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THE EFFECTIVENESS OF CZECH RESEARCH OUTPUTS

1. Introduction

Czech researchers often compare with and refer to better conditions for doing research in more developed EU countries and usually complain about underfinanced research at universities as well as in other sectors. But those are funds flowing into the area of R&D, its inputs. However, the requested equality between the Czech and foreign researchers should issue from the countries ratios: R&D input / R&D output. It was said and written about insufficient inputs.

The Czech government finances a large part (approximately 40% of all sources) of scientific research. And still, as already mentioned, Czech researchers call for more financial support for their research activities. This situation raises some obvious issues:

1. Does the government invest **enough, or too much**, in science?
2. Is it desirable to improve the way the science budget is allocated?
3. What are the weaknesses of the Czech research?

In order to answer these questions I have to continue with another question:

What is the current performance of the Czech R&D measured by its outputs and compared together countries?

To find an answer to the question I need to observe the current Czech academic performance.

2. Trade-off between „products" of research activities

The performance of any academic science could be characterised through two groups of indicators [4]: **scientific output** (or productivity which can be measured by a quantity and quality of scientific publications) and **utilisation of the results of science** (for example introduction of a new technology, machine or a product to the market, laboratory tests for private companies, etc.).

When research resources are used efficiently, science policy faces **a trade-off** between productivity and utilisation. It means that one of them may be improved only if the other one loses on its efficiency. And conversely when the science system has a weakness, both productivity and utilisation may be improved. Figure 1 shows the possibilities of research performance.

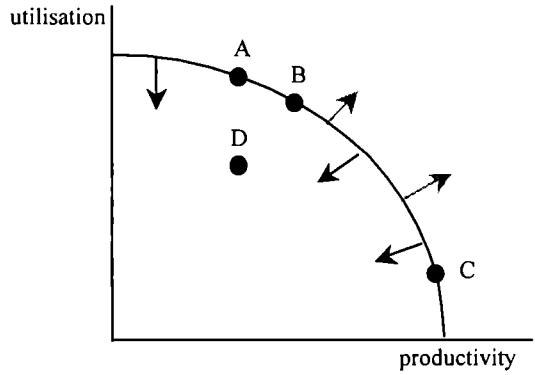

Fig. 1. Attainable combinations of output and utilisation

Source: [3, p. 51].

When efficient use is made of the available research resources, points like A, B or C (i.e. other points on the curve) are applicable. In these points, improving productivity necessarily implies reducing utilisation, and vice versa. For example, stronger incentives for utilisation may induce researchers to engage in more applied research (for which their input is indispensable) – but this necessarily reduces the time and effort these researchers spend on writing articles.

Hence, when academic science can be characterised by a point on the curve, **changes in government policy** necessarily involve a trade-off.

Above, it was said that the curve position depends on available research resources. So the politicians may focus either on increase of **financial** or **human resources** for R&D or both at best. And vice versa, if academic researchers leave for abroad or for other jobs within the country or research funds are cut, the curve moves to the left as indicated by the black arrows. Obviously, the second variant is undesirable.

If the policymakers decide to increase both types of research outputs they can do it only by moving the curve to the right as indicated by red arrows. So I go to another question: What governmental incentives can move the curve?

Under the condition that the research resources are fixed at the moment, let's search for reasons why points inside the curve like D are usually achieved. There, both output and utilisation can be improved in such a point. Researchers may be stimulated to create more scientific output through closer cooperation with private

researchers, who are a source of interesting problems and inspiration. As a consequence, **both publications and utilisation may increase**.

3. Current performance of R&D productivity in the Czech Republic

What point in the Figure 1 would apply to current Czech science? To find the point, two sets of indicators have to be reviewed: indicators of publication activities and indicators of research utilisation such as patents, inventions and innovations, etc.

