RESEARCH POLICIES REWARDING QUANTITY: ESTONIA AND UKRAINE

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Abstract

This article is resting on the theoretical model of Braun (2003) describing the delegation modes for public funding of research in the principal-agent framework. It aims to show by using the conceptualisation of utility functions of principal and agents on the various levels, how different motivations for producing different kinds of research outputs emerge for researchers and universities or public research organisations in Estonia and Ukraine. The article attempts to offer one explanation to why in some quantitative research output indicators both countries perform very well compared to much lower levels of innovation system indicators otherwise. Estonia is rewarding publications and Ukraine is rewarding utility model applications throughout different levels of the system.

Keywords: universities, PROs, publications, patents, utility models, incentives, research funding, transformation

JEL: I23, I28, O31, O38

1. Introduction

Many similar development problems characterise Central and Eastern European (CEE) transition countries, including the general fragmentation of the innovation system at all levels: country, regional and sectorial. It is typical that neither formal nor informal institutions are strong in supporting the innovation processes in these countries.

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Mismatches in developing the dynamic capabilities of different actors in the innovation system become evident, revealing that appropriate innovation capabilities are not matching in real time. The mismatch is caused by currently undertaking several weakly coordinated reforms, but also because of the lack of strategic plans or deficiencies in their implementation.

These transition countries can also be characterized by different alignment of innovation capabilities of firms and research-performing institutions (e.g. weak absorptive capacities of firms, weak applied research in the public science system) and lack of skills for commercializing research results. Governments with weak strategic development capabilities aggravate the situation by setting formal goals emulating those of Western countries (Havaš et al 2015), which leads to the strengthening of old routines in the innovation systems (path dependency) (Ukrainski et al 2015). The research policy in CEE countries has to also address the growing competition for stable or shrinking resources, which results in pressures to increase the effectiveness of research organizations (the so-called Red Queen hypothesis on competition).

The popular rhetoric that encourages the restructuring of transition countries into knowledge-based economies foresees reforms of both private and public sector governance systems. Companies need to be more innovative and to focus on R&D and high-tech exports. The public sector needs to increase efficiency, effectiveness, coordination, and cooperation capacity to provide policies that support the changes in private sector governance systems (Karo 2011). For that purpose, new public management (NPM) and planning programming budgeting systems (PPBS) as management concepts for public sectors have been used.

These approaches use various quantitative indicators in planning, implementation and auditing phases of management. Sometimes the use of quantitative indicators as target variables can have adverse effects. For example, "publication inflation", predicted by Geuna and Martin (2001), is one of the examples of the results of these quantitative targets within performance-based systems of management in the research setting. One would expect such quantitative indicators to be misused in many transition countries where the appropriate analytical support in terms of data availability is not sufficient for providing policy-makers the necessary background for adequate decision-making and evaluation. Butler (2006) has shown how, in Australia, the publication habits of researchers have changed in response to quantitative evaluation procedures in the university sector. The publication activity of Australian researchers increased substantially while relative citation impact decreased, leading her to question the appropriateness of such policies rewarding quantity.

This paper discusses two transition countries, Estonia and Ukraine, and their achievements in research outputs in terms of publications, patents, useful models and their applications. The aim is to elaborate the possible mechanisms behind the relative success of these quantitative aims of the research policy and highlight the incentives that matter for larger efforts behind these research outputs. This issue is very important for CEE countries in general because they differ vastly in the actors involved as well as in the relations and motivation they have for knowledge transfer. "*Countries are characterized by systemic differences and therefore what is best practice in one country or region will not be best practice in another. Therefore the more modest aim to develop 'good' and 'better' practices through 'learning by comparing' is more adequate*" (Lundvall, Tomlinson 2001: 122).

2. The Principal-Agent Delegation Problem in Quantity Rewarding Research Funding

The following discussion is based on Braun (2003: 310-311), where he explains the paradox of research funding for the government via the principal-agent theory. In his conceptualization the principal has the utility function, connecting the benefits from the research and associated costs in terms of funds transferred to the agents (research performers). More precisely, the specification of principal's utility function is the following:

$$U = x(e) - (a + b + a^{*} + b^{*} + C(D) + C(M)) \qquad (1)$$

where *U* = principal's utility (in wealth)
x(e) = the benefit (profit) for the principal from the effort of the agent
a = baseline (lump-sum) funding for research institutions
a^{*} = conditional baseline (lump-sum) funding for research institutions
b = project funding for the research
b^{*} = conditional project funding for the research
C(D) = decision costs related to the criteria for funding
C(M) = monitoring costs

The agents can be analysed on different levels – the institution level and the individual level, e.g. universities and PROs, faculties, research groups and individual researchers. Each of the types of agents may have different utility functions depending on the type of funding, specific values of the research services provided for the government, or specifics of the research field. More generally, the agent's utility function positively depends on the research income and is negatively associated with the costs of doing research. Hence the following utility function characterizes the agent:

$$V = a + b + a^{*} + b^{*} - \left(\frac{C(T)}{Y(e)} + C(A) + C(M)\right) + Y(e) \qquad (2)$$

where: *V* = agent's utility function
C(T) = time costs for the agent in conducting research for the principal.
C(A) = time costs for the agent for acquisition of funding projects
C(M) = costs stemming from monitoring efforts of the principal

Y(e) = the benefit (yield) of the agent's efforts in terms of reputation, career etc.

The time the agent uses for the research must be related to his own career purposes because the activities delegated by the principal (conducting research) are also rewarding the agent in terms of career, monetary benefits (salary, premiums, awards, licensing revenues), etc. Garcia and Sanz-Menendez (2005) discuss in more detail how the credibility cycle of the agents entails the competition of research funds, thus building a cycle of relationships between agents and the principal.

Different kinds of research activities are not similarly rewarding to the agent. Braun (2003: 311) offers the following example: ten hours used for an applied research project by the agent on the directive of the principal might be a waste for the agent if compared to basic research yielding a scientific publication contributing to the career of the researcher. In that case the agent loses ten hours of her time. If there are some benefits to the agent, the wasted time cost becomes smaller. Here many other factors influence the activities of the agent besides funding, like psychological factors and the demographic characteristics of the agent, the socialization environment of the researcher, the department's or the institution's prestige, organizational designs or the cumulative advantages of publishing (like the Matthew effect) and respective reinforcing processes in publishing (Fox 1983).

Braun (2003) links the utility models (1) and (2) to the funding systems in two main delegation types. The first type, blind delegation, is used when the principal entirely entrusts the scientific system (agents) to make decisions, act, and control research activities. Institutional funding and project-based funding grants are unconditional, i.e. they are provided for scientists without any specific conditions attached. The utility functions of the principal and agents are reflected in the equations (3) and (4) (Braun 2003:312-314):

$$U = x(e) - (a + b) \quad (3)$$
$$V = a + b + Y(e) - C(A) \quad (4)$$

The second type, delegation by incentives, is used when the principal establishes incentives for the research system via price signals, rewarding the preferred type or topic of research more generously. The agent can also use signals via research outputs (publications or patents) reflecting his innovative activities, so the coordination of individual scientists occurs via the mechanisms of signals that are perceived as valuable in the scientific community. How well the scientists respond to the incentives of the funders is determined by the wider conditions for researchers to fund their research. The utility functions then resemble the equations (5) and (6) (*Ibid*):

$$U = x(e) - (a + b + b^* + C(D) + C(M)) \quad (5)$$
$$V = a + b + b^* - \left(\frac{C(T)}{Y(e)} + C(A)\right) + Y(e) \quad (6)$$

While the first type of funding mode was gradually replaced in developed Western countries by the second type, in transition countries, the change occurred within a short time frame because the Soviet-type research system was dominated by blind delegation, where block grants were given to institutes and scientist-administrators had great autonomy in distributing the funds (Geuna, Martin 2003). The use of the NPM and PPBS management concepts additionally implies that the aims and evaluation bases are set quantitatively, giving the actors motives that align respectively with their actions.

