EXPECTED IMPACTS OF BIOTECHNOLOGY ON FOOD SAFETY IN CENTRAL AND EASTERN EUROPEAN COUNTRIES

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Abstract

Use of biotechnology in agricultural and food production has become one the most controversial issue in the last decade. Food safety is a crucial aspect of human life and therefore it is an issue of prime importance to the EU, however research on transition countries is practically nonexistent. We focus on Hungary, Slovakia, the Czech Republic, Slovenia and Romania using a Key Technology Survey, to analyse the biotechnologies that might have a strong impact upon food quality and health. We first investigate the likely future impacts of biotechnology on food safety than we employ foresight methodology. Third we apply cross-country comparison instead focusing on just one country. Results suggest that CEE countries are laggards in the development and application of biotechnology. We find that experts evaluate rather positively the effects of biotechnology on various types of hazards and large differences can be observed among country experts to assess these impacts.

Keywords: Biotechnology, Food Safety, Central-European Countries, Technology Foresight

I. Introduction

Use of biotechnology in agricultural and food production has become one the most controversial issue in the last decade. Recent research has focused on various aspects of the biotechnology including consumers' acceptance of GM food (see the survey by Lusk et al. 2005), regulatory issues (e.g. Evanson and Santaniello, 2004), adoption of biotechnology (Krishna and Qaim 2007, Buccola and Xia 2004, Barham et al. 2004), welfare impacts (Johnson et al. 2005, Sobolevsky et al. 2005), and trade policy (Anderson and Jackson 2005). Food safety is one of the major concerns relating to the impacts of biotechnology. Food safety is a crucial aspect of human life and therefore it is an issue of prime importance to the EU. Food safety has to be guaranteed through regulations with regard to inputs, production processes, outputs, transportation, storage, labelling, documentation of origin, traceability and the like, and by creating an adequate infrastructure for food markets and their smooth development. While the related literature is focussing almost exclusively on developed and developing countries, research on transition countries is practically nonexistent.

The paper contributes to this literature in three ways. First, we investigate the likely future impacts of biotechnology on food safety. Second we employ foresight methodology widely applied for industrial technology in recent years, but so far unexplored for the analysis of agricultural and food technology, except Lafourcade and Chapuy (2000), and Direction Gènèrale des Enterprises (2006). Third, contrary to common practice followed in most foresight projects, we apply cross-country comparison instead focusing on just one country.

The rest of the paper is organized as follows. Section 2 describes briefly foresight methodology and its importance in policy-making. Section 3 describes the survey design and the variables. The results are presented in section 4. The last section summarizes the outcomes of our analysis and offers some conclusions on the implications of biotechnologies for food safety in Central and Eastern European (CEE) countries.

II. Relevance of Foresight

The food industries in the CEE region are undergoing sweeping ownership, technological, organisational and financial changes. The new decision-making processes should put a strong emphasis on safety and quality standards. A foresight process is highly instrumental to tackle these complex issues. By bringing together the relevant stakeholders with their wide range of expertise and accumulated skills it is possible to (i) identify emerging technological and market opportunities and threats, (ii) consider S&T and socioeconomic factors in their entirety, and thus (iii) devise appropriate policies and strategies, based on consensus among these stakeholders. The ultimate goal is to identify future key technologies and new business models that are expected to promote the food safety requirements in food production.

The increasing number of foresight programmes – as systematic, participatory processes, collecting future intelligence and building medium-to-long-term visions, aimed at influencing present-day decisions and mobilising joint actions (EC DG Research, 2002) – suggests that foresight can be a useful policy tool in rather different national innovation systems. Emerging economies in the CEE region – faced with a number of similar or same challenges when trying to find their new role in the changing international settings, while still characterised by their own distinct level of socio-economic development, set of institutions, culture and norms – can also benefit significantly from conducting foresight programmes.