3.1. Scientific publications

Let's first have a look at some indicators based on scientific publications. Bibliometric analysis, e.g. evaluation of number of publications and their citations has become an integral part of other documents evaluating the level of R&D in OECD member countries as well as within EU countries. The most used and known source of data for the bibliometric evaluation is the source of information collected and processed by the Institute for Science Information – ISI, known under its current name Thomson ISI® in the U.S. The institute observes and regularly evaluates several thousands of scientific magazines from all around the world.

This article monitors a group of countries selected in order to compare the Czech Republic with more technologically developed not only European countries with highly efficient science, technologies and innovations but also with less developed countries, with other new EU members and Greece.

The first selected indicator – **the number of articles per million dollars invested in science** or said in other words the costs of an average article was 8 for the Czech Republic in 1997, and it was at about average level compared to 21 other countries (Figure 2). It was more than for example in the U.S., France and Austria, but less than in Belgium, Hungary and Sweden. Czech Republic ended in the middle of all countries – not bad not good.

As for the second indicator – **the number of articles per researcher**, the Czech performance was even less favourable with 0,6 article per researcher. Only the quarter of monitored countries reached worse results (for example Spain and Austria, Figure 3).

Neither the third of monitored indicators – **the relative production of publications (RPP) per 1000 inhabitants** brought a positive result for the CZ. In the monitored period 1999-2003, the Czech Republic was on the 12th position among 15 selected countries with the value RPP = 0,42, which was only a bit above the half of the average value for the whole EU (RPP = 0,74). But Poland, Slovenia and Hungary scored even worse (Figure 4).

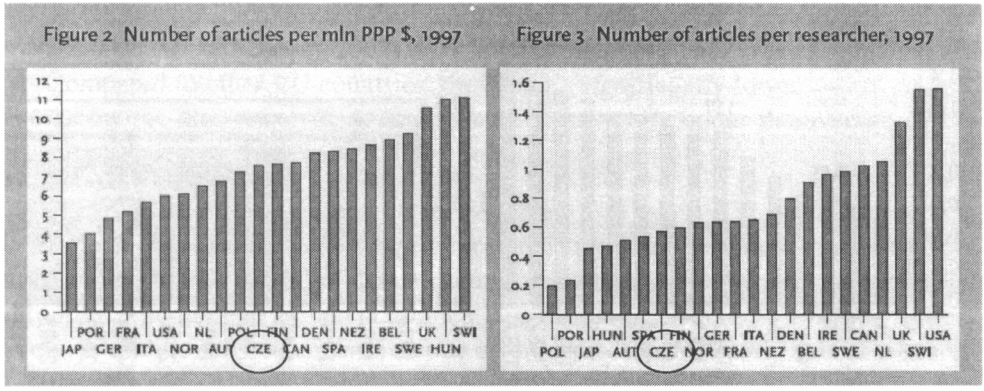

Fig. 2. Number of articles per mln PPP $, 1997 Fig. 3. Number of articles per researcher, 1997

Source: Institute for Science Information – ISI, Thomson ISI®, USA.

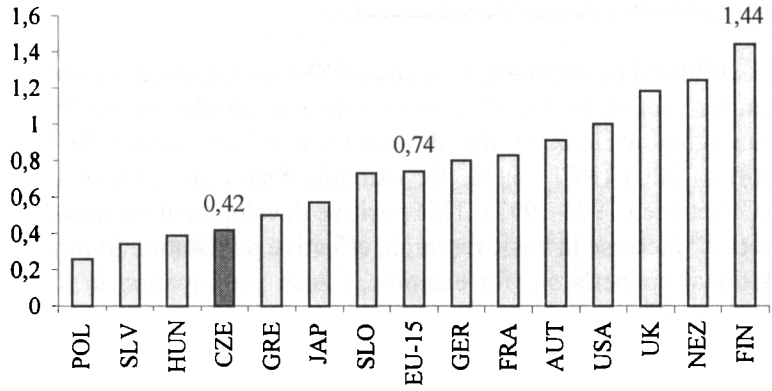

Fig. 4. RPP in selected countries (a year average from the period 1999-2003)

Source: Analyses of R&D in the Czech Republic, 2004.