According to Braun (2003), the shift from blind delegation towards delegation by incentives introduces two types of changes in the research system. The first is the "gold rush" phenomenon, which occurs under the conditions of decreasing unconditional institutional and project funding grants (*a* and *b* in equations (1) – (6)) leading the agents to rush into areas with the highest price signals or incentives set by the principal. The second change is that the reputation of the agents in a science system that typically relies on publications also shifts towards the quickest response in finding money for the research activities. This puts pressure on researchers to pursue their career while responding to the conditions of grants set by the principal while the return for the researchers decreases (Braun 2003).

The following factors become relevant: what kind of research output $x(e)$ the principal prefers by setting aims for the whole system as well as establishing the conditions and criteria for institutional or project-based research funding instruments. In the public management systems like NPM and PPBS, these aims are set using the quantitative indicators of research outputs with a certain perceived quality, ISI refereed publications or patents and utility models registered in the local or international patent office, for example. Therefore the wider setting of the institutional and funding environment plays a role in how researchers respond to the research policy.

3. Estonia and Ukraine: Developments of Research Systems

The innovation systems of former Soviet countries have developed quite differently; the Baltic States have discarded the old Soviet-style Academy of Science model and gave many more responsibilities to the universities (so-called European model, see also Lepori et al 2009). Estonia has, during the last decade, moved to an innovation system that is concentrated more on enterprises and universities as main actors, making it similar to the small Nordic countries but different from larger countries like the USA, Japan and South Korea, which rely more on public labs. The development of the Ukrainian system shared certain common features with the early stages of transformation in Poland, Hungary and some other Eastern European countries (Dyker 2004), but also reflected very similar developments to those in Russia (although more recently Russia has exerted a stronger focus on modernizing its R&D structures) (Yegorov 2009).

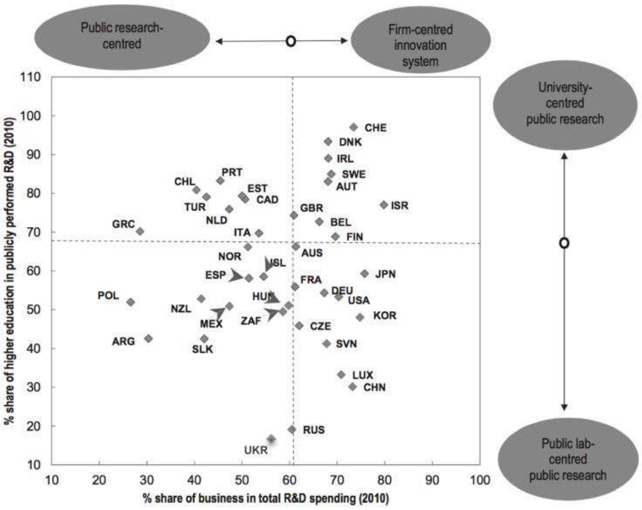

Figure 1. Archetypes of innovation systems in 2010

Source: OECD (2013: 28), Ukrainian data added by authors for the average of 2006-2009 provided by Strogylopoulos et al. 2011:14

The Ukrainian national system of innovation relies more on public research organisations (institutes and, to a smaller extent, former industrial branch-related research organisations and design bureaus), and as indicated by Yegorov (2008), universities are not the drivers in the innovation system, because despite their increasing research spending, it is still extremely low and many universities miss the R&D focus (see also Figure 1).

Stemming from the similar history of over-sized public R&D systems, both Estonia and Ukraine have concentrated their R&D activities into a smaller number of institutions. In Estonia the number of research-performing institutions is rather small and during reforms, the number of institutions significantly decreased. For example, in 2005, 111 research-performing institutions (Masso, Ukrainski 2008) were counted; since 2010 those institutions positively evaluated as R&D institutions involve six public and one private university plus 12 other R&D institutions (including development centres, museums, institutes and R&D companies).

In Ukraine, the number of research-performing organizations is much larger, but this number is shrinking (see Figure 2). It is interesting to note that in Ukraine, the major players can be seen in research institutes subordinate to the state-funded academies of sciences, which numbered 351 in total in 2012 and were distributed, according to Yegorov, Ranga (2014: 8) as the following: 199 National Academy of Sciences of Ukraine (NASU) institutes, 93 Ukrainian Academy of Agrarian Sciences institutes, 17 Academy of Pedagogical Sciences institutes, 35 Academy of Medical Sciences institutes, two Academy of Arts institutes and six Academy of Legal Sciences institutes.

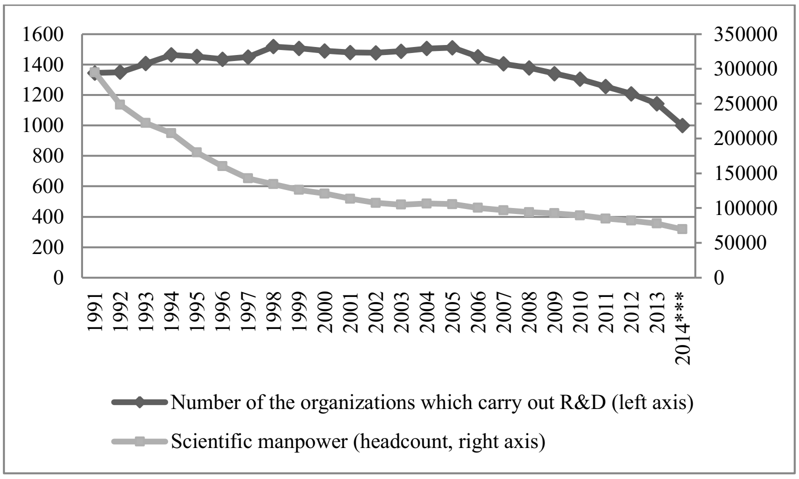

Figure 2. R&D institutions and scientific employees in Ukraine
Source: State Statistical Service of Ukraine (http://www.ukrstat.gov.ua/)
Notes: Since 2006 the organizations which carried out only scientific and technical services do not report. The data of 2014 exclude the temporarily occupied territories of the Autonomous Republic of Crimea, the city of Sevastopol and part of the anti-terrorist operation zone.

Ukrainian universities are primarily focused on higher education and only half (176 out of over 350) are research-performing (Yegorov, Ranga 2014). The universities are discouraged in performing R&D by low levels of R&D funding via state block grants and various state programs (Ibid.). The rest of the one thousand R&D-performing institutions in Ukraine comprise branch institutes and design bureaus, the number of which is changing as they are struggling for sustainability (depending on how their customers – factories are developing). Hence the two countries are rather different in their focus – Estonia focuses on universities as the main research performers and Ukraine on PROs.

