Systems Thinking for Research and Development Policy Impact Assessment in Latvia

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Abstract

Following EU's Lisbon strategy development of knowledge-based economy has become one of the headline objectives for the government of Latvia. In this paper we conceptualize driving forces and responses of government's commitment towards this objective. We investigate feedback loops that underlie dynamics of knowledge industry development. Increase in domestic Research and Development (R&D) activities is considered as a prerequisite for sustainable growth of knowledge economy. Dynamics of R&D supply and demand is further analysed and leverage points for different policy measures is identified. Scarce human resources is considered as the main impediment for building domestic R&D capability and impact from mix of policy options is assessed.

Key words: Knowledge-based Economy, R&D capability, Systems Thinking.

Background

In early 2005 the European Commission proposed a new start for the Lisbon strategy focusing the European Union's efforts on two principal tasks – delivering stronger, lasting growth and more and better jobs. Strategy also highlighted one of the headline objectives set out earlier in the Barcelona European Council - to increase spending of R&D and innovation with the aim of approaching 3% of GDP by 2010 [EU COMM 330]. Reinforced by EU commitment, expansion of knowledge-based economy in Latvia has become one of the government key objectives. Currently Latvia is lagging significantly behind developed EU countries with R&D spending estimated at only 0.44% from GDP. One of the main reasons for that is undeveloped national innovation system, which does not motivate active private sector participation (in 2004 private sector fraction of total R&D funding was 33.2%) [Bilinskis 2005]. Even on the EU level if current trends continue R&D investment might be considerably lower than agreed objective (estimated at 2.2%). For Latvia to come even close to targets set out in the Lisbon strategy radical changes in current practices for financing R&D and innovation activities shall be done. Lately this topic has become very high in the Ministry of Economics agenda. In particular activities for reforming National innovation system and adoption of EU structural funds has been initiated. It is expected that activities resulting from these initiatives will lead to substantially increased government funding for innovation, technology and public research institutions. This combined with increased institutional focus and finance from EU Regional Development fund shall boost also private sector innovation and R&D spending. However sound and coordinated economic, science and education policies are required to achieve optimal return from those investments.

Scope of the study

This study is carried out in two phases. Following were the main objectives of the first phase.

- To conceptualize driving forces and response of government intent for advancement of knowledge-based economy in Latvia.

- To identify high-level feedback structure of current knowledge industry growth and its limitations.
- To analyse domestic R&D demand and supply interactions.
- To identify government policy instruments for building domestic R&D and innovation capability.

In the second phase qualitative and quantitative analysis of key policy options and their impact assessment shall be done. System dynamics was chosen as a modelling methodology for this study. Summary findings and conceptual models built in the first phase are presented in this paper.

Government commitment for knowledge-based economy

Ministry of Economy has identified five knowledge-intensive sectors that are currently relevant in Latvia: Information and Communication Technology; Electronics; Materials science; Wood chemistry processing; Biotechnology and pharmacology. However for the most part, these sectors still remain marginal in the Latvian economy. In this paper we will investigate on the conceptual level relationships that are valid in all sectors. However for more quantitative studies each sector should be looked separately as they are in different development stages, levels of the main stock are diverse and might be exposed to industry specific feedback loops. Therefore building robust cross-sector simulation model might be very difficult task.

International experience has emphasized four pillars for developing a knowledge economy: a labour force with a high education, a system that favours research and development, easily accessible information technologies, and an open economy that leads to greater trade and foreign investment [Cleaver 2002]. Openness to international trade and investment as well as favourable business environment are cornerstones for modern economy and Latvia is well positioned in this sense particularly after joining EU. Therefore in this study the main focus is on human resources development and on technology acquiring and dissemination. Thus scientific education and training, R&D and innovation activities as well as the level information and communication technology penetration are identified as the main inputs for advance of knowledge-based economy.

Even the knowledge-based economy can be considered as a value on its own, government commitment for building it is more influenced by its outputs - sustainable growth and high employment level. It is widely accepted that by far the biggest growth factor of national product observed in developed countries over the last century can be explained by innovation driven increase in labour productivity and capital efficiency [Porter 1996]. Figure 1 shows feedback structure for government commitment, funding and knowledge-based economy relations. Knowledge and technology accumulation is deemed to be the main source for increase in labour productivity. In favourable economic environment it is also expected to increase industry competitiveness. This in its turn stimulates employment level; expands high added value industry and international performance, thus fuelling the growth of the national product.

