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THE ECONOMIC CONDITIONS OF ENTERPRISE FUNCTIONING

Developing the Sectorial Innovation System of Estonian Biotechnology

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All the main innovation processes in the biotech sector from basic research to commercialisation on the market are represented in Estonia. There is no real data about the division of R&D expenses between the public sector (university) and industry in governmental policy documents. This indicates both a lack of relevant information and of innovation policy based on it. The aim of this article is to evaluate the structure of innovation expenditures in the Estonian biotech public sector and private SMEs, and to shape supportive measures for knowledge transfer and entrepreneurship in the biotechnology sector. Empirical research in the business sector was carried out in two sample groups, Estonian research based biotech companies with an independent strategy, and subsidiaries of foreign companies mediating imported goods or just carrying out services (clinical trials) for their foreign owners, and thus not working with Estonian research results. Productivity per employee in the first group of firms was nearly three times lower than in the foreign owned companies. The gross funding structure proportion of basic and applied research, and product or service development in the Estonian biotechnology sector was deduced according to the R&D ratio formula as 11:5:1, which demonstrated the strong imbalance of the sectorial innovation processes. The private sector value for the same indicator was 1:2:2. The research-based companies were poorly financed, and the main public support was channelled into university basic research. One of the results of the small local market and poor funding is that the Estonian biotech businesses are much smaller in size than American and European companies – one-tenth to one-hundredth of the size. A few suggestions for improving the sectorial innovation system (SIS) are made. The process of balancing the R&D ratio is seen as an iterative process.

Keywords: *innovation models, biotechnology, R&D expenditures, sectorial innovation system.*

Introduction

Estonian biotech companies were established at the beginning of the 1990s, when Estonia's independence was re-establised. In their start-up period, sometimes even longer, these companies were mostly in some way or other related to universities. In the University of Tartu, life sciences have had long traditions since the 19th century, since the times of Estonian-born Karl Ernst von Baer (1792-1876) – "a Darwin scale scientist" (Raagmaa & Tamm, 2004). The importance of scientific knowledge and innovation for the European knowledge-based economy has been acknowledged mainly within the last five or six years (Rodrigues, 2002). The Estonian parliament has ratified the research and development strategy document 'Knowledge-Based Estonia' (2002). This strategy document admits that the ratio of expenditures on basic research, applied research and technological development (1:0.7:0.3, respectively; in further text also called the R&D ratio[1]) is highly disproportionate, deviating sharply from the respective figures of developed countries (ibid; Lester, 2001, Bergeron & Chan, 2004). However, besides some general orienting recommendations, there is no real solution that would optimise the division of R&D expenses between the public sector (university) and industry. This indicates both a lack of relevant information and of innovation policy based on it.

Research object: innovation processes in the biotechnology sector.

Research objective: to evaluate the proportions of the sectorial innovation system (SIS) of Estonian biotechnology.

Research tasks: mapping the general environment of the sector and measuring the R&D ratio, analysing the proportion between the innovation processes of the public and private sector, and shaping supportive measures to knowledge transfer and entrepreneurship in the biotechnology sector.

Research methods applied: the comparative analysis based on the general data mining was carried out using the commercial register, written overviews and Internet search; a special questionnaire was designed to collect managers' opinions/evaluations and get the data missing from annual reports.

Biotechnology was selected for the reason that all main innovation processes of the sector from basic research to commercialisation on the market are represented in Estonia. One cannot say the same about the others in business, not even about Estonia's most successful[2] knowledge-intensive sector – the information and computer technology (ICT) sector. The biotech sector is rather compact and consequently more readily accessible to empirical studies. Among other things, this article provides an opportunity to evaluate on the example of the Estonian biotech sector how well the actual innovation model of the public and private sectors works. Therefore, the influence of own national innovation environment on spin-off and knowledge transfer processes in a small country like Estonia should not be underrated, as besides the macroeconomic factors, it contains the national innovation system (NIS) (Marinova & Phillimore, 2003) and SIS (Malerba, 2004).

Innovation process: What makes biotech special

The understanding of innovation covers the structure of products, services, production and management of an organisation. Product innovation increases the satisfaction level of a customer, while process innovation increases efficiency and productivity. Innovation is associated with creativity and generation of new ideas, their realisation through invention, R&D in general and development of a new product. (Business..., 2002).