The simple production of publications is a quantitative indicator and does not predicate the publications quality. In order to evaluate a quality of a publication, the indicator of number of its citation is used, which under some restrictions (for example, it is not possible to compare number of citations of publications from different branches) predicts about an interest of world scientific community in the respective paper (research). Again, relative values are used for comparison so that small countries would not be disadvantaged. So, the fourth monitored indicator – **relative citation impact RCI** (Figure 5) expresses an average number of citations per one publication produced by research of a country in the period 1999-2003 without a respect to branches.

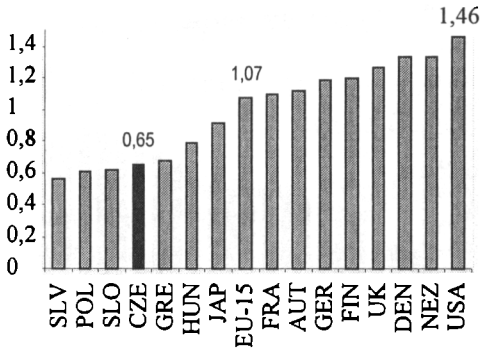

Fig. 5. Comparison of selected countries and the Czech Republic according to the RCI (the average value in 1999-2003)

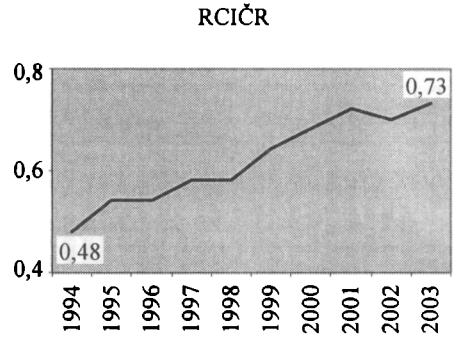

Fig. 6. Development of the RCI in the CZ in 1994-2003

Source: Analysis of R&D in the Czech Republic, 2004.

The CZ followed by Slovenia, Poland and Slovak Republic is closing the group of 15 countries ranked by the RCI, again rather frustrating result. It seems to be more encouraging to look at the development of the Czech RCI from 1994 (RCI = 0,48) to 2003 (RCI = 0,78, for example Spain and Ireland had the same average RCI between 1994-1997). This positive development is caused particularly by „production" increase in basic research, effective publication policy and increasing international cooperation (for example, Czech participation in the EU framework programmes).

3.2. Utilization of research

Turning to the utilisation of research, we face the problem that science contributes to welfare through many channels. Most available indicators, however, are limited to utilisation by private firms in the form of inventions, new technologies, patents and other form of innovations. So what do the indicators tell us about research utilization in the Czech Republic?

3.2.1. Innovations

The survey dedicated to innovation activities and harmonized for all EU countries (Community innovation survey) was applied also to CZ. It brought a lot of new information. The survey monitored the two year period 2002-2003 and addressed 4678 private companies from manufacturing and service sphere both financial and non-financial branches with at least 10 employees. From the survey the following is resulting (besides other information):

- There were **25,9% innovating companies** of all monitored companies in the CZ, that introduced in 2002-2003 either a product or a process innovation. Compared to other EU countries, the share is significantly lower.
- As for the number of innovations, the CZ is slightly under the average of EU countries.

3.2.2. Patents

Protection of intellectual property resulted from R&D as well as profits from the property are considered as important motivation factors for an entrepreneurial activities. The number of patent applications or number of granted patents respectively, is traditionally considered as one of the indicators of fruitfulness of research and development.

The Figure 7 depicts the **relative numbers of applications filed at European Property Office (EPO)**. The highest number of applications was in 2003 reported by Finland, Netherlands, Germany and Denmark – 205,173 123 and 114 respectively. For most of the countries an obvious increase in applications since 2000 is characteristic except of Greece and the new member countries inclusive of the Czech Republic, where in the monitored period even patent applications decreased (from 3,6 in 2000 to 2,6 in 2003).