The development of the research systems is closely linked with funding (see also Figure 3). According to the Statistical Service in Ukraine, the R&D investment level is low and shrinking, as, for example, in 2013 the amount of R&D funding from the state budget was only 0.33% of the GDP (from all funding sources, a total of 0.77% of the GDP), and by 2015 it decreased further to 0.27%. This is the lowest rate of funding for science in Ukraine since it gained independence (Recommendations on… 2015). In Estonia, an upward trend (with some downturns) can be seen with the government contributing around 0.7-0.8% of GDP and business-related expenditure being more volatile and responsible for the sizeable peak in 2011-2012.

In 2014, the further reduction of total R&D expenditure to 1.45% of the GDP was registered according to the data of Statistics Estonia. This clearly has an impact on research outcomes.

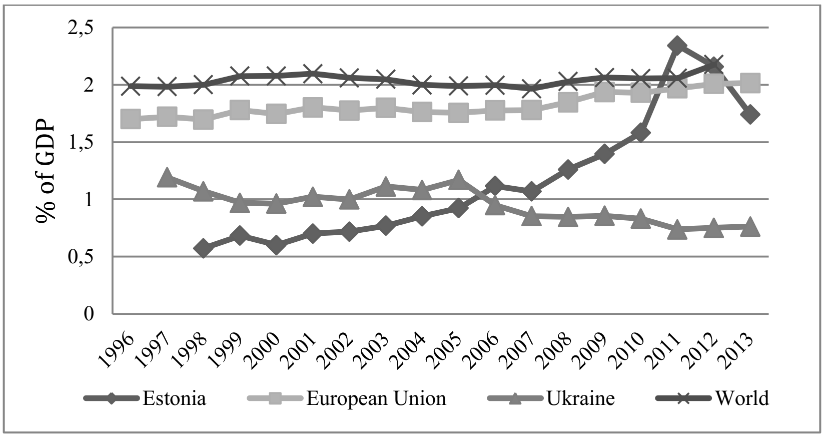

Figure 3. R&D expenditure as share of GDP
Source: The World Bank. World Development Indicators, last updated 22.12.2015

In research funding, the blind mode of delegation dominant in the Soviet research systems changed in both countries during transition. In Ukraine, institutional funding still dominates and the system resembles more closely blind delegation on behalf of the state. However, different other funding streams (private firms, competitive grants, international funds) have emerged. Although there are no internationally comparable funding indicators on the national level for Ukraine or Estonia, one can say, based on the NASU annual report, that in 2011-2015, block funding has covered about 56-63% of total funding in NASU institutes. The competitive research grants were 18-20% and contracts with firms 19-20% (NASU 2016).

In Estonia, the delegation by incentives funding mode prevails as project-based funding instruments' share in funding is extremely high (over 90% of total research funding). Only one instrument (so-called baseline funding), which is not project based but is still competitive, exists. Therefore, Estonia stands out with the highest project-based funding share in Europe (compared, e.g. to Ireland with 67%, Germany with 36%, the Netherlands with 31%, and Estonia with 96%). By looking at the university level, the share of project funding in total research funding varies a little, but it is still above 90% in all public universities, who are the main research performers (Ukrainski et al 2015). As in Estonia some R&D institutes have been 100% project funded since the early 2000s, it has been found that the growing number of institutes within the University of Tartu, the largest research performer in Estonia, also fund their research this way (Ukrainski et al. 2015). Therefore, Estonia seems to have completely abandoned the blind delegation type of research funding, implying that the coefficient $a = 0$ and a^* is very low in the utility functions (it can also be expected that the cost parameters *C(D)* and *C(M)* are therefore higher for the principal (equation 5) and *C(A)* and *C(M)* higher for the agent (equation 6)). In Ukraine, a and a^* are much higher compared to Estonia.

Estonian universities as main research performers are autonomous in responding to the incentives set by the government (principal). A study conducted by the European University Association (Estermann et al 2011), concluded that Estonian universities have very high autonomy compared to other European universities in terms of organisational matters, financial matters, staffing and academic matters. Yegorov and Ranga (2015) describe the Ukrainian university system as being led by the government in terms of general strategy and administration.

One important aspect, also characterizing the competition within the research systems, is the number of researchers (relative to funding). According to the Ukrainian State Statistical service, the number of researchers has dropped four and a half times (from 313,079 in 1990 to 69,404 in 2014). The shrinking processes seems not have stopped yet. In Estonia, the relative stability of the number of employees in the higher education sector has been achieved and in the business sector this number has even grown due to relatively better labour compensation (see Figure 4).

In recent years, the business sector has improved its R&D capabilities substantially in Estonia. The respective business expenditure (BERD) has in the past years grown to 1.45% of the GDP, which is above the EU average. The R&D activities of firms have been highly concentrated, and in international comparison it has been pointed out that it is difficult for Estonia to be successful as a knowledge-based economy if only 10% of businesses are involved in R&D (European Commission 2012). Calculations based on Statistics Estonia data show that the concentration of business R&D has increased over time. In 2009, the expenditures of the 50 largest companies totalled 30%; in 2012 it was 85% of total R&D expenditure (Ukrainski, Varblane 2015). In other words, in Estonia the investments of only a few companies were behind the rapid increase in business R&D expenditure. It should also be noted that a similar concentration can be seen in Ukraine, where the R&D is also performed in a relatively small number of firms. Methodologically comparable statistics are not available, but a similar survey to the CIS of EUROSTAT reveals that in 2014 only about 26% of innovative firms (approximately 16-17% of all firms surveyed) spent money on R&D, while the rest spent it on acquiring new machinery, equipment, software, etc. (Science and innovation… 2014).

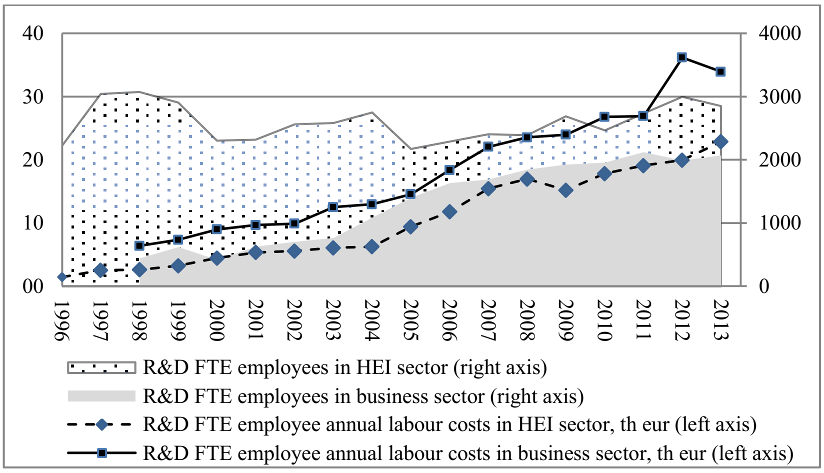

Figure 4. R&D employees and annual R&D labour costs in Estonia
Source: Ukrainski (2016), calculated by using Statistics Estonia Electronic Database

The number of R&D employees has grown in the EU to over 3000 employees per million several years ago. Estonian development has followed this trajectory (see Figure 5). The number of researchers in Ukraine has dropped significantly, and per million inhabitants it is almost three times lower than in the EU, on average. The main reason for this is the decrease in funding levels lasting for several years. According to Yegorov (2009), out of 83 thousand researchers, 65 thousand worked in R&D as a secondary job, which is a specific characteristic showing that the financing gap is even higher. The systems are similarly characterised by aging of research staff, but there has been a huge outflow of researchers to other jobs as well as through emigration, especially in the 1990s (Yegorov 2009). The decline of R&D funding that started in the 1990s and lasted throughout the following decade meant that the bulk of it has been spent on wages and on bills for utilities (Yegorov 2009). There has been significant amortization of the equipment, which has probably further eroded scientific research possibilities, especially in fields of natural and engineering sciences, where equipment plays a significant role.

