traditional industrial policy, as it emerged especially after World War I, was based on four pillars:

- Protection of the national industry by import barriers, government procurement and subsidies;
- The establishment of institutes for applied R&D from which industry and agriculture would benefit;
- Expansion of technical education at all levels;
- Establishment of extension services—intermediaries between R&D institutions and users of technology; this was first applied in agriculture and copied in the industrial sector after WWII.

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Although it was not called that way, one could say the concept of the knowledge economy was conceived a hundred years ago. Industrial policy was quite successful and all but the first of the above measures are still successfully applied today.

The stage of traditional industrial policy extended well into the post World War II economic boom, say into the early 1980s. When recession set in around 1969 and depression after the oil crisis of 1973, politicians responded by strengthening the protection part of industrial policy. Japan's Ministry of International Trade and Industry (MITI) deliberately kept prices of industrial goods high inside the country in order to allow its industry to export at low prices. Likewise, the European Union (EU) kept protecting agricultural production, even when this led to large surpluses.

Two trends put an end to protection policies. In the Netherlands, the government's subsidising policy ended in a debacle. As a naval country, Holland had a century-old tradition in shipbuilding; it was innovations in this sector that made the country the largest trader and most powerful naval nation in the world in the seventeenth century. However, in the 1960s it turned out that the country's shipbuilding could no longer compete on world markets. In the late 1960s the government forced three large shipbuilders into a merger: Rijn-Schelde-Verolme (RSV) was thus created. This company received large subsidies, the equivalent of over € 1 billion. It did not help; the company went bankrupt in 1983. A parliamentary enquiry into the use of government funds was held in 1984—the first enquiry of this kind since the post-war investigation into collaboration with the Nazis. All kinds of abuse came to light. The president of RSV had built himself a villa on an island in the Irish Sea with his wife shopping on the mainland with a (government-subsidised) company helicopter. Other European countries similarly had to abandon the policy of government subsidies. The harsh lesson was:

Lesson 1 It is better to let a business go bust than to fight global competition with subsidies.

This lesson was applied shortly afterwards. Fokker, the national aircraft manufacturer—in the 1920s the largest of its kind in the world—went bankrupt in 1996, despite substantial government support for the development of new types of aircraft. The government refused to finance a relaunch. The demise of this flagship enterprise was another trauma but a multitude of successful companies emerged out of its ashes. Although the country does no longer manufacture aircraft, today the Netherlands has a thriving aircraft and airspace sector, part of a strong industry-knowledge cluster. This led to an early lesson in cluster policy, to which we will come back later:

Lesson 2 A well-designed technology cluster can deliver more value than an enterprise on its own.

Guided by the old insight that *global trade benefits all,* institutions such as the EU, General Agreement on Tariffs and Trade (GATT) and World Trade Organisation (WTO) negotiated the opening up of borders and stimulated competition and free market conditions (the 'level playing field'). Governments were forced to abandon the protection of their industries through subsidies, import regulations and public procurement. The failing Doha Development Round unfortunately shows there is still a wide gap between countries around the world when it comes to applying this principle.

2 Stage 2. Technology Policy

As a result of the two developments, it became clear that traditional industrial policy had to be reconsidered. In addition, government budgets had shrunk after the economic crises of 1973 and 1979. The effectiveness of the vast amounts of pubic funds spent—in blind faith—on applied and fundamental R&D became scrutinised. Analysis broadly revealed the following:

- Public and private R&D were almost completely separate worlds. In the Netherlands, public institutes for applied R&D made less than 2 % of their income from industrial contracts; in other countries it was similarly small. Contracts for private R&D from state agencies were negligible, except in the USA.
- The publicly funded institutes for applied R&D had lost contact with the world they were supposed to be working for. What they did sometimes looked more like their hobby than service to industry.
- Fundamental research did not contribute to the economy at all. One could say it was designed that way as using the results of 'pure' science for something as vulgar as industry and private profit was considered inconceivable by many in the 1970s. The emergence of spinoffs from large US publicly funded research activities, however, showed that there could be substantial benefit and that the role of fundamental research had to be reconsidered.
- Large companies spent significant amounts of money on R&D while mid-sized enterprises and *small- and medium-sized enterprises* (SMEs) did very little, too little at least in the eyes of analysts and policy-makers.
- Extension services flourished in agriculture but hardly came off the ground in industry.
- Interest in technical education was waning in the post-revolutionary years of the 1970s. In addition, the school curriculum was not in sync with the demands of industry. Technical schools of large enterprises were closed in cost reduction drives.