Herein technological innovation will be used in its narrow meaning; some authors also include organisational (Clark, 2003) and social innovation in that scheme. However, most authors agree on defining innovation primarily as a process and not as the result of a process (Trott, 1998; Dundon, 2002; etc.). It follows from the statements and writings of many researchers and participants in the innovation process that the prevailing innovation models are either explicitly or implicitly linearly based on 'technology push'. The subconscious impact of this model on our thinking has been so profound that we usually take the validity of this simple scheme for granted, as experienced by D. Mahdjoubi in the USA (1997). This way of thinking is also evident in the aforementioned Estonian R&D strategy document. Any innovation deficiencies are thought to be compensated for by simply beefing up R&D financing (Knowledge-Based…, 2002; etc.). A second-generation linear innovation model, which puts the emphasis on the needs of a customer, the so-called 'market pull' model, dates from the 1970s (Trott, 1998). The shortcomings of both linear models include inadequate differentiation between the processes from the perspective of technology and non-consideration of the feedback processes both within the given innovation chain and in the marketing and technological environment. Next, the third-generation model is known as the 'coupling model' (Rothwell, 2002; Trott, 1998). It takes into account the iterative process of successful innovation, regardless of whether it was triggered off by market or a technical idea (Ettlie, 2000). A similar model is also the interactive innovation model of Rothwell and Zegveld; its further developments have been described by several authors (Trott, 1998; Rothwell, 2002; Mahdjoubi, 1997). Such models represent technological innovation in relation to the needs of society and the development of technical and manufacturing environment. An interactive innovation model improved by the present author is presented in Figure 1. This model is characterised by reciprocal feedback between single processes and also between the processes and the environment. At the same time, it should be noted that these feedback loops not only represent the intermediary processes between an idea and a product, but also with the environment where it all happens. A more differentiated innovation chain is also more consistent with the fact that many profitable improvements require no research at all (Drucker, 1998) and development takes place in the engineering and design phase. But the model points out diverse relations of production and services with sales and after-sales operations (see shaded arrows in Figure 1). The whole modern innovation process is related to learning and knowledge processes both inside the company and society. Learning as one of the main processes in knowledge accumulation should be considered on individual, organisational and social levels. This leads to the social innovation model which reframes the technological innovation described in Figure 1.

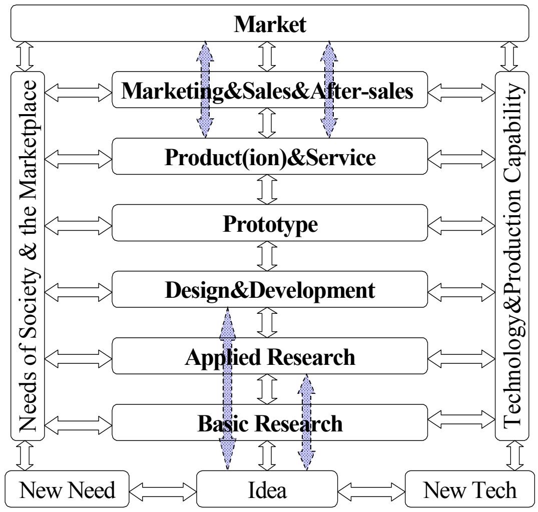

Figure 1. An interactive model of technological innovation (compiled and improved by the author from Rothwell, 2002 and Mahdjoubi, 1997)

It also bears on the fact that innovation management is primarily learning and knowledge management, while innovation strategy is respectively a knowledge strategy.

Realisation of different models of innovation is to a very great extent dependent on the business environment. The SIS includes boundaries and demand, knowledge and technology, actors and networks, and different institutions making biotech a non-linear process (Nightingale & Martin, 2004). Besides the processes described in Figure 1, sectorial aspects of innovation include the supply chain and non-firm organisations such as universities and other public and private organisations. According to Zeller, a biotech cluster describes path dependency, input-output system and actors surrounding the companies (2001). These attributes complement one another: research traditions and supportive infrastructure are especially important at the start-up phase of biotech businesses. Geographic proximity enables start-ups to establish themselves later as the firm grows and moves away "since its market and field of reference are often international" (Lemarié et al, 2001). The attributes of biotechnology are science, networks and divisions of innovative labour. Universities, venture capital and the national health system play key roles in the biotech sector of Europe. Special for European biotech is that university-industry links are less developed than in the USA (Malerba, 2004).