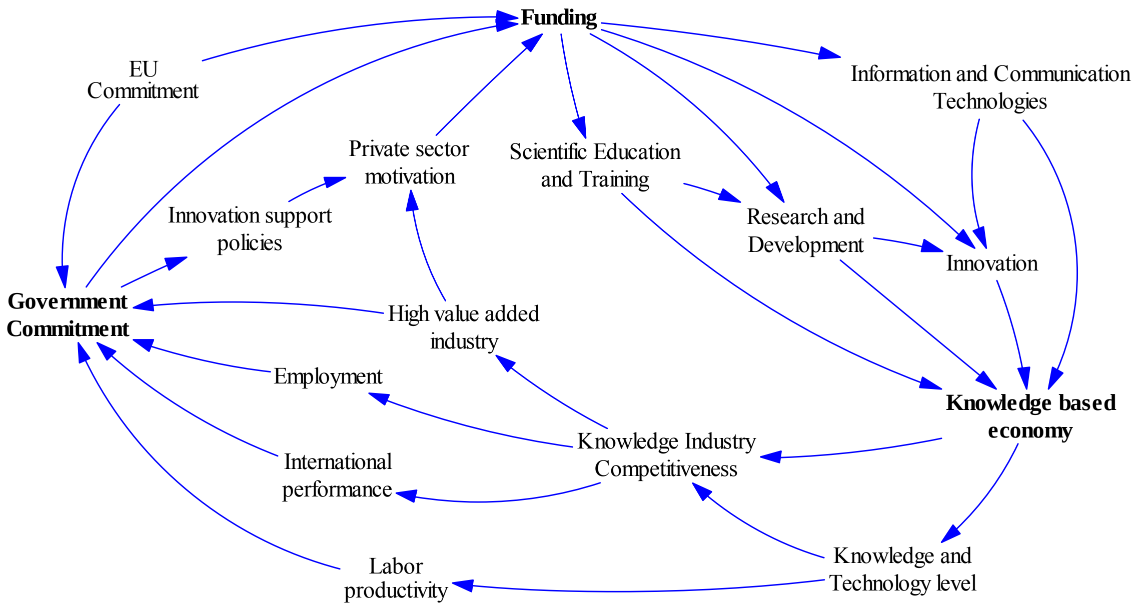

Figure 1. Government commitment, funding and knowledge-based economy.

Growing industry with high added value catalyzed by government support policies shall also increase private sector motivation to fund further R&D and innovation activities. Thus high level of EU funding, increasing public and prospectively also private funding shall provide sound financial base for development of knowledge-based economy pillars.

Technology transfer and knowledge industry

Two basic channels exist for firms that seek to upgrade their technological capacities: either they can develop their own R&D capability, or they can acquire new technologies from other firms and partners. Foreign technology transfers in emerging and relatively small countries like Latvia are essential. This is partly due to limited financial and human resources in local firms and insufficient critical mass in industry to create lasting demand for research institutions. In the recent survey about two-thirds of the firms indicated that they had benefited from technology transfers over the past few years, versus one-third that reported having developed their own R&D capacities. However these two options are complements rather than substitutes and only 14% of Latvian firms reported conducting R&D without receiving any external technology transfer [World bank 2003]. It is observed that countries are in either of the two possible phases with respect to the levels of private and public R&D expenditure: the phase in which private R&D of the country is dormant (i.e. insufficient private R&D) and the phase in which private R&D is at a self-sustaining state [Güven 2002]. In year 2003 private sector funded only 33.2 % of total R&D activities Latvia.

The dynamics of technology level growth has been described both in macroeconomics text books [Romer 1996] and system dynamics literature [Weil 2005]. Here as the first step we have analyzed feedback structure of knowledge industry development driven by the technology transfer (see Figure 2).