It was obvious that new policy had to be designed and a debate emerged that is still going on today in many countries. On the one hand, there are those who argue that ad to be designed and a debate emerged that is still going on today inches of industry. Examples of general measures are: lower taxes, fiscal stimulation of investments and R&D, low labour costs, deregulation and many others. It is not surprising to find many macro-economists in this camp, as they tend to think in macro-terms anyway. On the other side, people with a background in branch-specific industrial policy, argued that general methods are not powerful enough and now that the government had stopped 'picking losers', it should 'pick winners' and stimulate them in various ways. The two sides of the debate differ fundamentally in their view on the role of the state. The idea that the state is responsible for the economy and hence should draft an industrial development plan with priority sectors that are selected top-down, is basically Marxist. ‘Picking winners’ is a subjective process; there are no objective criteria. Velzing, who carried out a careful analysis of the Netherlands’ innovation policy in the period 1976–2010, shows that in certain cases, ‘picking winners’ came down to ‘picking lobbies’ (Velzing 2013). This leads to our next lesson:

> **Lesson 3** General measures work; top-down selected branch-specific measures do not.

The ‘generalists’ side’ came with a new approach that turned the defensive policies into offensive, future-oriented, ones. In the Netherlands, in 1982, a year before the demise of RSV, a new minister of economic affairs installed an advisory committee, which was to give recommendations for what was then called ‘technology policy’. One of the present authors was a member of this committee; another member later became the minister of economic affairs who decided not to continue subsidising Fokker. In 1984, the committee came up with a comprehensive programme (Zegveld et al. 1984) to:

- Stimulate private R&D through tax incentives (the scheme is now called Wet bevordering speur- en ontwikkelingswerk; WBSO);
- Use large parts of the applied R&D budget for funding industry-initiated R&D;
- Encourage (technical) universities to work for industry;
- Support spin-offs from institutes of fundamental research;
- Give industry a greater role in the development of the curricula of technical schools;
- Improve the know-how infrastructures (see below) of the various economic activities.

This was followed later by the creation of a number of public–private partnerships for innovation (OECD 2004).

The report of the technology policy committee included a revival of the concept of innovation in the Schumpeterian sense (Schumpeter 1911). Initially, this approach did not go down well in a country where the leading economic elite were all staunch Keynesians, including several prime ministers and high-ranking civil servants. Although they did belong to the camp of the ‘generalists’, they still believed in the virtues of ‘value-free’ R&D. The technology policy report brought the concept of ‘know-how infrastructure’ to Holland, that is, the chain of people or organisations from fundamental research to ultimate users. This concept was already known in agriculture, especially through the work of Everett Rogers (Rogers 1962). It was adapted for industry by Christopher Freeman and his influential school at the University of Sussex in Brighton, UK (Freeman 1987). Later, Freeman developed the concept further to what he called the ‘National Innovation System’ (NIS), a term now common and widespread (Freeman and Soete, 1997). Freeman’s definition of a NIS is *“the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies”*.

The idea of the national innovation system is that each element of the 'chain' is of equal importance; the missing of one makes the rest inoperable. The elements should not only be present, they should also be properly linked. The concept of the NIS was later to be developed into that of clusters.

Lesson 4 A full-fledged know-how infrastructure is what matters; R&D is just one component.

Despite this 'lesson', the comparison of the share of GDP devoted to R&D in different countries still has an almost sacred significance while it says actually very little about a country's potential for innovation. The reason for this may be that the percentage of gross domestic product (GDP) devoted to R&D is so easy to measure and compare between countries (Velzing 2013).

3 Stage 3. Innovation Policy

One may say that the development of traditional industrial policy into technology policy has greatly stimulated European economies. After a long absence, the subject of technology was back on the political agendas. Nevertheless, the insight emerged—we are now in the early 1990s—that, having the chain of elements of the know-how infrastructure nicely in place, does not automatically lead to an increase in economic activity. From this insight emerged a new approach: innovation policy. Innovation policy is based on five pillars:

1. Stimulate entrepreneurship by reducing red tape and costs to start an enterprise and by creating accelerators and incubators, especially near institutes of higher technical learning;
2. Bring public institutes for fundamental and applied research closer to the market;
3. Stimulate the development of clusters of economic activity;
4. Engage in pre-competitive research;
5. Follow and support entrepreneurs rather than invent all kind of programmes at government level;
6. Use universities as an essential element in the stimulation of the knowledge-based economy.

We will discuss these items below.