Application of biotech in healthcare adds complexity to the model in Figure 1, viz. the time dimension. A biotech innovation from discovery to market is slow and expensive: the preclinical stage lasts 6.1, the clinical stage – 6.9 and approval – 2.3 years. In the US, "the approval process for biotech medicines is estimated to cost between $200 million and $350 million and take from seven to 12 years". An important aspect is the patenting policy to protect the exclusive rights of the companies on their inventions and keep up investors' interest to finance them. (Walker, 1999).

Patent protection lasts too shortly (in different countries 15-20 years) by comparison with the three market preparation stages and costs too much for small and medium-size enterprises (SME) to use the full market potential and benefit from own invention. But often SMEs such as, for example, pharmaceuticals firms, are more efficient in creating new products than large companies. This is the subject of interest for strategic mergers and acquisitions (M&A) to obtain technology, competence and market by having bigger pharmaceutical companies (Lemarié et al, 2001). On the other hand, this can be the strategy of SMEs to create higher goodwill (Matthews et al, 2003). The companies in M&A behave according to an open innovation model (Chesbrough, 2003). The regional biotech SIS is closely connected with the (local) NIS, but via supply and market chains the biotech companies extend far across the borders. That means global openness of the business sector.

Most of the Estonian biotech companies are more or less related to universities and public R&D-institutions. There are two main ways to commercialise the results of academic research: by knowledge (technology) transfer to either new start-up (spin-off) companies or to existing businesses (Shane, 2005; Sheen, 2002). Both ways follow different routes of transferring new technologies to industry. New technologies can be produced, on the one hand, by undergraduate and post-graduate studies/research, by contract and collaborative research, and by the creation of new strategic (technology) platforms, or on the other hand, simply by auditing and licensing previous R&D results (*ibid*). In both cases the university-company relations are usually regulated by a licence agreement. Herein the knowledge transfer is viewed as a phenomenon permeating all stages (phases) of innovation in society.

Public and private actors (universities and biotech companies) seem to be partners in the Estonian NIS. Is the open innovation model inherent in both main partners of the NIS? This raises the question about the correspondence between generation of new scientific knowledge at universities and companies' needs for knowledge in both Estonia and abroad.

Methodology and sample

The current empirical study had two main purposes: to map the biotech innovation processes and expenditures of private businesses, and to reveal the expenditures of the public sector. Our detailed interviews in SMEs permit us to draw some conclusions about their innovation models and strategies. The public sector is carrying expenses related to the NIS as a whole, incl. regulatory systems, governmental agencies, IP-policy, universities, etc. There are several sources of funding the budgets related directly to the biotech sector. The public sources of information are the webpages of the following (funding) institutions:

1. The Estonian Science Foundation (ESF),
2. The Estonian Ministry of Education and Research (MoE),
3. The Ministry of Economic Affairs and Communications together with the national development agency Enterprise Estonia (EE).

Most of the selected companies are biomedical businesses. The foreign-owned companies performing simple production and packaging operations of pharmaceuticals in Estonia were excluded as they are not knowledge-intensive. Very traditional biotechnology industries, for example, yeast production, and for the same reason, other food industries were also excluded. The total number 32 (beginning of 2006) of the Estonian biotechnology companies was small enough to determine the sample for study. The companies that had no sales (no annual report) yet were excluded from the research sample. The rest of the 25 registered firms (Annex 1) were SMEs, and 2/3 of them were related to the biomedical field. All their annual reports were studied for the purposes of the sector's statistics. The companies whose businesses only mediate the goods of foreign companies, or carry (clinical trials) services for their foreign owners and therefore have neither independent strategy nor direct relations to the Estonian biotech R&D base were excluded from the sample of further detailed research (group SME2). After excluding Egene as an exceptional one, 19 more or less research-based biotech SMEs (group SME1) remained, nearly 1/3 of them spin-offs of the University of Tartu. For mapping the innovation processes in the companies, their annual reports were studied. The reports revealed data about sales and investments into fixed assets and export markets. However, the annual report usually contains no data about expenditure on innovation processes according to Figure 1. Nor does it provide information about new trends in the business environment and other innovation factors such as intellectual property (IP) and knowledge transfer.

Therefore, a special questionnaire was designed for mapping managers' opinions/evaluation and getting the data missing from the annual reports:

1. relative share of expenses earmarked for innovation processes in their companies,
2. relations with the public innovation support system and the expediency of the support measures to the companies' needs,
3. personnel strategy,
4. competences in the field of their own technology, product development, marketing and sales, (strategic) management etc.,
5. knowledge transfer, incl. openness of the innovation processes and networking in the fields listed above,
6. IP and patent pool.