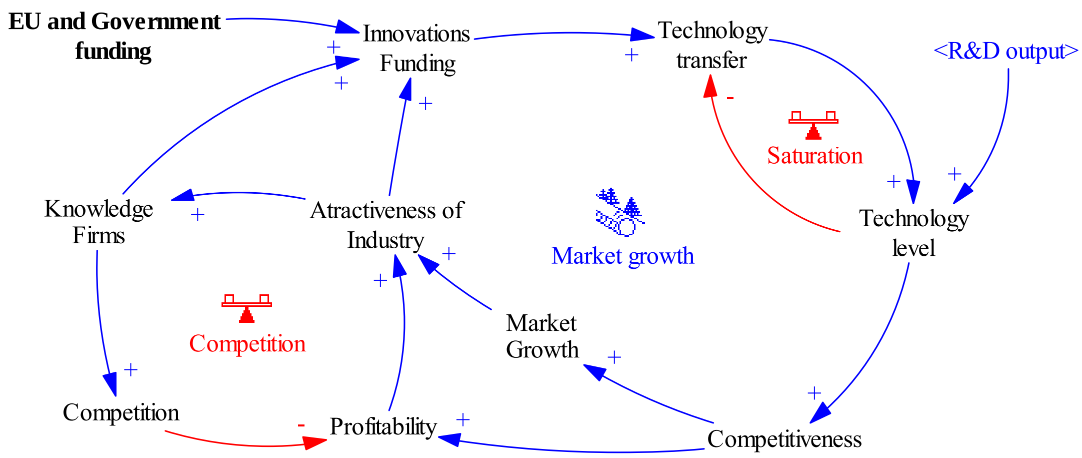

Figure 2. Technology transfer and knowledge industry growth.

In the first step of analysis we exclude R&D output impact and assume that technology level is determined by technology transfer, which is defined as “acquisition of knowledge and technology results from purchases of external knowledge and capital goods (machinery, equipment, software) and services embodied with new knowledge or technology that do not involve interaction with the source” [OECD 2005]. Technology level is considered as main driver of industry competitiveness that leads to increase in profitability and market growth (in Latvia case mainly through exports). Profitability and market size determine industry attractiveness, which in turn cause more knowledge firms enter the market. It’s expected that government support combined with significant EU funding will push innovation activities significantly in the coming years. However in longer term increasing number of knowledge firms shall generate also higher level of private sector funding for innovation and further technology transfers. Two balancing loops have been identified that back off the growth of technology level and market. The first is characterised by diminishing returns from technology transfer when the technology level in industry reaches saturation. In the second loop growing number of knowledge firms increase the intensity of competition, which negatively impact the profitability and taper the attractiveness of industry.

Building R&D capability

So far we have limited the model with an assumption that in a small country like Latvia with limited domestic R&D capability technology transfer is the only driver for rise of technology level. This is reasonable scenario in the initial phases of building knowledge-based industry but is considered not sustainable for long-term growth. It's highlighted by technology saturation feedback loop in Figure 2. Thus building domestic R&D capabilities is considered to be a key factor for further advancement of knowledge-based economy.

There is a long tradition in system dynamics community of modelling complex interactions within innovation process – starting from R&D activities [Roberts 1963], [Weil 2005] to new product introduction and diffusion [Ford 1998], [Milling 2001]. Comprehensive models for investigation of innovation dynamics on the firm and industry level are built. In our study focus is on leverage points and instruments that government can use to build effective national innovation system and promote public and private R&D activities.

The key linkage from R&D supply and demand model to knowledge industry is through R&D output (number of innovations, patents) that has positive link to the technology level. Generally R&D output is product of R&D activities (Figure 3). Some authors [Milling 2001] have criticized the attempts to define production function for R&D similar to that of material goods where output is produced by allocated resources like budgets, people and laboratory equipment. Thus partly stochastic nature of this link shall be addressed when simulation models are built. Increasing output of R&D activities has several important endogenous impacts – its enhances the technology competence level of involved stakeholders and increases motivation for research that is crucial for keeping existing and attracting new scientists and technical personnel. Beside that high level of R&D output informs educational institutions and help them to adjust their programs that in a longer run influence the availability of scientific and technical personnel with required competencies.