4 The Role of the Entrepreneur

In most books on national innovation systems or technology policy, the word 'entrepreneur' was hardly mentioned. Again Schumpeter was revisited, especially in the work of Peter Drucker (Drucker 1985). The notion of Schumpeter and Drucker that the entrepreneur is the central and crucial element in innovation, the *creative* *destructor*, became mainstream. Thus, stimulating entrepreneurship turned out to be the cornerstone of innovation policy. Although most people would not go as far as Proudhon who called ownership theft, in the 1970s the entrepreneur was widely seen as a locust that feeds on society for his own benefit. Suddenly and under the influence of the success of a new generation of entrepreneurs in the USA in the 1990s, he came to be regarded as the national saviour. Cost and red tape for setting up an enterprise were brought down sharply. All kinds of facilities were created, at the national, regional and municipal levels, such as incubators, coaches and venture capital. Entrepreneurship became popular; competitions for the best ideas, start-ups and young enterprises took place and enjoyed much publicity. In 2002, there were some 300 business incubators in the UK, supporting 20,000 businesses (UN-ECE 2009). Still, the total effect on the economy was limited as many new companies were just free lancers, for instance in the IT field.

Lesson 5 Enable and stimulate entrepreneurship

The view that the role of a government is inherently limited and that one should rather ‘let the market do its work’, became especially popular after the demise of the model of central economic planning in 1989. Governments started supporting the work of entrepreneurs rather than inventing all kinds of programmes themselves. Many countries, starting with Finland, set up high-level National Innovation Councils to coordinate the nation’s efforts in innovation. In Finland, this council is chaired by the prime minister and comprised of members from the research community and industry.

Lesson 6 The government should support but not replace the entrepreneur.

5 Stimulating Demand for R&D

There was another lesson from the collapse of the central planning system. The central planning model was entirely focussed on the development of the supply side. Markets hardly existed in the former Soviet Union and its allies, with catastrophic economic and eventually political consequences. The lesson that stimulating demand is more effective than creating supply also applies to government-sponsored R&D.

Lesson 7 Stimulating demand for R&D is more effective than stimulating supply.

As an example, the Dutch Ministry of Economic Affairs adopted a programme under which vouchers would be given to SMEs to pay (in part) for R&D activities of universities and public R&D institutes. The model was quite successful and was imitated in some other countries. In another scheme, the government would supplement investments by venture capital firms and business angels with 50 % of the investment—up to a maximum. These supplements carried a higher degree of risk than the contribution of the investor. If the investment were successful, the government would get its original amount back, plus compound interest. If it failed, the investor would have priority in receiving proceeds from the failed enterprise. The government would not evaluate the investment but follow the instinct and expertise of the investor, in other words, no red tape.

6 Cluster Policy

As for classical industrial policy, i.e. the policy not related to innovation, the work of Michael Porter (Porter 1990) demonstrated that 'clusters' play a powerful role in economic development and that these should hence be stimulated. Clusters are groups of related economic activities (manufacturing enterprises, their suppliers, their advisors) and corresponding schools and R&D institutes, preferably at one location or region. Or, in the words of Porter: A geographically proximate group of interconnected companies, suppliers, service providers and associated institutions in a particular field, linked by externalities of various types (Porter 2003). Companies compete but also collaborate; staff can move from one company to another, from R&D institutes to companies and vice versa, or staff members can start their own enterprise. In other words, a cluster is a kind of ecosystem in which all players benefit from competition and collaboration. Clusters have one or more 'drivers', such as common marketing, technology, logistics, quality standards (as in French wine) or others. If innovation is the 'driver', they are called 'smart clusters'. Since Porter's work, establishing and developing clusters became a major concern of many governments. Up till then, regional development was very much a matter of support to regional industry, ad hoc investments to stimulate employment, improving infrastructure, etc.The cluster approach proved to be more effective; even simple measures such as creating contacts between actors and establishing 'missing links' such as schools and research institutes, turned out to yield excellent results.

Lesson 8 Stimulating clusters can be an effective way to achieve economic growth.

Stimulating clusters is now at the core of EU policy with the essential notion that 'business should be in the driving seat' (European Commission 2013). A good example of a smart cluster is the horticulture sector in the Netherlands. It is comprised of a large number of growers of flowers, some with greenhouses of 100 hectares. Most of the flowers are exported through auction centres, some 12 million flowers per day; the main auction hall has a floor space of a hundred football fields, many of them climate controlled. The sector maintains its competitive advantage through the development of new seeds (by specialised enterprises) and cutting edge logistics: roses cut in Holland in the morning are on sale in New York by lunchtime. The auction halls, all of them cooperatives, have merged and they have adopted a system for remote trading through the Internet. A common—Calvinistic—culture facilitates communication. The sector has an effective marketing and PR apparatus in Holland and abroad and it has common quality standards. The lesson is:

Lesson 9 The more ‘drivers’ a cluster has, the more effective it is.

There have been many attempts to create clusters and many have failed. Failure often occurs when governments decide ‘top-down’ which clusters have potential and should hence be stimulated, another form of ‘picking winners’. Most successful clusters have emerged from private initiative, ‘bottom-up’. At some point in time, they need government support, in terms of fundamental R&D, infrastructure, regulation and sometimes credits for common activities and start-ups. The lesson is:

Lesson 10 Bottom-up clusters can be successful; top-down clusters often result in failure.