Foresight programmes do not have a single, all-encompassing theory to support them, and thus they rely on a range of – somewhat overlapping – theories and methods, including (i) evolutionary economics of innovation; (ii) sociology of science and technology; (iii) actor - network theories; (iv) political sciences analyses of policy processes; (v) communication, co-operation, and participation theories; (vi) decision-preparatory and future-oriented methods, techniques. This list is far from exhaustive, and most likely disciples of these theories would change the grouping, the order of their own discipline or even the wording used here. That might be an interesting discussion in its own right, indeed, for theoretical purposes. Yet, the intention here is just to indicate the 'eclectic' – and thus complex – nature of foresight programmes, rather than attempting to provide a meticulous, comprehensive treatise of these issues.

A number of technological, economic, societal, political and environmental trends affect all countries and most areas of policy-making, thus a new culture of future-oriented thinking is needed. Foresight can assist policy processes in various ways. It stresses the possibility of different futures (or future states), as opposed to the assumption that there is an already given, pre-determined future, and hence highlights the opportunity of shaping our futures. Further, it can enhance flexibility in policy making and implementation, broaden perspectives, and encourage thinking outside the box ("think of the unthinkable"). It can also contribute to (i) reduce technological, economic or social uncertainties by identifying various futures and policy options, (ii) make better informed decisions by bringing together different communities with their complementary knowledge and experience, (iii) obtain public support by improving transparency, and thus (iv) improve overall efficiency of public spending.

Foresight is a relevant decision-preparatory tool in emerging economies, too, not being in the forefront of technological development. CEE countries are faced by a number of specific challenges, most importantly due to their transition processes (fundamental political, economic and social changes), as well as to major changes in their external environment. Given these specific factors, there are even stronger needs for strategic thinking in CEE than in the advanced countries.

III. Survey Design

Our survey covers 6 CEE countries: Croatia, the Czech Republic, Hungary, Romania, Slovakia, and Slovenia. We have selected a Key Technology Survey (KTS) to analyse the possible future technologies that might have a strong impact upon food quality and health. In each country, a panel of experts has been selected, with R&D, governmental, and industrial background, respectively. Around 900 experts have been requested to fill the on-line KTS, and 434 of them have replied.

Table 1 shows the basic characteristics of respondents. In the region 43 percent of them have Ph.D degree and they work mainly at universities or other R&D organisations (53 percent), and less in business (30 percent) or government (11 per cent).

- insert table 1. here -

The online questionnaire has been organised as follows: after a brief introductory section focusing on the characteristics of the respondents, the experts have been requested to select those groups of technologies they are familiar with. We have defined 6 large groups of technologies: test and measurement, food packaging, biotechnology, nanotechnology, ICT and functional food. Within these groups a total of 28 individual potential key technologies have been included. Questions focused on the global development of the technology, the level of development and practical applications in their own country, and potential impacts on employment, economic growth, food safety and quality, as well as health. In this paper we focus exclusively on 5 individual biotechnologies and their impacts on food safety (see description of them in the Appendix).

IV. Results

General Findings

First we present the general findings. Given the space limits, we have pooled the expert assessments on individual biotechnologies into one group by simple averaging over various technologies.

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The most striking result is a high variation among the experts by countries to assess the global level development of biotechnology (Figure 1). In the region only 20 per cent of all respondents find that biotechnology is already widely used globally. Croatia, Czech Republic and Slovakia are below the regional average, whilst the other three countries are above. Interestingly, combining the share of widely used and first industrial application is less than 50 per cent for all countries, including the region as a whole.

Figure 2 reveals that CEE countries are lagging behind in the development of biotechnology: just a small minority of experts find that their country's position is excellent. The share of fair or weak position together is predominant in all countries, ranging between 70 and 95 percent. Hungary, Romania and Slovakia are below the regional mean.

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The situation of application of biotechnology is somewhat better compared to development but it is still far from current level of global development of biotechnology. The share of widely used and applied by leading actors is above 30 per cent, except Romania. Contrary to previous cases, countries are closer to the regional average; we cannot observe huge differences among them.