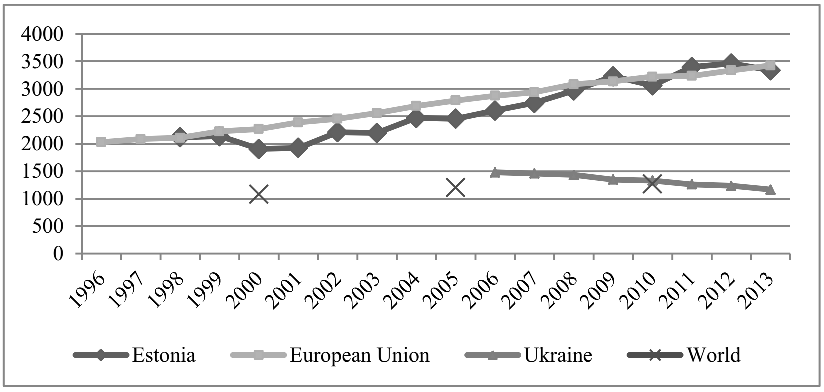

Figure 5. The number of researchers per million inhabitants
Source: The World Bank. World Development Indicators (last updated 22.12.2015)

The background conditions are quite different for Ukraine and Estonia - the first has been in recent years a shrinking research system, while the second one has been expanding in terms of researchers and funding. It can be argued that in both countries, research-performing institutions (universities and PROs) have experienced intensified competition. In Ukraine, the competition increases in terms of vertical coordination for decreasing basic funding. In Estonia the decline of the number of students as well as opened up markets for higher education via EU accession have strengthened the competition for (foreign) students (see also Ukrainski et al 2015). As Watts et al (2015) point out that in this competitive race, "running fast" in terms of the Red Queen hypothesis allows the achievement of a high number of publications and high international accreditation rankings. "Running slow" shows maladaptive consequences adversely affecting growth rates, quality and staff performance of universities and PROs.

4. The Knowledge Creation Outputs in the Innovation Systems of Ukraine and Estonia

The knowledge creation outputs are typically publications and patents (Leydesdorff, Wagner 2009). To see the dynamics of these outputs for Ukraine and Estonia, the Global Innovation Index comparison is used, placing the respective output values between 0 and 100 depending on the countries' relative position to other countries in the world. Figure 6 shows that the general index for these countries remains in the middle range among all the countries (52.8 for Estonia and 36.5 for Ukraine) and a similar indicator level is seen for the knowledge creation sub-index (31.9 and 49.2, respectively). Still, some very high levels of indicators are revealed in knowledge creation outputs and these are, to an extent, patents, but utility models (value of 100) for Ukraine and scientific and technical publications (value of 73.5) for Estonia also play an important role. These indicators reflect exceedingly high levels compared to other indicators characterizing the innovation systems. We discuss the incentives behind these quantitative research outputs below in more detail.

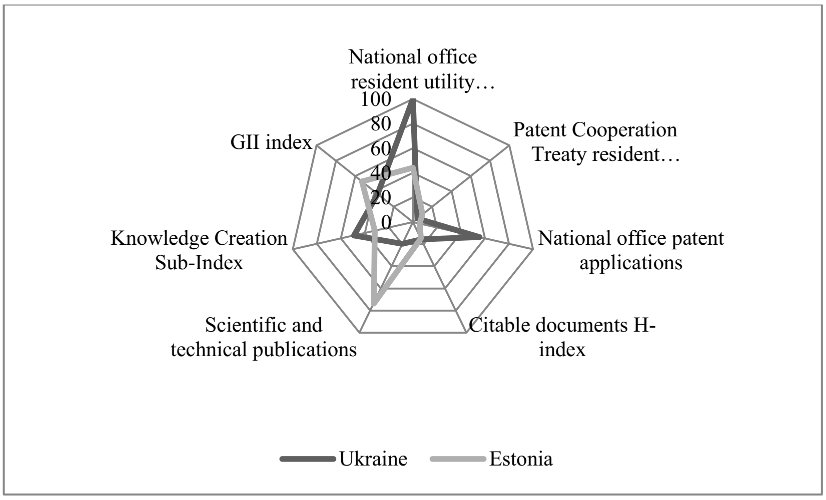

Figure 6. GII index, Knowledge creation sub-index and indicators in 2015
Source: The Global Innovation Index 2015

If we first look at the publications in the field of science and technology, which were strongest in both countries before transition compared to social sciences and humanities, we see that indeed the number of publications seems to have increased very fast in Estonia. It almost tripled in the period of 1993-2011, while in the EU and in the world it increased about 1.5 times. Of course the initial level of international publications was very low in both countries, as the Soviet research system did not encourage and reward publication activities. In the Ukrainian case the number of publications jumped to almost 3000 publications in 1994 but has shrunk thereafter and shows a persistent downward trend. The possible reasons are associated with the decline of the system, but also with the possible reward mechanisms that are absent in publications and exist only in patenting or utility model registration. Strogylopoulos et al (2011: 7) describe how more than two thirds of academic employees with scientific degrees in Ukraine are working in HEIs producing approximately 77% of research papers. The data in NASU (2016:30) show that only about 23-24% are published internationally. As in the innovation system, research institutes dominate (with clear focus on technical and natural sciences), and the publication output is also less important compared to more "applied" type of output – patents and utility models.

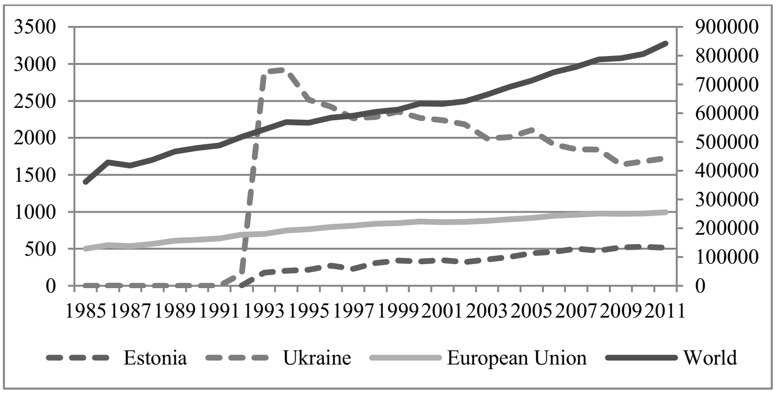

Figure 7. Number of scientific and technical journal articles
Source: The World Bank. World Development Indicators (last updated 22.12.2015).
Note: Scientific and technical journal articles refer to the number of scientific and engineering articles published in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences.

By looking at all publications we can see that the number of total publications in both countries has increased considering all fields of science (and so have the citations of those publications, Figure 8 and Figure 9). In 2011-2015, on average, the number of publications has achieved 114% over the average level of 2005-2009 in Ukraine. For Estonia, the same indicator is 169% (see also Figure 9). Citations have increased respectively to 196% in the case of Ukraine and 301% in the case of Estonia.