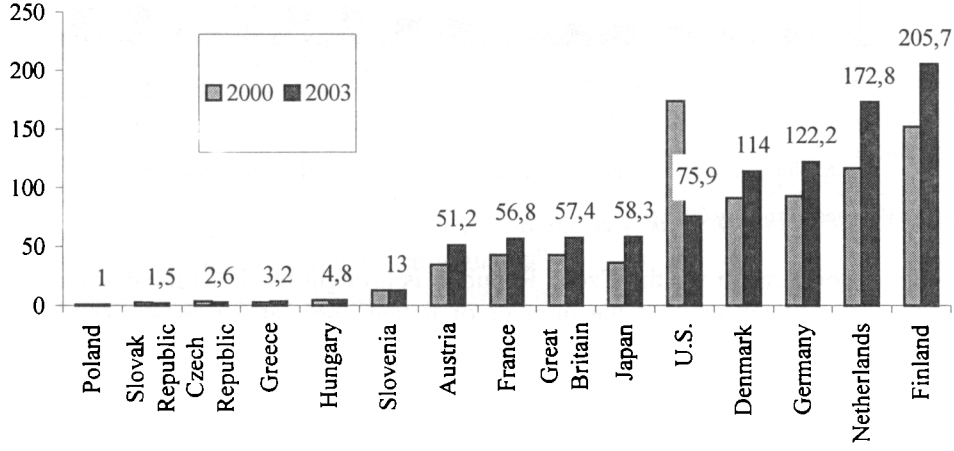

Fig. 7. Number of patent applications filled at EPO, total numbers per one million of inhabitants

Source: European Property Office Yearbooks, 1996 to 2001, Section of Statistics – total numbers of applications; RVV – conversions to one million of inhabitants.

The number of applications from Poland is the lowest of all monitored countries. Slovenia achieved the best result from new member countries but there was no increase between 2000 and 2003. The difference between the number of

applications from the Czech Republic and from the developed countries (Finland, Netherlands and Germany) is enormous.

The given numbers testify on the surviving **underestimation of the importance of concrete and marketable R&D knowledge in the research organisations** in the Czech Republic. The process of transformation of the economy is obviously more demanding and longer than expected.

Numbers of patents really granted by EPO are generally in line with numbers of patent applications in accordance with the previous graph. The advanced countries report several times higher numbers of patents granted when compared with the new member countries and Greece.

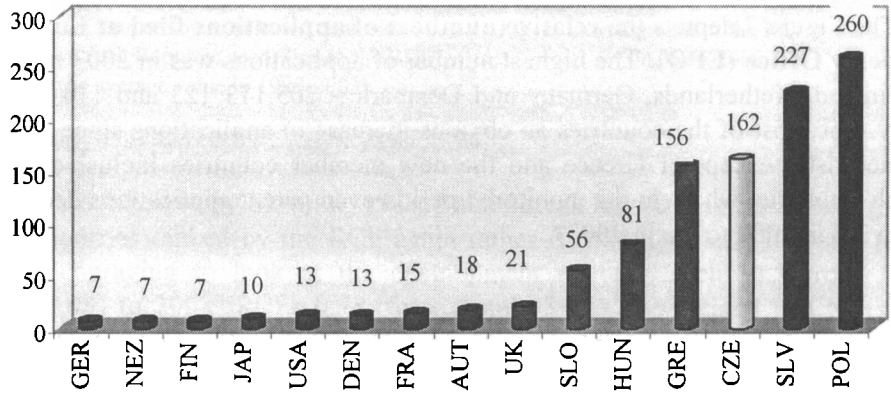

Fig. 8. Number of publications/ 1 patent application/ 1 million inhabitants in 2003

Source: European Property Office.

Even worse result for the Czech Republic is brought by the comparison of the number of publications and the number of patent applications as shown on the previous graph (Figure 8). In 2003,162 publications resulted to only 1 patent application in the Czech Republic. It basically expresses and re-confirms the low practical contribution of the research publications and also it shows on dominant focus on basic research. Hungary and Slovenia, the countries with similar original conditions, achieved twice as better results than the CZ. And it shows on reserves in our R&D.