The data were gathered by half-structured interviewing, which permitted us to get prompt answers to questions and specify concrete information about the company. The interviews and data collection were carried out by two master students[3], both managers at biotech companies. Regrettably, the quite comprehensive data gathered by the researchers can be only partly exhibited in the paper.

Results and Discussion

Over 300 researchers are employed in biotechnology or related fields in universities and other institutions. In the economic meaning, the biotech sector is still very small − the companies employed approx. 200 people in 2004. But the sector is growing faster than the Estonian economy as a whole. The sales of the research-based sample of biotech companies, SME1, grew at the rate 11-17 % per year, and the sales of SME2 even 14-47 % per year in the period 2001−2004. The research-based group accounted for 41.1 % of the total sales 13 million EUR of the sector in 2004 (Figure 2).

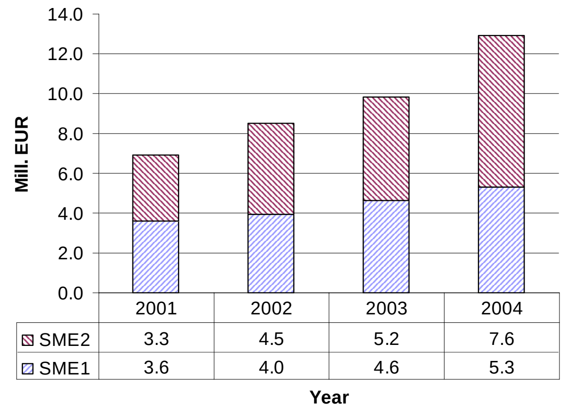

Figure 2. Sales of the Estonian biotech SMEs, million EUR per year (the author's calculations based on annual reports)

All the Estonian biotech companies in sample SME1 can provisionally be divided into three groups (Talpsep, 2005): the first "wave" of companies was established 12-15 years ago (3 companies), the second 5-9 and the third one 1-5 years ago (accordingly 10 and 6 companies). The added value per employee of the research-based companies has been growing at the rate over 20 % per year, reaching more than 15 700 and sales – 38 350 EUR/year per employee in 2004 (Figure 3). The total number of employees of SMEs in the sample was about 135 (SME2: 68).

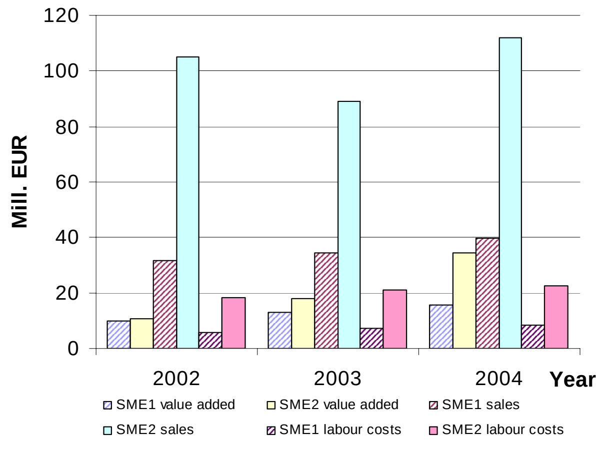

Figure 3. Value added, sales and labour costs per employee in Estonian biotech SMEs, thousand EUR per year (the author's calculations based on annual reports)

Figure 2 and 3 demonstrate that even though they started from nearly the same level of value added productivity (per employee), the growth in the R&D-based SMEs was lower than in the SME2 group. In SME1, relative productivity, value added and sales per employee remained 2.2 and 2.8 times, and salaries (calculated from labour costs per employee) 2.7 times lower than in SME2. From Figure 4 one can conclude that the companies in SME2 with foreign financing are more flexible with their expenses (losses 2002-2003). The growth of value added in SME2 was much faster than in the research-based group SME1 in last three years.