Clusters fail because of a mal-designed concept, lack of monitoring and evaluation, limited engagement of the firms concerned and lack of attention to trans-regional aspects.

7 Precompetitive Research

In the 1980s, innovation became a concern of the European Union. In 1983, Pehr Gyllenhammar initiated the European Round Table of Industrialists that was to become a powerful lobby group. Its meetings were attended by Etienne Davignon, member and later vice-president of the European Commission. Mr. Davignon started cooperation between European enterprises in innovation. On one occasion, he called a meeting of some six Vice-Presidents R&D of European IT companies. Naturally, they had heard of each other but they had never met. One of them said afterwards: ‘During the first ten minutes we just watched each other. The silence was awesome’. The meeting led to a precompetitive research programme into ways of boosting chip technology, directed mainly against Japanese enterprises. The idea of precompetitive research is that companies can collaborate in, say, a manufacturing technology while they could still compete in the market with distinctive products; in other words, competition is not jeopardised. The model has been used in numerous smaller and larger co-operations. For instance, at Technical University of Delft (TU Delft) some ten oil companies sponsor a foundation that funds PhD research. The companies have the privilege of jointly choosing the subjects and receiving information prior to publication. Such schemes can be instrumental in fostering the innovation efforts of the group’s members without violating anti-trust laws. Since the days of Davignon, the European Union has also taken a role in coordinating Member States’ innovation policies (Djarova and Zegveld 2009).

Lesson 11 Precompetitive research reduces the cost and risk of innovation, especially with SMEs.

8 The Role of Universities and the Concept of the Knowledge-Based Economy

There is one specific element of entrepreneurship that we need to highlight. In the 1980s, governments became aware of the fact that in the USA many of the new IT firms were in fact spin-offs of universities. The point was made in a dramatic way by the now legendary 'BankBoston Report'. This study demonstrated that if the companies founded by MIT graduates and faculty were to form an independent nation, their total revenue would make that nation the 24th-largest economy in the world. The 4,000 MIT-related companies (located worldwide) that existed in 1997 employed 1.1 million people and their annual world sales amounted to $ 232 billion. That is roughly equal to a gross domestic product of $ 116 billion, which compares to the 1996 GDP of South Africa or Thailand. The study also showed that MIT `imports' entrepreneurs, as many companies were not spinouts of the university, but rather came to Massachusetts to benefit from its presence. These conclusions were confirmed by a report of the Kaufmann Foundation, written by MIT professor Ed Roberts, who established that up to 2009 MIT alumni founded 25,800 active companies that employ 3.3 million people and generate an annual revenue of $ 2 trillion (2 million–million), making them the 11th largest economy in the world, had they formed an independent nation—something like India, the Russian Federation or Spain (Roberts 2009). Another study concludes that between 1980 and 2004, US universities created 4,543 companies, including Genentech, Chiron and Google (Financial Times 2006).

Lesson 12 Universities can be powerful sources of new economic activity.

The story goes that the BankBoston report inspired the then British Chancellor of the Exchequer, Gordon Brown, to make funds available—on a competitive basis—to universities in order to start courses in entrepreneurship and facilities to support technostarters, that are students or academics who set up new, technology-based firms. It was the first time universities would receive public money through a channel other than the Departments of Education and Science. This support happily coincided with a change in the role that universities saw for themselves. For instance, in the 1990s at the University of Cambridge, UK, it became clear that the rising costs of front-line research could no longer be funded by public money alone. This awareness led to the development of a vast programme of collaboration with industry and facilities for technostarters. As a result, Cambridge today is not only host to the university with the largest number of Nobel prizes in the world, but also the nucleus of a thriving entrepreneurial environment, similar to the clusters around Stanford University and MIT. K.U. Leuven in Belgium started to systematically and professionally commercialise outcomes of its research efforts. The university thus earned substantial income with which it could sustain a top-level research programme, while, in addition, technoparks started mushrooming around the old city. In the Netherlands, Wageningen UR, the combination of the Agricultural University and some 12 institutes of applied research, as well as the TU Delft likewise started activities concerning commercialisation of results of research, either by collaborating with industry or by spinning out new technology-based firms. Agriculture today is a high-tech business, at least in the Netherlands. It made this small country with a large population, much industry and an awful climate the second largest exporter of food in the world, after the USA.

Top universities owe their success to fundamental research in the first place. Universities can act as engineering bureaus, of course, and they frequently do, but fundamental research remains the source of new technology-based firms.

Lesson 13 The basis of all innovation is fundamental research.