3.2.3. Inventions

Most of inventions result from long term research activities and so it may also predicate about a practical contributions of research, in other words, on its effectiveness.

The Figure 9 outlines the stagnation in numbers of Czech inventions applied in the CZ between 1998 and 2003 as well as 5 times higher number of foreign invention applications. These numbers also do not speak in favour of Czech research effectiveness.

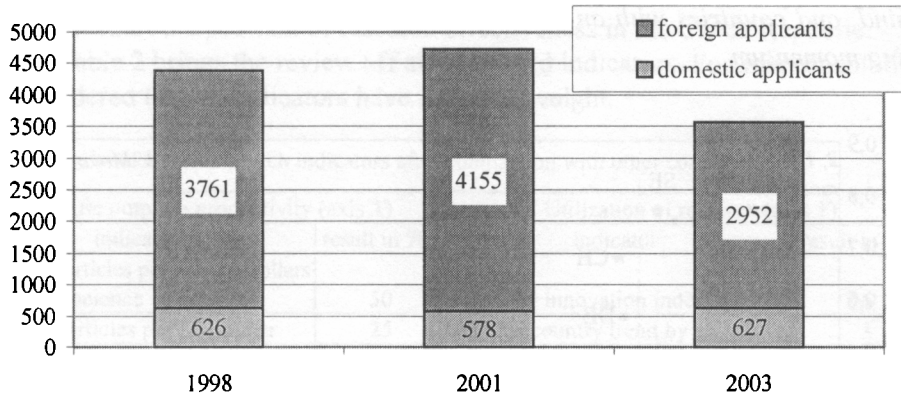

Fig. 9. Invention applications in the Czech Republic, total numbers

Source: A year book of the Czech statistical office, 2003.

3.2.4. Multi-criterial comparison of Czech innovation environment

More complex information about how the Czech Republic scored in 2004 among other candidate and EU countries in the area of innovating activities (inclusive of their results – patents, inventions and innovations) is released in the annual publication by the European Innovation Scoreboard – EIS. The most complex indicator is **the summary innovation index (SII** – see selected countries in the Table 1). The SII gives an „at a glance" overview of aggregate national innovation performance. According to this indicator, the CZ is far behind the EU average (0,40) with the value **0,27**. Sweden and Finland remain the innovative leaders within the EU. Estonia and Slovenia lead the EU10 group of the new Member States. They approach the EU25 average and rank above a number of EU15 countries. Better values than the CZ were achieved surprisingly also non-member Bulgaria.

Figure 10 graphs the current performance as shown by the SII (vertical axis) against

Table 1. Summary innovation index SII, 2004

Country	SII	Country	SII
TR	0,05	BG	0,28
PL	0,14	PT	0,3
RO	0,15	ES	0,3
CY	0,17	SI	0,32
LV	0,18	**EU-15**	**0,44**
SK	0,24	NL	0,45
HU	0,25	DE	0,56
LT	0,26	**FI**	**0,75**
CZ	**0,27**	**SE**	**0,76**

Source: European Innovation Scoreboard 2004.

the medium-term trend performance (horizontal axis) for 30 countries for which trend data are available. This creates four quadrants: *countries above both the average EU trend and the average EU SII are moving ahead, countries below the average SII but with an above average trend performance are catching up, countries with a below average SII and a below average trend are falling further behind, and countries with an above average SII and a below average trend are losing momentum.*