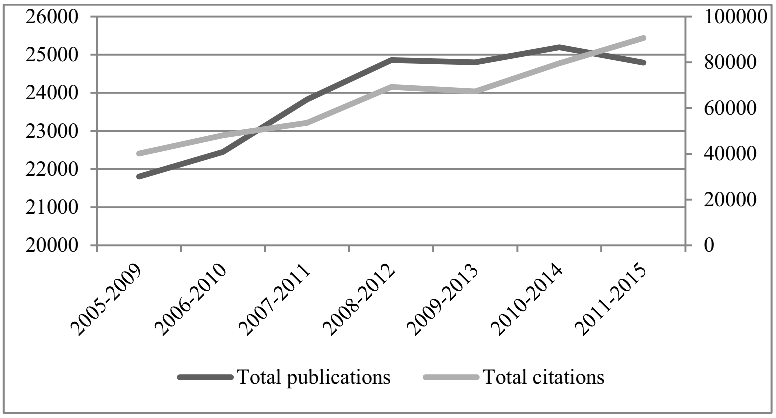

Figure 8. ISI Publications and citations of Ukraine
Source: Thomson Reuters. ISI WOS Essential Science Indicators 2016

In Estonia, the resulting incentives of different levels of the research system have led to the domination of publication as a main strategic output of research. It can be argued that in producing the output, the motivations on the individual, research group, university and system level coincide. In Knowledge–Based-Estonia 2007-2014 (hereinafter KBE-2), a research and innovation strategy document, the number of ISI publications is the only indicator that exceeds the target value by 1.5 times. Perhaps it is also an indicator which is more easily achievable compared to productivity and cooperation indicators characterizing the functionality of the whole innovation system. Secondly it is understandable to researchers, managers and policy-makers in the same way and is also well-suited to all interests. There is no other indicator with comparable incentives at all levels. In Estonia, high-level publication activity is sometimes also rewarded on the faculty level with financial benefits. The broader role of scientists in society is not well understood and discussed. The third-mission aims are quite confusing as they are not incorporated into the general logic of research and funding procedures and often seem as an additional and optional task for researchers (de Jong et al. 2015). In the researchers' utility function, it would only enhance *C(T)* leaving *Y(e)* relatively unchanged.

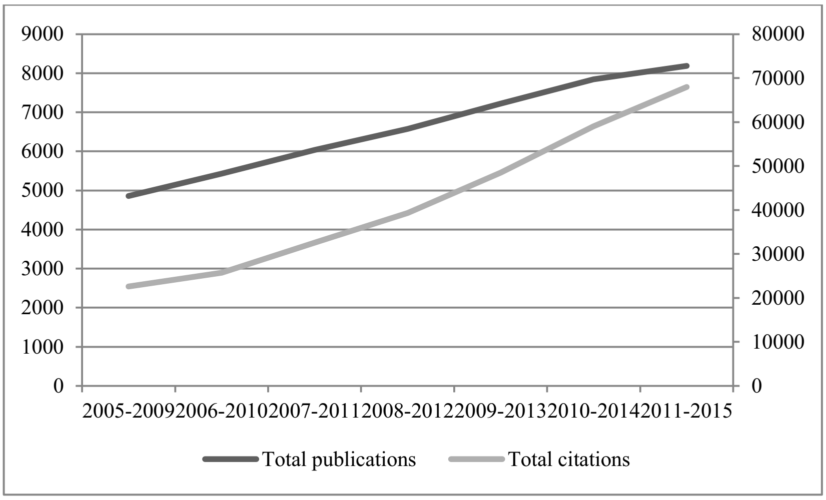

Figure 9. ISI Publications and citations in Estonia
Source: Thomson Reuters. ISI WOS Essential Science Indicators 2016

In Ukraine, the necessary legal framework for intellectual property protection was formed in 2000 when the respective basic laws were adopted (Kossko 2014). This resulted in a growing number of patent applications and granted patents. However, the trend turned in 2003 towards a rapid increase of applications in utility models because after a short-term patent (6 years), patents on improvements based on research experiments could be applied for (Kossko 2014: 92). Countrywide competitions between PROs based on utility models and patents (e.g. "Honoured Inventor of Ukraine") as well as competition between the institutions within the system of Academy of Science (“Inventor of the Year”) exist in Ukraine to support the engagement of the PROs and individual researchers in applying patents (Ibid.). Utility models can be registered within 3 months and they are not expensive to apply for (thus making *C(T)* in relation to *Y(e)* smaller). Although the importance of patenting here is illuminated in Ukrainian NASU institutes, their role as a university quality indicator for the wider public is recognized (Leydesdorff et al 2015).

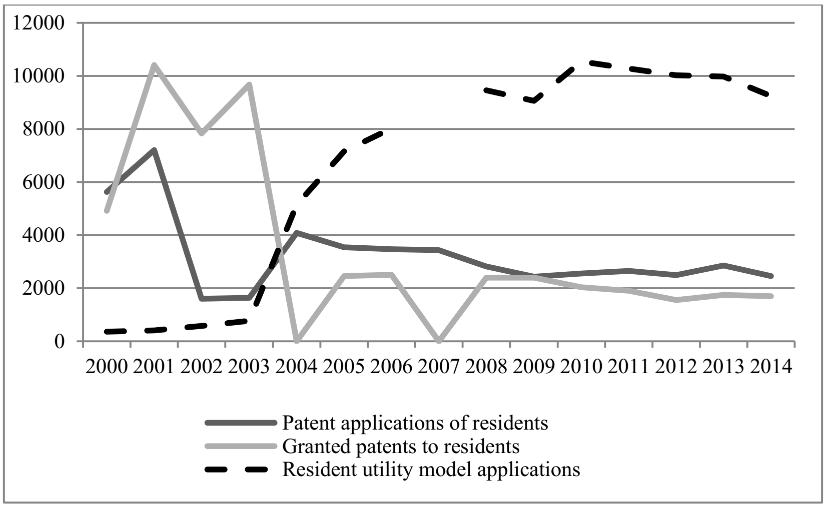

Figure 10. Patent applications, utility model applications and granted patents to residents of Ukraine
Source: WIPO Statistical Country Profile 2016

In Estonia, patents and patent applications are defined as a research indicator for different purposes (research funding, academic career, PhD thesis). The allocation of baseline funding is also based on the number of high-level publications in internationally recognized journals, the number of high-level research monographs and the number of patents and patent applications. A patent application is equal to two and a granted patent to three high-level research publications. Research publications determine 50% of basic finance (Riigi Teataja 2005) Regulation on baseline funding § 3).[5] In order to be eligible for the position of a professor, the candidate, among the other requirements, must have supervised one defended PhD thesis or have research results published (R&D Act § 8). The University of Tartu (UT) and Tallinn University of Technology (TUT), which are the main universities in Estonia, consider, under certain conditions, patents/patent applications to be equal with high-level publications (University of Tartu (2014) § 17; Tallinn University of

[5] Since 2016, the proportion has been changed to 40% and the proportion of research contracts to 50% (https://www.riigiteataja.ee/akt/127012016005).

Technology (2012) § 18). However, the costs associated with patenting are making the C(T) higher in relation to Y(e) if compared to publications.