The new role governments adopted in stimulating academic entrepreneurship and the notion of universities that cutting edge research required collaboration with industry, coincided with a trend in large technology-based enterprises to substantially reduce their efforts in fundamental research. They would rather outsource most of it to external partners. For instance, in the 1960s, Shell had a fundamental research laboratory employing 4,000 people in Amsterdam; they had a similar institute in Houston. Such facilities transformed the oil and chemical industries and were also a rich source of scientific papers and professors. When we visited the place as students, it felt like holy ground. Now this effort has been significantly reduced—certain companies even abandoned fundamental research altogether. They rather buy it from universities and other R&D institutes on a project basis, often within a framework contract. At the same time, they would sell their know-how to others, including competitors. In other words, industrial R&D had become a regular business practice with its own bottom line.

The new role of universities led to the formulation of the concept of the Third Generation University (3GU) (Wissema 2009). This needs some explanation. Medieval universities are viewed as First Generation Universities; they focussed on education while activities that we would now call R&D were carried out by scientists/inventors outside the universities. These scientists (think of Galilei) would often be opposed by the academic establishment, which would defend traditional insight. During the Renaissance, the concept of 'modern science' was developed. It was based on the observation of nature, experimentation, logical reasoning and openness of methodology and results for inspection by peers. The University of Berlin, now Humboldt University, established after the Napoleonic time, was the first to put modern science into practice. The focus was now on scientific development—the second university objective; education took place in its slipstream. The University of Berlin was also the first to use the national language rather than Latin. Thus, German became the language of science in the nineteenth century. The 3GU emerged after World War II. Just as the Humboldt type university (Second Generation University, 2GU) added scientific development to its role in education, the 3GU added know-how commercialisation and collaboration with companies and entrepreneurs as its (third) objective. In the globalised world, 3GUs compete for the

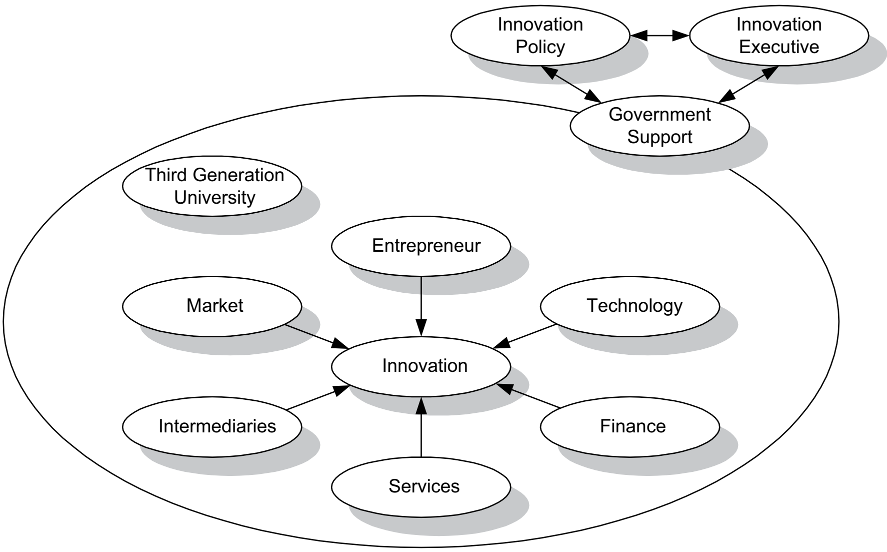

Fig. 1 A new model of the National Innovation System

best students, staff and research contracts worldwide, adopting English as the new lingua franca in science.

Lesson 14 English is the lingua franca of universities as Latin used to be in the Middle Ages.

9 A New Model for Innovation Policy

Before embarking on a discussion of the trends that will shape future innovation policy, let us come back to the concept of the NIS. NIS-models are used to analyse innovation systems, which leads to detecting their shortcomings and then to offering remedies, so all analysis starts with a good model. Freeman's NIS model is still widely used. However, as we noted above, it does not consider the role of the entrepreneur as central to innovation. In addition, the concept of the 3GU was not known in his days.

We, therefore, propose to adopt a new model and we like to present the one we have used for analysing NISs in recent years (Fig. 1).

According to this model, six elements are central to innovation, whether in an existing enterprise or a start-up:

1. The entrepreneur who brings a product to the market, or puts an innovation in marketing, manufacturing, logistics or organisation to use.

2. Technology, one of the two wings on which innovation flies. All industrial innovation is based on the application of new knowledge or insight.
3. Market, the other wing of the innovation plane. Without a receptive market, inventions cannot become innovations.
4. Intermediaries, extension services' agents that assist in the transfer of the technical and market knowledge to the entrepreneur. They are present inside any innovative corporation as well as in branch organisations.
5. Finance, the fuel of the innovation plane.
6. Services. In addition to the auditing, economic and technical services (they are mandatory in any well-functioning market economy) there are services specialised in working with start-ups and new ventures.