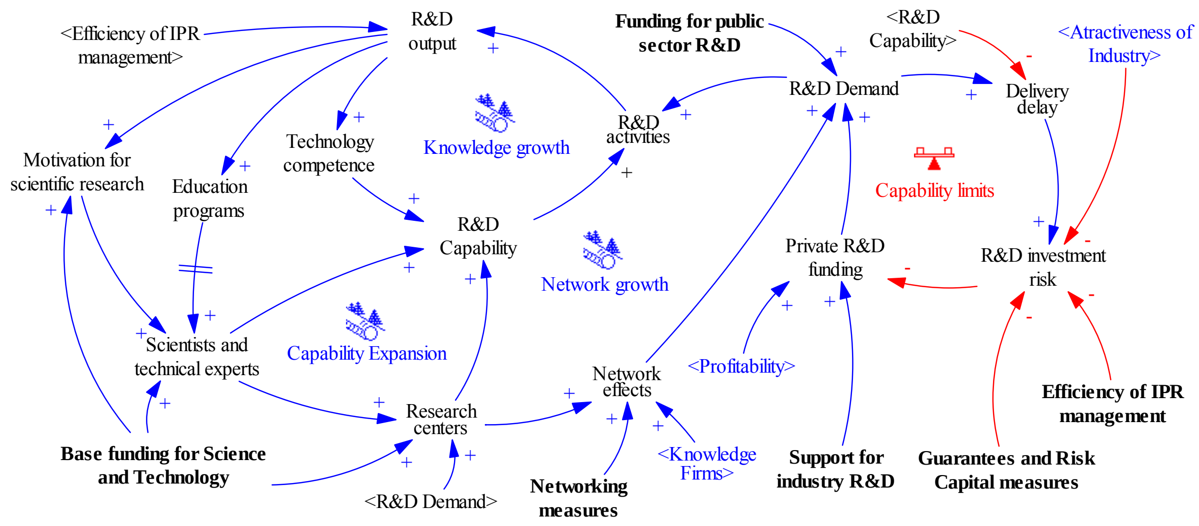

Figure 3. R&D demand and supply.

Research and development capability that constitutes supply side for R&D activities is a function from number active scientists and technical experts, their technology knowledge and number of research centres that operate in the respective sector. Number of scientists and technical persons is driven by motivation of existing researchers to continue and newcomers to get involved in R&D activities. In a long run adjustment of secondary and tertiary education programs to industry demands will also increase the availability of human resource with the right competence. It's considered that one of the key leverage points for government to increase R&D capability is to provide adequate base funding for science and technology. This includes infrastructure investments and running costs for public research centres (important part of it is attractive remuneration level for key scientific personnel). Research centres provide infrastructure, legal and intellectual property management framework for R&D activities. Public research centres in Latvia currently fully depend on government finance. However as links with industry, applied research and experimental development will expand, more dynamic interactions with R&D demand shall be establish. Thus evolution of research centres would become more market driven, which eventually would increase their competitiveness and lead to more effective utilization of public funding.

Public and private funding for domestic research projects constitutes the demand for R&D activities. Public sector R&D spending is directly determined by government policies whereas private sector contribution exhibits more complex dynamics. It's influenced by industry attractiveness and profitability of the knowledge firms as well as perceived R&D investment risk. Our focus here is on R&D activities performed within the country (knowledge import and contracting R&D to foreign research institutions is considered as a part of technology transfer). Therefore demand to the large extent depends on contacts and level of cooperation between knowledge firms and local research centres. By strengthening R&D and innovation linkages between industry and public research organisations and stimulating inter-firm networking government can have notable impact on increasing domestic demand. On the other hand inadequate capability of domestic R&D performers is hampering domestic demand and thus increase the investment risk. That in turn has adverse effect on private sector R&D spending.

Increase of private sector R&D spending is a key objective in building knowledge-based economy. Variety of policy instruments is available for government to influence private sector motivation. The first set of policy measures focus on reduction of R&D investment risk. Much R&D work is paid for through finance supplied in the form of equity investments or certain types of loans. Longer-term reinvestment of profits into further R&D by more established knowledge intensive firms is typically built on this foundation. Loan and equity guarantees are financial instruments, which transfer part or all of the risk of investment from investors to the provider of the guarantee. The most basic justification for guarantees is market failure in the sense that R&D projects with favourable risk-return profiles are unable to obtain external financing. Other direct leverage point for government to reduce the R&D investment risk is support for research institutions and industry in managing intellectual property rights. The policy instruments for developing favourable intellectual property rights regime include clarification of ownership of IP; adequate funding for the cost of protecting IP through patenting, for legal costs and for professional intellectual property asset management [EU 2003]. Second set of policy measures is aimed at direct advance of domestic R&D demand either through increased funding for public sector R&D projects or through supporting private projects (through grants, fiscal and other direct or indirect measures).

Scarce human resources

Capability for applied research and experimental technology development was to the large extent destroyed in Latvia together with industry demand collapse in early nineties. Period of fundamental transformation of economy and low public funding has significantly decreased domestic R&D activities. This has lead to the situation where many scientists, engineers and other key personnel have changed their occupation or even left the country. Also number of doctoral students in natural and engineering sciences involved in research has deteriorated. Thus significant human resource gap has evolved and it has become one of the major impediments for rebuilding R&D capability in Latvia.