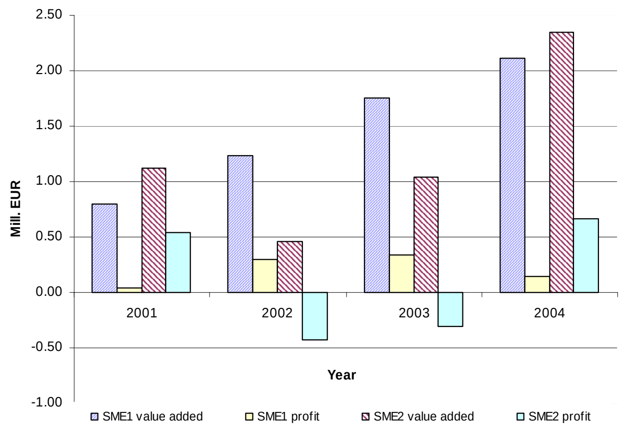

Figure 4. Value added and profit of two groups of Estonian biotech SMEs, million EUR (the author's calculations based on annual reports)

The findings about the Estonian biotech sector from the interviews with managers of the group SME1:

1. The companies are mostly profitable, but their own capability to invest in development is quite limited;
2. The sales of the Estonian biotech companies split between production and services almost equally;
3. The companies' experience in entrepreneurship and marketing was nearly three times lower (evaluation marks: 1.4-1.6; scale: min. 1, max. 5) than in research (4.7);
4. Attention to market development is growing in the biotech companies (sector): the number of marketing and sales personnel grew from 21 to 29 in the period 2002-2004;
5. The share of export in sales went up by nearly 10% in the period 2002-2004;
6. Only a third of the biotech companies have adopted a growth-oriented strategy;
7. International knowledge transfer and networking is mostly related to research and practically never to commercialisation of the research results;
8. Estonian partners are more involved in basic and applied research (50-52% of the total R&D-expenses financed by SMEs) than foreign partners (5-7%); own participation of the companies is higher in product development (more than 75%) and product testing (54%).

The survey demonstrated the Estonian biotech companies' growing market-orientation and a shift to the open innovation model.

In order to provide a better picture of R&D and other innovation processes in Estonian biotechnology, the author mapped the system of public funding according to the structure of a general model of technological innovation. The results are shown in Table 1. The corresponding funding and expenditures by the public and private sectors are shown in Table 2.

Besides the above-mentioned Estonian funding institutions, the biotech sector is also financed by the European ones. Three of the interviewed companies have received support from EU projects as partners. According to the information provided by the Foundation Archimedes (Estonian…, 2002), the Estonian partners' share has been less than €100 000 in a 3-year period.

Table 1

Innovation funding structure of the Estonian biotechnology sector in 2004
(the author's calculations based on public information and managers' estimations)

Expenditure	Public funding			Private funding		Total	
	Fund	1 000 EUR	%	1 000 EUR	%	1 000 EUR	%
Marketing & Sales	EE	204	29.7	486	70.3	691	10.0
Production & Infrastructure	EE	498	72.1	192	27.9	691	10.0
Prototype	EE	0	0.0	66	100.0	66	1.0
Design & Development	EE	0	0.0	286	100.0	286	4.1
Applied research	EE	1 278	84.2	241	15.8	1 510	22.0
Basic research*	MoE, ESF	3 528	96.7	119	3.3	3 647	52.8
Total per year		5 510	80.6	1 391	20.2	6 900	100.0

*Note: *Allocations for doctoral studies are included in the biotech research allocation.*

The preliminary evaluation of the innovation expenditure structure of the Estonian biotechnology sector (Table 1) shows the prevailing role of public funding, which is about 80% of the total budget (can be even more if we take into account all the running EU projects). As Table 2 shows, 4.62 million EUR (Public basic and applied research expenditures together), i.e. 83.8 % of public R&D funding were channelled for university research, while only 0.19 million EUR had the aim to support private applied research in 2004. This support is not remarkable compared with Australia, Portugal, Switzerland or Hungary, where the share of government-financed business R&D exceeds 70% of the research budget (Lambert…, 2003). From Table 1 one can deduce the ratio of gross funding structure of basic and applied research, and product/service development in the Estonian biotechnology sector financed by the government to accord to the ratio 11:4:0. Is this R&D-ratio the best solution for the NIS? About 60 % of US government's R&D funding in 2000 was spent on development, while the remaining money was split almost evenly between basic and applied research (Bergeron & Chan 2004). This makes the public R&D-ratio to be 1:1:3 in the USA and demonstrates a predominance of basic research among other stages of innovation in Estonia.