The Estonian universities have also created financial incentives to patent. The Procedure for managing intellectual property created at UT establishes an institutional ownerships regime (see Kelli et al 2014; Mets, Kelli 2012) and in return entitles the inventors to 65/80 of the net income received from the transfer for use of the university's intellectual property (§ 19). Principles for handling intellectual property in Tallinn University of Technology have the same approach. The inventor receives 40% of the profit (§ 11). However, these rewards are uncertain, which makes publications even more preferable to the researchers as a scientific output.

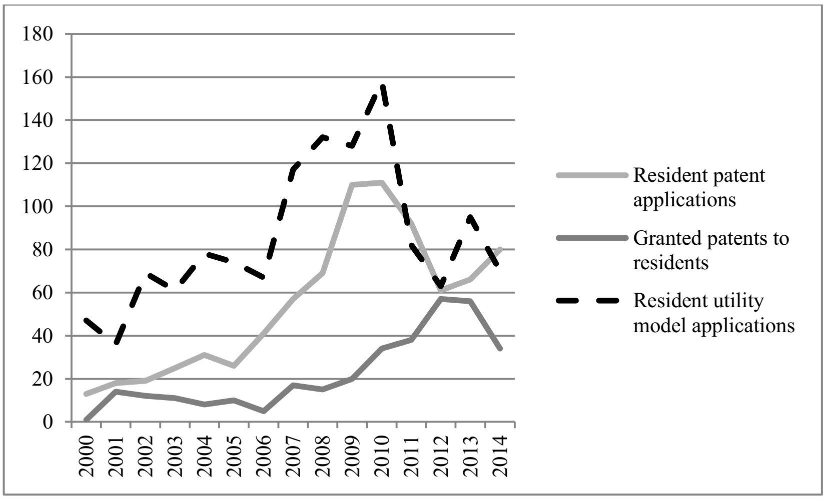

Figure 11. Patent applications, utility model applications and granted patents to residents of Estonia
Source: WIPO Statistical Country Profile 2016

The government sees the number of granted patents as a strategic indicator of KBE-2 set for the year 2013 (45 EPO patents) (KBE-2: 36). In reality this indicator has not been not achieved. Estonian residents were granted 9 patents and registered 43 patent applications. WIPO data show that both the applications and granted patents have even decreased in number in recent years. The data of the Estonian Patent Office for 2013 also show only 25 applications, but granted 47 patents. It can be said that the strategic aim for increasing patents as research outputs has not been achieved as it entails costs for the researchers (the application procedure as well as patenting the invention in different countries, the so-called patent family), while the revenues for the researchers considering patents are low (considering the formula, it is included in the parameter $a*$ in the equation (6), which is very small, about 5% of the total research funding).

5. Conclusion and Discussion

CEE countries place their emphasis on the impulses from academia as central to the innovation system (Molas-Gallart, Davies 2006; Tiits et al 2008). It is understandable since this phase of development is driven by investment rather than innovation, and firms' capability to become an important pull-factor for innovation activities is rather limited. Additionally, the actors involved are searching for their roles and are also, to some extent, strengthening their core capabilities and therefore do not move beyond them.

In Estonia and Ukraine, the shift from the blind delegation mode to the incentive mode has led to the "gold rush" phenomenon predicted by Braun (2003), but in different aspects of the innovation systems has been dependent on the aims set for these systems. Table 1 summarizes the incentives in the research systems of Estonia and Ukraine to respond to the quantitative aims – publications and patents (utility models). These incentives include motivation of individual researchers as well as incentives coming from evaluation procedures (at multiple levels and from monitoring instruments).

It is visible from the motives that the Estonian system is focused on publication production as a sign on the quality and internationally acceptable levels of research, while connectivity to the economy is less relevant. The Ukrainian system is much more related to its economy, and international connectivity is only increasing in relevance. In both cases, these "formalistic approaches" to increase respective quantitative aims should not be enhanced. Inventions need to be patented when there are clear business incentives and business models, to determine the invention's wider value. More complex aspects such as the size of the patent family, public-private cooperation in the creation of inventions, patent citations, successful commercialization, etc. should be taken into account. It is especially relevant for Ukraine because Soviet-inherited aircraft and steel industry, but also mining, atomic power stations etc. still exist there (these are vanished or substantially restructured in Estonia). The technical research solutions offered by Ukrainian research institutions could be still useful there.

Also in the case of publications, these reflect only partly the role of the research system in society. It is necessary that the awareness and motivations for universities and scientists (also working out specific indicators suitable and understandable in the context of different science fields to evaluate these activities) are guided towards connectivity with the economy and society more broadly. Also, it would be advisable to include these expectations in the funding schemes and strategic planning (as NPM and PPBS are still dominant) so that the third mission would become a part of scientists' careers. Due to the focus of the current article the authors do not address issues relating to the improvement of patent indicators here.

Table 1. Supporting incentives for knowledge creation indicators in Estonia and Ukraine

Level/Country	Estonia	Ukraine
Research system level	The output (x(e)) is measured in publications and patents. Universities as research performers dominate, weak incentives for applied research Baseline funding is minimal, implying that ($a + a^* < b + b^*$; a $(= 0) < a^*$)	The output (x(e)) is measured in patents and registered utility models (applications of science) PROs dominate, weak incentives to publish, technology transfer motives strong. Baseline funding is scarce but dominant, hence ($a + a^* > b + b^*$)
Institution (university/PRO) level	Benefit (*Y(e)*) is higher in publications compared to patents (less costly, rewards in university rankings, etc.) Distribution criteria for a* (baseline funding) are based on 50% of publication counts, patents are equated with 3 and patent applications with 2 publications). Production costs *(C(T))* are higher in the case of patents compared to publications (therefore *C(T)/Y(e)* is smaller for publications)	Benefit (*Y(e)*) is higher in patents and utility models via public contests, awards. Distribution criteria for a and a* are influenced by high esteem of the PRO Costs compared to benefits (*C(T)/Y(e)*) are lower in case of utility models (compared to patents, but probably also to publications)
Research group level	Success in high esteem, also dependent on the success in project applications (*b* and *b**) is based on publications history (thus supporting incentives to publish) Scientific esteem, and careers of the group (*Y(e)*) are based on publications and citations	Patents and utility models (*x(e)*) are encouraged in competitions between the institutions (Honoured inventor of Ukraine) The funding (*a, a*, b, b**) are influenced by the high esteem of the research group (based on the applications in the economy)
Researcher level	ISI publications as a means for legitimizing expertise for project applications *(b* and *b**) Scientific esteem and career (Y(e)) is based on publications and citations	Output (*x(e)*) is encouraged in competition between the institutions within the system of Academy of Science ("Inventor of the Year") Career development (*Y(e)*) is supported by patenting activities (as PROs dominate)

Source: Authors' compilation

Acknowledgements

This research has been financed by the Estonian Ministry of Foreign Affairs through the Development Cooperation project titled: "Improvement of regulatory and institutional framework of academia-industry knowledge transfer and development of core implementation competencies of knowledge transfer to enhance the knowledge based economy in Ukraine" (No 174-2015-A).