In addition:

- 3GUs. Although not incorporated in the traditional descriptions of an NIS, the combination of a research university with other knowledge generators, financiers, intermediaries and support institutions, usually located on the campus of the university, greatly boosts innovation.
- Government support comprised of an Innovation Policy Unit and an Innovation Executive.

Concerning the latter, innovation is greatly enhanced if a government has an active innovation policy and if it has assigned the task of implementing this policy to a single dedicated body. We would like to suggest two possible structures:

1. The Innovation Policy Unit, which defines the government objectives and programmes and makes budgets available to stimulate innovation.
2. Innovation Executive, the executor of innovation policy on behalf of the government. The Finns created Tekes, an innovation and technology centre, with an annual budget of € 600 million and a staff of 360. They also created a venture-capital fund, Finnvera and a collection of accelerators, jointly financed by the government and industry. The result is an impressive number of new enterprises; 300 were founded by former employees of Nokia alone (Northern Lights 2013).

This model has been used as the basis for analysis of the NIS in the Netherlands, Poland, Bulgaria and Kazakhstan. Depending on the result one can design an innovation policy for a particular country, region, or sector such as IT, energy and agriculture.

10 Recommendations for Future Innovation Policy

From the above, it will not be surprising that we give as our first recommendation:

Recommendation 1 Stimulate clusters, based on bottom-up initiatives.

Although we are not in favour of governments 'picking winners', it is useful if governments:

Recommendation 2 Create awareness about the potential of clusters.

Analysing the effects of promoting the growth of high-potential entrepreneurial ventures and venture capital funds, Josh Lerner notes in a recent study (Lerner 2009): 'While the pubic sector is important in stimulating these activities, I will note that far more often than not, public programs have been failures. Many of these failures could have been avoided if leaders had taken some relatively simple steps in designing and implementing their efforts'. He then analyses common misconceptions, both in the design phase of a government programme and in the phase of implementation. He also gives good recommendations.

The fact that public funds are very much under scrutiny, as part of austerity drives, will no doubt lead to more pressure on the effectiveness of innovation policy. We might therefore expect much more—and more honest—evaluations of stimulation programmes, better monitoring as they proceed and better evaluation when they are completed. Needless to say that such monitoring and evaluation should not put an additional burden on the entrepreneurs: let them do their work. Literature provides ample evidence that there is substantial experience with such monitoring and evaluation (Klein Woolthuis 2005). However, every country has to develop its own methodology (Biegelbauer and Borras 2003).

Recommendation 3 Put more intelligence into the design, implementation, monitoring and evaluation of government programmes.

The idea that governments are the greatest obstacles for innovation is clearly a myth. In a recent book, Mariana Mazzucato found that all components of computers and smart-phones emerge from state-sponsored fundamental research: the internet, wireless networks, global positioning systems (GPS), microelectronics, touch screen displays and voice activation (Mazzucato 2013). GPS and the Internet were created by the US Department of Defence—no company could have done it instead. In his review of the book, Martin Wolf concludes: 'The failure to recognise the role of the government in driving innovation may well be the greatest threat to rising prosperity' (Wolf 2013). In the discussion above, we have shown that, if governments are to stimulate innovation and create a knowledge-based economy, they should finance, in whole or in part, fundamental research. At least half of this research is to be carried out in dialogue with the business sector; the other half is to be 'value-free', as an instrument of our developing civilisation.

Recommendation 4 Continue financing fundamental research, half of it in consultation with the business sector.

In addition, in line with the analysis presented above, money given to precompetitive research is generally well spent.

Recommendation 5 Co-finance precompetitive research.

This argument can be carried a little further if one considers the monumental cost of cutting edge fundamental research. On 2 April 2013, the USA announced a US$ 3 billion research project to find out how the brain works by mapping the activity of every neuron in the human brain. This project, named Brain Research through Advancing Innovative Neurotechnologies (BRAIN for short), is also referred to as the Brain Activity Map Project. It is based on the Human Genome Project that also cost US$ 3 billion (The Economist 2013a). While European governments are cutting back on fundamental research, the USA is financing large and imaginative programmes. Fortunately, Europe, in the Conseil Européen pour la Recherche Nucléaire (CERN) and European Space Agency (ESA) projects, also carries out significant multination fundamental research. Such projects will eventually result in economic activities, even if one cannot remotely say which. Hence:

Recommendation 6 Initiate large, preferably pan-European, imaginative projects in fundamental research.