The R&D-ratio of the public and private sectors together is 11:5:1. In the business sector, the ratio is approximately 1:2:2, and together with public support 1:3:2. As Estonian research based biotech companies are mostly profitable (see Figure 4: SME1), then the budget according to the latter ratio 1:3:2 will provide for the existence of the firms in the short run. But whether the industrial R&D expenditure is sufficient for the development of industry on the level of the national strategic goals in the long run – this is the question about the national innovation strategy as a whole.

The gross public R&D expenditure (5 510 000 EUR) of the biotech sector nearly exceeds the sales of the sector (Figure 2: SME1). This is the first sign of a possible imbalance between the expenditure on research (financed by the Estonian tax-payer) and revenue on the society level.

Table 2

Structure of innovation funding and expenditure in the public and private sectors of biotechnology in Estonia in 2004
(the author's calculations)

Expenditure type	Public fund & expenditure, Public to Private support, 1 000EUR, %					Private fund & expend. structure, 1 000EUR,%		
	Fund	Public expendit.	Expenditure, %	Public support	Support, %	Fund	Expenditure	Expenditure, %
Marketing & Sales	204	89	1.6	115	2.1	486	601	35.5
Production & Infrastruct.	498	498	9.0	0	0.0	192	192	11.4
Prototype	0	0	0.0	0	0.0	66	66	3.9
Design & Development	0	0	0.0	0	0.0	286	286	16.9
Applied research	1 278	1 091	19.8	187	3.4	241	428	25.3
Basic research	3 528	3 528	64.0	0	0.0	119	119	7.0
Total per year	5 510	5 207	94.5	303	5.5	1 390	1 693	100.0

The growth rate of Estonian companies is of the same 15-20 % scale as that of American companies (Resilience…, 2003), but the businesses are much (10-100 times) smaller in size. Additionally, there are other characteristics differentiating Estonian biotechnology from industry in Europe and the USA:

1. Low level of research expenses in Estonian companies;
2. Profitability of Estonian biotech (small) companies;
3. Low level of venture capital investment in Estonian biotech;

4. Weak connections between university research and companies' R&D.

The first three aspects will be discussed here, and the fourth one in the next section. The main reasons of these above differences can derive from several circumstances related to the Estonian economic environment, policy and development so far. Since 1992, the Estonian government has practised a liberal economic policy, providing only modest support to companies of any business sector, incl. biotech. The main survival condition of the companies has thus been the balance between costs and revenues. Biotechnology is mainly a sector whose outcome and results are feeding other bigger industries, like pharmacy and healthcare in the USA. In Estonia, however, these markets are too tiny to form bigger companies without international sales. The low income of Estonian biotech does not ensure enough resources to SMEs for the creation and protection of new IP. The short history of Estonian market economy has no examples of local business angels, and venture capitalists experienced in the sector. The comparatively modest business environment of the sector does not encourage foreign investors to enter the local businesses as it has happened in ICT.

Estonian biotechnology research institutions (for example, the University of Tartu) have very rare licence sales – 2-4 deals per year, and the incoming sums are insignificant by comparison with the expenses. Biotech research funding by the government does not balance out with the real business needs. These records can refer to two circumstances:

1. A low scientific level of biotech research at the Estonian universities.
2. Ignorance of the market demand obstructs creation of new technologies with a high commercial value.

The first speculation does not seem to be true as research funding and results evaluation are subjected to strict quality control by various Estonian and European institutions. This statement is best justified by the fact that since 2000, several Estonian R&D institutions have been granted the status of European centres of excellence. However, the other presumption is more probable as knowledge transfer is not a success indicator for university research. At first glance, the motivation of the university as a partner depends on the system of motivating and evaluating researchers and professors. There is very little co-operation between research and the business sector in Estonia. Consequently, the structure of research expenditure in the public sector mostly reflects the success of Estonian biosciences, not the success of biotech as an economy or business sector.

Another negative trend is visible in Figure 3. The salaries on the medium level of the country (approx. 525 EUR) in research-based SMEs cannot stimulate highly qualified personnel in the long run. This is the reason why subcontractor and mediator firms pay nearly three times more to their Estonian personnel. Salaries of the same level as in SME2 are not possible in poorly-financed Estonian SMEs; as a result, own biotech industry may never catch up with Estonian science and may lose the potential created by the research sector. Or may become a mere subcontractor for international companies.