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KVANTITEETI TASUSTAV TEADUSPOLIITIKA: EESTI JA UKRAINA[1]

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Paljusid Kesk-ja Ida-Euroopa (KIE) riike iseloomustavad sarnased arenguprobleemid, mis väljenduvad innovatsioonisüsteemide fragmenteerituses kõigil tasanditel (riik, regioon ja majandusharu). On üsna tüüpiline, et nii formaalsed kui ka mitteformaalses institutsioonid ei toeta neis riikides innovatsioonide loomist ning osaliste võimekused ei ole innovatsioonisüsteemides hästi reaalajas sobituvad. Üheks põhjuseks on siin ka mitmete, omavahel nõrgalt koordineeritud reformide samaaegne toimumine.

Kuna KIE riikide valitsuste võimekused riike strateegiliselt arendada on suhteliselt nõrgad, siis sageli seatakse arengule formaalsed eesmärgid, mis jäljendavad arenenud lääneriikide omi (Havaš et al 2015), mis viib tegelikult vanade rutiinide (rajasõltuvuse) tugevnemiseni (Ukrainski et al 2015). KIE riikide teaduspoliitika peab lisaks strateegiliste eesmärkide puudumisele veel toime tulema stabiilsete või kahanevate ressurssidega, mis omakorda kasvatab survet teadusasutuste efektiivsusele. Järjest enam kasutatakse kvantitatiivsetele tulemusindikaatoritele orienteeritud juhtimiskontseptsioone (NPM ja PPBS) seejuures arvestamata, et kvantitatiivsete eesmärk-indikaatorite kasutamisel võivad olla ka soovimatud tulemused, nt publikatsioonide inflatsioon jne.

Artiklis kasutatakse Braun'i (2003: 310-311) mudelit, kus ta selgitab teaduse finantseerimise paradoksi printsipaali-agendi teooria kaudu. Selle mudelis sisaldab printsipaali kasulikkusfunktsioon (1) teadustegevusega soetud kasusid ning kulusid, mis on seotud rahastuse ülekandmisega agendile (kelleks võivad olla üksikteadlased või ka teadusasutused – need, kes teadustööd teevad). Kasulikkusfunktsioon on seega:

$$U = x(e) - (a + b + a^* + b^* + C(D) + C(M)), \qquad (1)$$

[1] Artikkel "Research Policies Rewarding Quantity: Estonia and Ukraine" asub publikatsiooni CD-l.

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kus U = printsipaali kasulikkus (heaolu)
$x(e)$ = printsipaali kasu (kasum), mis tuleneb agendi pingutusest
a = teadusasutuste baasfinantseerimine (*lump-sum*)
a^* = tingimuslik teadusasutuste baasfinantseerimine (*lump-sum*)
b = teaduse projektipõhine finantseerimine
b^* = tingimuslik projektipõhine finantseerimine
$C(D)$ = rahastamistingimustega seotud otsustamise kulud
$C(M)$ = järelevalve kulud.

Agentide kasulikkusfunktsioonid võivad olla erinevad sõltuvalt sellest, kas agenti vaadeldakse indiviidi, teadusgrupi või –asutuse tasandil, kellel kõigil võivad olla erinevad kasulikkusfunktsioonid sõltuvalt rahastamisest ja teadusvaldkonna spetsiifikast. Agendi kasulikkus (2) sõltub positiivselt teadustuludest ja negatiivselt teadustööga seotud pingutusest ja kuludest:

$$V = a + b + a^* + b^* - \left(\frac{C(T)}{Y(e)} + C(A) + C(M)\right) + Y(e) \quad (2)$$

kus: V = agendi kasulikkusfunktsioon
$C(T)$ = printsipaali jaoks tehtava teadustööga seotud ajakulu
$C(A)$ = ajakulu, mis on seotud projektirahastuse hankimisega
$C(M)$ = kulud, mis tulenevad printsipaali järelvalvest
$Y(e)$ = agendi pingutusest tulenev kasu (tulemus) reputatsiooni, karjääri jm mõttes.

Aeg, mille agent pühendab teadustööle peab olema seotud ka muu kasuga agendi jaoks ($Y(e)$). Garcia ja Sanz-Menendez (2005) selgitavad sellise tsükli kujunemist printsipaali ja agendi vahel.

Braun (2003) näitab, kuidas kasulikkused (1) ja (2) sõltuvad teaduse rahastamismehhanismidest, mille alusel printsipaal delegeerib agendile teadustöö ülesande. Esimene tüüp, nn pime delegeerimine, on seesugune, kus printsipaal usaldab otsuste tegemise, teadustöö läbiviimise ja kontrolli täielikult agentide (teadussüsteemi) kätte. Nii institutsionaalne kui ka projektipõhine rahastamine on tingimusteta ja kasulikkusfunktsioonid on väljendatavad vastavalt võrranditega (3) ja (4) (Braun 2003:312-314):

$$U = x(e) - (a + b) \quad (3)$$
$$V = a + b + Y(e) - C(A) \quad (4)$$

Teise tüübi puhul, kus delegeeritakse läbi stiimulite, kasutab printsipaal hinnasignaale ja tasusid, mis on kõrgemad mingi eesmärgiks oleva teadustöö tüübi või ka teema osas. Agent saab omakorda signaliseerida teadustulemuste (nt publikatsioonid ja patendid) kaudu enda innovatiivsust ja nii toimub teadussüsteemis individuaalsete teadlaste koordineerimine seesuguste signaalide abil, mida teadlaskond peab väärtuslikuks. Teadlaste reageerimise tundlikkus signaalidele omakorda sõltub laiematest rahastamistingimustest. Kasulikkusfunktsioonid on järgmised (*Ibid*):

$$U = x(e) - (a + b + b^* + C(D) + C(M)) \quad (5)$$

$$V = a + b + b^* - \left(\frac{C(T)}{Y(e)} + C(A)\right) + Y(e) \quad (6)$$

Arenenud lääneriikides toimus esimest tüüpi delegeerimisviisi asendumine teisega järk-järguliselt. Üleminekuriikides toimus selline muutus väga lühikese aja vältel. Sotsialistlikus süsteemis valitses nn. "pime delegeerimine," kus instituutidele anti blokk-grandid ning teadlastel-administraatoritel oli rahastuse jagamisel suur autonoomia (Geuna, Martin 2003).

Braun (2003) toob välja, et muutus ühelt delegeerimisviisilt teisele toob teadussüsteemi jaoks kaasa rea muudatusi. Esimene neist on "kullapalaviku" sündroom, mis tekib kui tingimusteta institutsionaalne ja projektipõhine rahastamine väheneb (a ja b võrrandites (1) – (6)), mis viib agendid hõivama teadusvaldkondi, kus on kõrgeimad hinnasignaalid või tasud. Teine muutus väljendub asjaolus, et kui tavapäraselt rajaneb teadlaste reputatsioon nende publikatsioonides, siis see nihkub teaduse tegemiseks kiireima rahastamisvõimaluse leidmise suunas. Viimane omakorda sunnib teadlasi püüdma oma karjääri arendada täites seejuures samuti rahastajapoolseid tingimusi grantide saamiseks. Samal ajal teadustulud teadlase jaoks vähenevad (Braun 2003). NPM ja PPBS juhtimiskontseptsioonide kasvav kasutamine KIE riikides tähendab lisaks, et eesmärgid ja tulemuste hindamine baseerub kasvavalt kvantitatiivsetel indikaatoritel, mis annab agentidele lisamotivatsiooni oma tegevusi joondada lähtuvalt neist indikaatoritest. Oluliseks muutub see, kuidas printsipaal mõõdab/hindab teaduse eesmärke ja tulemusi (*x(e))* ning samuti, missuguseid lisatingimusi ta rahastamisele esitab. Kvantitatiivseid indikaatoreid eelistavate juhtimiskontseptsioonide (NPM ja PPBS) puhul on need tulemused väljendatud tavapäraselt teatud kvaliteediga publikatsioonide (nt ISI WoS-is indekseeritud) ning ka patenditaotluste või saadud patentide alusel.