Just as important as the obvious 'discovery' that it is the entrepreneur who is the central player in innovation—whether in a start-up or as an 'internal entrepreneur' in an existing firm—is the observation that entrepreneurs flourish in an enterprising culture. Such a culture is lacking in Europe and large parts of Asia. Entrants in the labour market prefer the—perceived—security of jobs in large firms, financial institutions and government to taking risks. A notable exception is entrepreneurship in agriculture, at least in countries in which land ownership is in the hands of the actual farmers; liberalisation of land ownership, as in Colombia for instance, is often a first step in the economic development of a nation. Carl Schramm, then at the Kaufmann Foundation, notes that the ultimate competitive advantage of the USA is its entrepreneurial culture while technology and finance are widely available to anyone on the globe (Schramm 2006). In his column in the Financial Times, Luke Johnson, himself an entrepreneur and business angel, writes that 'more than anything, the vital ingredient anyone requires to reach great heights in business (or indeed any walk of life) is hunger' (Johnson 2013a). This 'vital ingredient' is lacking in Europe's and Asia's middle classes—rich kids do not have an incentive to do it the hard way and be an entrepreneur.

The question then is: how to create an entrepreneurial culture? In the Netherlands, we have government-sponsored programmes at primary and secondary school level. However, the amounts of money spent on supporting (potential) entrepreneurs stand in sharp contrast to the (limited) funds spent on awareness. In addition, it would be better to target such efforts on specific groups, for instance, second-generation immigrants who are more likely to create an enterprise than indigenous citizens. At TU Delft, we started a short mandatory course for all students in order to create awareness of entrepreneurship. Speakers are mostly young alumni-entrepreneurs who tell their story. This is more effective than lecturing as students often feel: If he can do it, so can I. Of course, only a few students will actually become entrepreneurs. However, our attitude is: we accept that many students will not follow the call but we do not accept that they would never be offered the opportunity. Just as fundamental research is the basis of applied research and subsequently inventions and innovations, entrepreneurial awareness is the basis of new economic activities.

Recommendation 7 Stimulate a national entrepreneurial culture.

Only few entrepreneurs create large companies; most are self-employed. It is like football: the broader the base, the higher the top. Self-employment has become popular in Europe. In the Netherlands, for example, one in eight workers is self-employed; 30 % of the workforce have higher education, 7 of the country's 13 universities are in the top-20 list of the EU. Entire sectors, as different as consulting and construction, thrive on self-employment. Such a system has many advantages. It is seen as one of the reasons why the economic crisis has hit the country less severely than others. It allows for a very dynamic, flexible and motivated labour force. It makes people proud of themselves and it fosters individual life styles. SMEs often grow out of self-employment. However, a conducive environment should be in place: adequate pension arrangements, no worse than those for workers on fixed labour contracts, health insurance—in short, all the perks that come with a government job or a job in industry. In 2009, France created more favourable conditions for entrepreneurs/self-employed. The outcome was 550,000 new start-ups in 2012 (Carnegy 2013). So, it is easy. To sum up: every nation benefits from encouraging self-employment:

Recommendation 8 Stimulate and facilitate starters and self-employment.

Women entrepreneurship is another aspect of entrepreneurship we need to address. In Europe, the percentage of women in employment is lower than that of men. The share of women entrepreneurs is far lower than male entrepreneurs, less than 10 % in the UK. In contrast, in developing countries women are responsible for half of all micro-businesses (Johnson 2013b). The interest of women in entrepreneurship is large. Recently, with Ecorys Consulting and Research, a consultancy, we were assigned to run a project for Women Entrepreneurship Support for Confederation of Turkish Tradesmen and Craftsmen (TESK), the Turkish SME organisation. The project provided awareness programmes, coaching and training—for would-be as well as established women entrepreneurs. We were supposed to train 4,000 women and did not think we would reach that target. In the end the number topped 9,500; women came in by busloads. Although contributing to the family budget was a major driver for women to attend, gaining some independence and being a role model for their daughters was equally important. Women would face different challenges than men, who have usually better connections in the business and banking world. Asked about the main obstacles to women entrepreneurship, women in the Western part of Turkey gave the usual answers: difficult to find good people, difficult to market a product, financing is too expensive and so on. In Eastern Turkey, the obstacles were first the husband, then the father, then the father-in-law.

Most likely a similar enquiry in other traditional societies in Europe would yield the same results. When men come home from work, they relax. Women take care of the family; they lead a double life. Now, the attitudes are changing. Attitudes are already different in Eastern Europe where women employment has been common and women entrepreneurship is catching up. In most countries of the world there are now more female students than male; they usually perform better as well. The call for women to participate in economic life is widespread. For instance, recently Shinzo Abe, Japan's prime minister, called for at least one woman on corporate boards. Still, entrepreneurship is a gender issue: it is different for men than for women. Creating awareness and stimulating entrepreneurship among women therefore requires specific instruments, alongside the traditional training in marketing, finance etc.