Conclusions

In conclusion, it can be mentioned that the public research sector has been playing the leading role in the development of research-based biotechnology while the business sector has had only marginal economic importance in Estonia. No economic efficiency at the national level can be achieved by the biotech sector without restructuring the research and technology transfer environment. By the current author's estimation, the R&D ratio 11:5:1 of the Estonian biotech sector describes the situation in even more unsatisfactory terms than do the figures in the strategy document about the national innovation processes all together. From the previous analysis it is possible to suppose that the examined R&D ratio describes a clearly unbalanced situation of public R&D and education expenditures on society level. This is quite a normative approach, but it is difficult to establish the right ratio for Estonia. Obviously, the process of balancing R&D and innovation expenses and expedient state budget is an iterative process which needs its own strategy, policy and monitoring system on the national level. There are several good examples of strategy building (Meyer, 2003; Parayil, 2005) that Estonia might follow. This presumes creating Estonian own competence centres for innovation and technology transfer research, and sectorial development. The conclusion drawn on the basis of the biotech sector is that there is no simple formula for the success of R&D-based businesses in a small economy.

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Endnotes

[1] The author was unable to find what the basis of this concrete value for the R&D ratio is.
[2] We can mention, for example, success stories of MicroLink and Skype.
[3] Hereby the author expresses his thanks to Indrek Kask, *MSc*, and Tiit Talpsep, *MSc*, for the empirical data for the paper.

ANNEX: List of Companies Studied

Applied Phenomics, Asper Biotech, Bestenbalt, Bimkemi, Biodata, Bioexpert, Celecure, FIT Biotech, Egeen, Iasgen, Immunotron, Inbio, Kevelt, Labas, Labema, LabExpert, Mikrotaim, Naxo, Prosyntest, Quantum, Quattromed, Quintiles, Solis Biodyne, Torrosen, Visgenyx

Tõnis Mets

Estijos biotechnologijų sektorinės inovacijų sistemos plėtra

Santrauka

Estijai būdingi visi pagrindiniai inovatyvūs procesai, vykstantys biotechnologijų sektoriuje, pradedant nuo elementarių tyrimų iki komercializavimo rinkoje. Vyriausybės politikos dokumentuose nėra tikslių duomenų apie R&D išlaidų pasiskirstymą tarp viešojo sektoriaus (universitetai) ir pramonės. Tai parodo atitinkamos informacijos ir inovacijų politikos trūkumą. Šio straipsnio tikslas yra įvertinti išlaidų, skirtų Estijos biotechnologijų inovacijoms viešajam sektoriuje ir privačiose SVV įmonėse, struktūrą bei pritaikyti žinių perdavimo ir novatoriško verslumo (antreprenerystės) paramos būdus biotechnologijų sektoriuje. Dvejose verslo sektoriaus bandomosiose grupėse buvo atliktas empirinis tyrimas: Estijos tyrimais grįstose biotechnologijų įmonėse, įgyvendinančiose nepriklausomas strategijas ir užsienio kompanijų filialuose, kurie tarpininkauja importuojant prekes ar paprasčiausiai teikia paslaugas užsienio savininkams, ir dėl to nepatenka į Estijos tyrimų rezultatus. Pirmoje įmonių grupėje produktyvumas, tenkantis vienam darbuotojui, buvo beveik tris kartus žemesnis, palyginti su produktyvumu užsieniečių valdomose kompanijose. Aiški fundamentinių ir taikomųjų tyrimų, produkto ar paslaugos vystymo finansavimo proporcijų struktūra, Estijos biotechnologijų sektoriuje, buvo nustatyta pagal R&D santykio formulę, tokią kaip 11:5:1, kuri parodė didelį sektorinių inovacijų procesų disbalansą. Privataus sektoriaus vertė, remiantis tais pačiais indikatoriais, buvo lygi santykiui 1:2:2. Tyrimus vykdančių įmonių veikla buvo menkai finansuojama, ir pagrindinė valstybės pagalba nukreipta į universitetų fundamentinius tyrimus. Vienas iš mažos vietinės rinkos ir nepakankamo finansavimo rezultatų yra tai, kad Estijos biotechnologijų sektoriuje veikiančios įmonės daug mažesnės, palyginti su Amerikos ir Europos įmonėmis. Yra pateikta keletas pasiūlymų, kaip pagerinti sektorinę inovacijų sistemą (SIS). R&D koeficiento kitimo procesas yra laikomas interaktyviu procesu.

Raktažodžiai: *inovacijų modeliai, biotechnologijos, R&D išlaidos, sektorinė inovacijų sistema.*

The language of the article is not edited

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