Käesolevas artiklis läbi viidud Eesti ja Ukraina võrdlus näitas, et sarnaselt teiste KIE riikidega (Molas-Gallart, Davies 2006; Tiits et al. 2008) panevad vaatlusalused riigid oma innovatsioonisüsteemides suuremat rõhku teadusest tulevale tõukeimpulsile. See on mõistetav, kuna arengut tingivad pigem investeeringud kui innovatsioon ning samuti on piiratud ettevõtete võimekused olla innovatsiooni nõudjateks teadusasutustelt. Lisaks on nii ettevõtted kui ka teadusasutused keskendunud eelkõige oma tuumkompetentside arendamisele. Finantseerimises on suurem nihe stiimulite kasutamise suunas Eestis ja mõningane nihe Ukrainas viinud "kullapalaviku" ilminguteni, mida Braun (2003) ennustas. Samal ajal on riikide vahel erinevused, mida printsipaal ja ka agendid peavad teadussüsteemi eesmärkideks ja olulisteks tulemusteks.

Tabel 1 summeerib teadusssüsteemide stiimulid Ukrainas ja Eestis, millele teadlased reageerivad, eesmärkideks püstitatud kvantitatiivsete indikaatorite (publikatsioonid ja kasulikud mudelid) saavutamisel. Need stiimulid tulenevad nii üksikteadlaste motivatsioonist kui ka mitmetel tasanditel kasutatavatest evalveerimisprotseduuridest.

Tabel 1. Stiimulid, mis toetavad Eesti ja Ukraina teaduse indikaatorite saavutamist

Tase/Riik	Eesti	Ukraina
Teadus-süsteemi tasand	Väljundit (x(e)) mõõdetakse publikatsioonides ja patentides. Agentide hulgas domineerivad ülikoolid teadustöö läbiviijatena, tulenevalt sellest on stiimulid rakendusuuringuteks nõrgad. Baasfinantseerimine on minimaalne, st ($a + a^* < b + b^*; a\ (= 0) < a^*$)	Väljundit (x(e)) mõõdetakse patentides ja registreeritud kasulikes mudelites (teaduse rakendused). Teadusinstituudid domineerivad, neil on stiimulid (rahvusvaheliseks) publitseerimiseks madalad, kuid kõrged tehnoloogia ülekande stiimulid. Baasfinantseerimine on napp, kuid siiski domineeriv finantseerimise vorm, st ($a + a^* > b + b^*$)
Institutsiooni (ülikool/-teadus-instituut) tasand	Kasum/tulem (*Y(e)*) on suurem publikatsioonidest võrreldes patentidega (väiksemad tootmiskulud, tulud kõrgemast positsioonist rahvusvahelistes pingeridades jne). Baasfinantseerimise a* jagamise kriteeriumid baseeruvad 50% ulatuses publikatsioonide arvule, patendid on võrdsustatud 3 ja patenditaotlused 2 publikatsiooniga. Tootmiskulud *(C(T))* on patentide puhul kõrgemad võrreldes publikatsioonidega (seetõttu *C(T)/Y(e)* on publikatsioonide puhul väiksem).	Kasum/tulem (*Y(e)*) on kõrgem patentidest ja kasulikest mudelitest (viimaste tootmiskulud madalad, tulud võistlusest, auhindadest). Baasfinantseerimise (a ja a*) tingimusi mõjutab eelkõige teadusinstituudi kõrge maine. Kulud on võrreldes tuludega (*C(T)/Y(e)*) on madalad kasulike mudelite puhul võrrelduna patentide, kuid tõenäoliselt ka publikatsioonidega.
Uurimisgrupi tasand	Edukus nii maine mõttes, kuid tulenevalt ka projektipõhise rahastuse (*b* ja *b**) saamisel sõltub avaldatud publikatsioonidest (seega toetab publitseerimise ajalugu). Teaduslik maine ja grupi "karjäär" (*Y(e)*) baseeruvad publikatsioonidele ja tsiteeringutele.	Patente ja kasulikke mudeleid (*x(e)*) loovad uurimisgrupid saavad auhindu instituutide vahelistel konkurssidel (*Honoured inventor of Ukraine*). Rahastamine (*a*, *a**, *b*, *b**) sõltub teadusgrupi mainest, mis omakorda sõltub rakenduste (patentide, kasulike mudelite) arvust.
Teadlase tasand	ISI WoS publikatsioonid kui vahend oma ekspertiisi legitimiseerimiseks selleks, et saada projektipõhist rahastust (*b* ja *b**). Teaduslik maine ja karjäär (Y(e)) baseerub rohkem publikatsioonidele ja patentidele (ülikoolid domineerivad).	Tulemust (*x(e)*) ergutatakse konkursside abil (nt Ukraina Teaduste Akadeemia auhind "*Inventor of the Year*"). Karjääri arengut (*Y(e)*) toetavad rakenduslikud tulemused (kuna instituudid domineerivad).

Allikas: Autorite koostatud

Erinevaid stiimuleid kirjeldades võib näha, et Eesti süsteem on fokuseeritud publikatsioonidele kui kvaliteetsele ja rahvusvaheliselt aktsepteeritava tasemega teadusele. Samal ajal on teaduse rakendatavus ja seosed majandusega vähem-olulised. Ukraina süsteem on palju rohkem seotud rakenduslike tulemustega ja rahvusvaheline publitseerimine alles hakkab mingit rolli mängima. Mõlemal juhul on siiski soovitav pehmendada "formalistlikke lähenemisviise" kvantitatiivsete eesmärkide saavutamiseks. Näiteks leiutisi peaks patenteerima ainult siis, kui neis on selged ärilised võimalused ja mudelid, mis määravad leiutise laiema väärtuse. Kvantitatiivsete hinnangutena sobiksid komplekssemad näitajad nagu patendipere suurus, avaliku-erasektori koostöö leiutise loomusel, patentide tsiteeritavus, kommertsialiseerimise edukus jne. See on eriti oluline Ukraina puhul, kus nõu-kogude perioodist päritud lennuki- ja terasetööstus, mäetööstus, tuumaelektrijaamad jne. eksisteerivad veel (need on kadunud või oluliselt restruktureeritud Eestis). Seetõttu Ukraina teaduse tulemusi saaks nendes sektorites rakendada.

Publikatsioonide puhul tuleb märkida, et need peegeldavad ainult osaliselt teaduse rolli ühiskonnas. Seetõttu on väga oluline, et ülikoolide ja teadlaste stiimulid on suunatud samuti majanduse ja ühiskonna vajadustele ning samuti töötatakse välja sobivad ja arusaadavad indikaatorid erinevate teadusvaldkondade kontekstis teadustegevuse hindamiseks. On oluline, et need ootused sisalduksid nii strateegi-listes plaanides kui ka rahastamise skeemides (kuna NPM ja PPBS on ikkagi domineerivad) ja muutuksid osaks teadlaste karjäärist.