Recommendation 9 Create awareness and stimulate women entrepreneurship.

It is not only through funding of R&D that governments enable innovation. By applying stricter environmental and safety standards they create a market for innovation. Just think how the ever more stringent Californian emission standards influenced the automotive industry. Banning leaded fuel and then adopting constantly lowering emission thresholds has spurred innovation.

Recommendation 10 Initiate or continue innovative government procurement and regulation.

In the Netherlands, the Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek (TNO) is the umbrella organisation for many of the applied R&D institutes that work for the private sector. As part of some austerity programme of the 1980s, it was decided that TNO should increase its financial intake from contracts with industry, at the expense of the basic subsidy. At the time, some people feared that this would be the end of TNO but the measure has worked miracles. Both efficiency and effectiveness improved as scientists were forced to recognise the demands of the market and act accordingly. Companies went through a similar process. In the 1990s, we helped introduce business unit management (Wissema 1992) in the (then) fibre division of AkzoNobel. Service groups would serve business units just as business units would serve the market. Many shed a tear when the once mighty corporate engineering group gave presentations to business units, modestly offering its services. But here too, it worked like magic.

We believe it is still better to privatise public R&D institutes altogether (Wissema 2014). The same goes for universities. Staff would lose their secure civil servant status and salaries would depend on labour market conditions. Now, salaries follow government standards. For instance, in Holland the salary of a full professor equals that of a one-star general or the prosecutor in a court of appeal. What is the logic? Privatisation would increase efficiency and flexibility while governments could still apply quality standards, as they do in, say, the food industry. Recently Jeff Bezos, founder of Amazon.com, bought the Washington Post. Imagine what would happen if people like him would buy universities.

Recommendation 11 Privatise R&D Institutes and universities. Stimulate the trend towards 3GUs.

Last but not least, a word on education. Even when avoiding the hyperbole of the 'knowledge-economy'—all economic activity is based on knowledge, going back to the fire and the wheel—the role of education in society is of paramount importance. While Europe is struggling with high unemployment rates, IT-specialists are in short supply and good technicians work overtime. Today, education is changing fundamentally; there are at least three prominent trends. First, there is the emergence of IBM's Watson computer. Watson (Wikipedia 2011) is an artificial intelligence computer that accepts questions and gives answers in natural language. The computer made history by winning, in 2011, the American quiz show Jeopardy, competing with two all time human winners. This was an event similar to the victory of IBM's Deep Blue computer in the chess match against Garry Kasparov in 1997, a mere 14 years earlier. Watson means that Star Wars' R2-D2 has become reality. One might say: what does this have to do with education? Watson only has a RAM memory of 16 terabyte; during the game, it was not connected to the Internet. A 4-terabyte memory is already quite common in laptop computers and back-up storage. With the ongoing miniaturisation of electronics one may wonder when Watson will be incorporated in smart phones. When it happens, the need for learning facts will disappear—Watson will know everything.

The second trend is internet-enabled distance learning. Massive Open Online Courses (MOOCs), threaten to make many schools and universities redundant. The revolution began with start-ups such as Udacity and Coursera, and many universities followed by cooperating with them. Moreover, many have put all their teaching material online to be used for free; Oxford and Cambridge are notable exceptions. Even more important than the fact that students save time and money, MOOCs make individualised education possible—the end of standard courses is nigh. It is, says Bill Gates, 'A special time in education' (The Economist 2013b). On-line courses and the availability of educational software might benefit children from deprived backgrounds, wherever they may be. Thus, technology will eradicate the last pockets of illiteracy. It seems that New York is one of the drivers of the changes. Former major Michael Bloomberg turned it into a laboratory for a multitude of educational experiments, made possible, in part, by many start-ups (Delves Broughton 2013).

Still, on-line courses and educational software do not change the basics of the process of learning as we have known it since antiquity: pupils lined up in front of a teacher who writes on the blackboard, now a computer screen. Most computer-based courses only put textbook material on the Internet. The emergence of interactive software may change that. This is a real new way of learning that will revolutionise teaching. The danger of this development is that, since interactive books require much investment, the economies of scale will do their work, resulting in international chains of schools and universities using the same material. Diversity may become the victim of it.

Although education is not normally considered part of industrial or innovation policy; we touch upon it, as education is another basis of innovation. Governments would do wise to innovate learning in order to keep their workforce competitive.

Recommendation 12 Overhaul the educational system.

11 Conclusion

In this chapter, we have offered a review of industrial and innovation policy from a historic perspective. When economic and social conditions change, so must industrial policy. Certain instruments turn out to be timeless while others quickly become obsolete. New technologies require new government measures. We drew some lessons from past experience. An analysis of current trends and an evaluation of past achievements yielded a set of 12 recommendations, some old, some new.

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