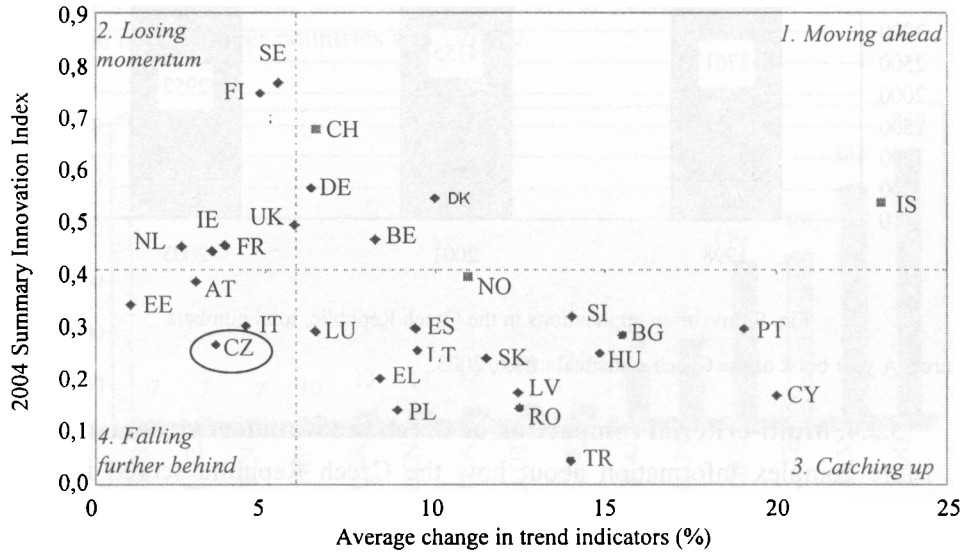

Fig. 10. Average country trend by SII

Source: [2].

The Czech Republic is situated in the least favourable position – in the first quadrant together with Estonia, Austria and Italy. Portugal, Latvia, Cyprus, Hungary, Slovakia, Spain, Slovenia, Luxembourg and Poland are situated in the **„catching up"** quadrant. Slovenia maintains a strong trend performance combined with a current performance close to the EU25 average. Iceland and Denmark are „moving ahead" with above average values for current performance and trend. Finland and Sweden are the top performers on the SII but with below average trends.

4. Conclusion

The main – positive – contribution of the paper lies in the critical look at the 'evidence base' for government policy: what do we actually know about effects of policy options, what can be empirically assessed? The analysis touches upon many

of the popular issues in science policy and gives a valuable overview of the empirical soundness of these issues.

After comparison of Czech and foreign, mostly EU bibliometric indicators expressing the scientific output of research activities and indicators of research utilization such as patents, innovation, inventions and the summary innovation index I can chart the position of research effectiveness in the Czech Republic.

The Table 2 brings the review off all examined indicators. For simpler solution, it is considered that all indicators have the same weight.

Table 2. Results of Czech research indicators after comparison with other countries

Scientific output – productivity (axis *X*)		Utilization of research (axis *Y*)	
indicator	result in % *	indicator	result in % *
number of articles per million dollars invested in science	50	summary innovation index **	36
number of articles per researcher	25	average country trend by sii	3
relative production of publications (rpp) per 1000 inhabitants	30		
relative citation impact rci	44		
total average result	37	total average result	20

Notes:

* 100% is equal to the best result among all monitored countries.

** Already including activities in the area of patents, innovations, inventions and also human resources).

Source: own study.

Knowing the percentage values in both groups of indicators gained from comparison with other countries, I could chart the situation in the Czech Republic easily to the point D. But I must consider also conditions under which our scientists have to do their research as well as the conditions under which Czech private companies can invest to their research. It would be another long chapter. For this article I can use the knowledge obtained in my previous research for my thesis and draw the curve of attainable combinations for the Czech Republic and for example for Finland, because it which usually achieves the best results in the area of R&D. The location of the curve is limited by both financial and legal support of R&D and both areas are on very poor level in the CZ compared to Finland. Based on my previous research of R&D inputs (total expenditures, relative – GDP share expenditures, but under conditions of different price levels etc.) in both countries I can asses it on about **40% level of Finish curve of attainable outputs.**

The percent rates calculated for the Czech research efficiency (37% for the productivity – publication activities and 20% for the utilization) respond to the research conditions of the country with best research political and fiscal conditions (which I put equal to Finland here).