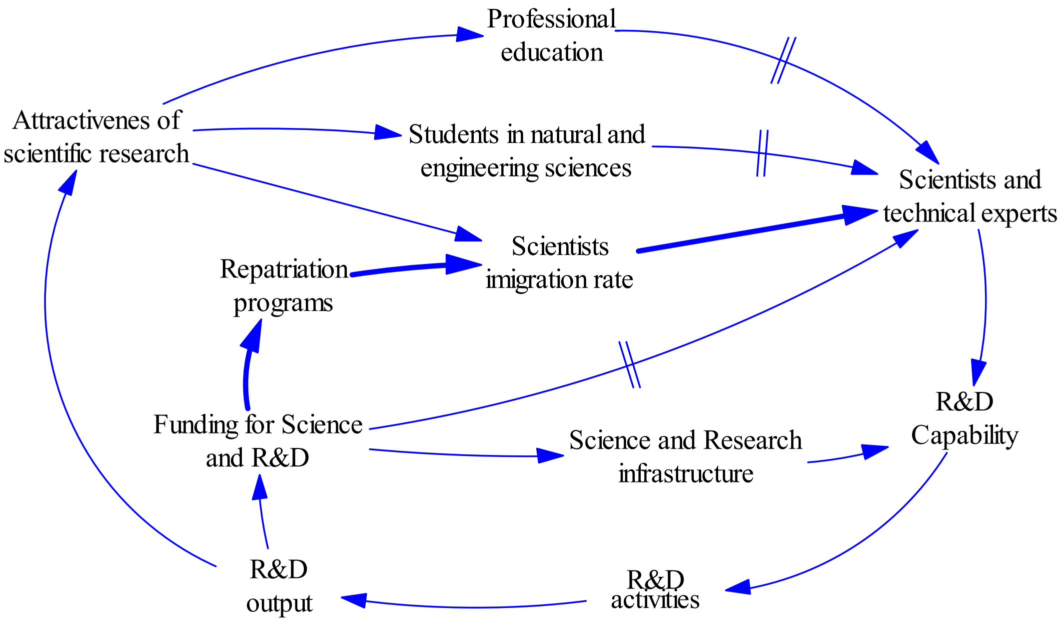

Figure 4. R&D resource adequacy.

Basic feedback structure for dynamics of scientific and technical experts is shown in Figure 4. Disproportion between students in social and humanitarian sciences vis-à-vis natural and engineering sciences has evolved during slow down in R&D activity. Gradual increase in funding for personnel involved in R&D activities in the long-term will motivate more graduates to start work for research. However there will be significant time delay before attractiveness for scientific research and its status in society is regained and new scientists and technical experts are educated.

The only viable leverage that can deliver results in relatively short term is change in (currently negative) immigration rate of key R&D personnel. This can be achieved through repatriation programs for Latvian scientists that would be interested to return to the country or attraction of foreign researchers in chosen sectors. However both options require very focused increase in funding which is difficult to achieve without explicit support from government programs.

Conclusions and further steps

Latvia is on the way towards knowledge-based economy and government shall have a sound economic, science and education policy to drive this journey. Several policy instruments are available to influence the process. Systemic approach with coordination between public institutions and industry is required to find the right mix of policy measures and to achieve optimal results.

Technology import and domestic R&D are the main sources of the knowledge required for innovations. Openness and support for technology transfer is very important for the small country like Latvia particularly in the period of relatively low domestic R&D capability. However technology transfer alone is not sufficient for sustainable growth. Advances in scientific education, research and technological development are needed to sustain competitiveness. Holistic view on complex R&D supply and demand interactions is taken to evaluate the impact of different policy instruments.

Scarce number of scientific and technical personnel capable for competitive applied research and experimental technology development is considered as one of major impediment for advance in domestic R&D capability. Investments for human resources and research infrastructure shall be balanced to achieve adequate return. Both short and long term policy options for increasing R&D

capability require close cooperation between government institutions (in particular Ministry of Science and Education and Ministry of Economics).

Further quantitative analysis for policy impact assessment is considered in following areas.

- Dynamics of R&D capability expansion – simulation model for scientific and technical personnel development (considering age structure) and balance between human resource and infrastructure funding.
- Industry dynamics, innovation, R&D supply and demand in chosen sector (electronics).

Figures

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