The outer curve on the following figure charts the attainable combinations in Finland and the inner one in the Czech Republic. There we can see that the point D seems to be far below the attainable curve for Finland, which I put equal to 100% level. What is more important for Czech policy makers is that the point D is also below the curve of Czech attainable combinations – at about 60% of Czech curve at the axis X (37% of 60 that expresses position of Czech Republic to Finland) and at 33% of Czech curve at the axis Y (20% of 60).

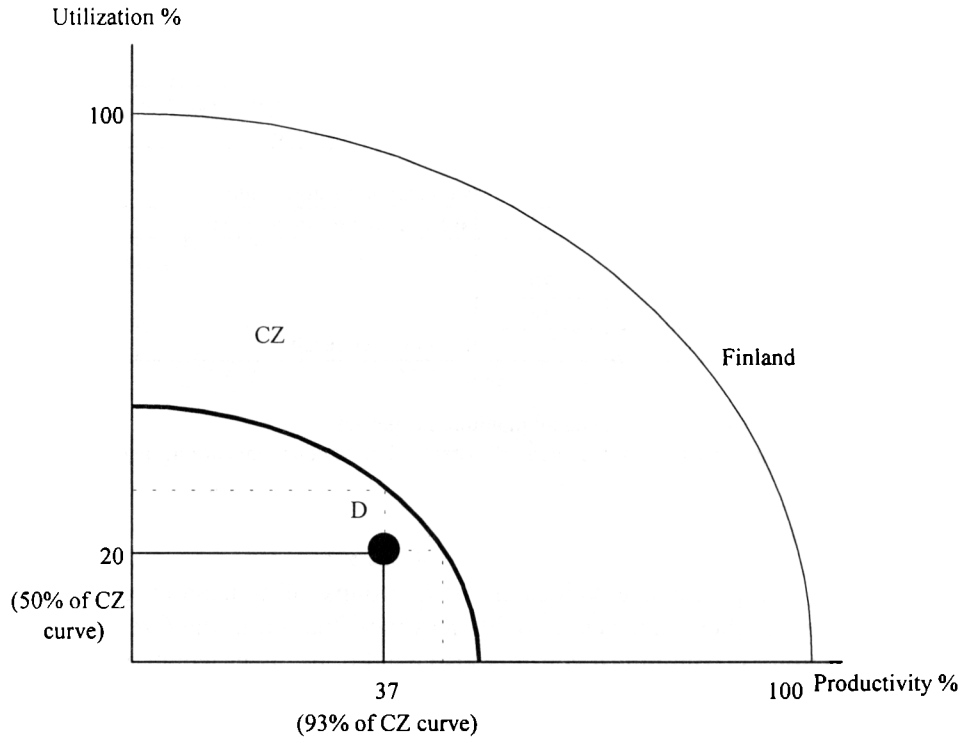

Fig. 11. Location of Czech research under current conditions and research policy

Source: own study.

What does it mean? The obtained review of the Czech R&D Performance and outputs allows me to the three questions put in the paper introduction:

1. The Czech government invests enough but policy makers should put more effort in controlling of how the funds are used and if the final outputs correspond with promises in grant and other applications for public support. Only when the outputs will be comparable to those from more developed countries, then policy makers can start working on moving the curve to the right, in the direction to the Finish curve and get our R&D to more favourable position of attainable combinations, to the level of more developed EU countries.

2. Yes, it is desirable to improve the way the science budget is allocated. It was already confirmed in the previous answer that there are reserves (charted by the red discontinuous lines) in utilization of available inputs in the Czech research. In the frame of given conditions, our researchers could at the same utilization produce a bit more publications or at the same productivity even 50% more practical outputs such as patents, innovations and new inventions as they produce now. The fact, that they are below the limits of Czech R&D means, that **the current policy and fiscal incentives do not stimulate researchers enough and so they may be improved.**

3. The weakness of the Czech R&D reflect the above written. Above everything I would highlight the lack or rather poor control of the public funds utilization and the low number of practical output – patents and innovations. After all the output comparison with developed Finland speaks for everything.

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