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Potential impacts

Next we have asked the experts to evaluate the potential impacts of the biotechnology on food safety by 2020 in their country. Following the literature on food safety, we divide theses issues into three main categories: biological hazard, chemical hazard and physical hazard (Valeeva et al. 2004).

Experts find that biotechnology has significant positive effects on biological hazards (Figure 4). However, the share of weak positive impacts exceeds the fraction of significant positive effects for all countries, except Croatia. Interestingly, respondents do no find that biotechnology has significant negative impacts on biological hazard. The share of weak negative effects is below 15 percent.

The opinions on the chemical hazards show a fairly similar pattern. Respondents evaluate that biotechnology has positive weak and significant impacts on chemical hazards for all countries. The share of these two categories is 60 percent in the region as a whole, Croatia, Romania, Slovakia exceeds the mean level. Similarly to biological hazards experts do no find negative and significant effect at all. (Figure 5)

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The potential impacts of biotechnology on the physical hazards are evaluated differently in the region. In general, expert find that it has mainly positive effects on the physical hazards, but its extent vary considerably. Slovakian experts think that biotechnology has no significant effects, whilst about 30 per cent of Croatian and Hungarian respondents identify this kind of impact. Similarly to the other two types of hazards, the level of negative impacts is low.

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Key technologies selection

To identify those technologies that are considered to be critical for the future development of the sector in terms of food safety, the following "three – input" graphs should be built:

- Current level of technological development vs. Position of your country in the development of the technology, taking into account the overall positive impact for each technology.
- Current level of technological development vs. Position of your country in the application of the technology, taking into account the overall positive impact for each technology.

We calculate (for each technology) the relative position of a given country, according to de following formula:

(*) ***Current position of your country = (1* N_W + 2*N_F+ 3*N_G+ 4*N_E)/N_T***

Where:

NW, the number of experts who have evaluated the position of their country as Weak,

NF, the number of experts who have evaluated the position of their country as Fair,

NG, the number of experts who have evaluated de position of their country as Good,

NE, the number of experts who have evaluated the position of their country as Excellent and

NT, the total number of experts who have assessed the technology.

(*) in relation to both, the development and the application of the technology

Current level of technological development = (1* N_N+ 2*$N_{R\&D}$+ 3*N_P+ 4*N_{IA} + 5*N_{WU})/N_T

Where:

NN, the number of experts who believe the technology is at a nascent stage,

NR&D, the number of experts who believe that there are sound R&D results in relation to the technology under study,

NP, the number of experts who believe a working prototype of the technology is available,

NIA, the number of experts who believe the first industrial applications of the technology are available, NW, the number of experts who believe the technology is in widespread use and,

NT, the total number of experts who have assessed the technology.

In addition, for each technology included in the KTQ, an average value of the positive impacts which have been assessed should be calculated, according to the following formula:

Individual impact for each topic (x):

$$I_X = [5*(N_{W+})_X + 10*(N_{S+})_X]/(N_T)_X$$

NW+ = number of experts who believe the technology in question has a weak positive impact

NS+ = number of experts who believe the technology in question has a significant positive impact

NT = the total number of experts who have assessed the technology

X relates to each of the topics the experts have been asked to evaluate (Growth, Employment, Food Safety, Health and Food Quality).

Then, the overall impact (I_T) for each technology can be calculated as follows:

$$I_T = (I_1 + I_2 + I_3 +\ldots + I_N) / N$$

Where:

$\mathbf{I_1, \ldots I_N}$ are the individual impacts which have been previously calculated.

N is the number of topics which have been assessed (N=5)

We applied the two selection criteria to identify the common key technologies within biotechnology, i.e. those technologies were selected as common key technologies for the region. First, technologies with higher than 5 overall positive impact were selected. Second, these technologies should be relevant key technologies for minimum three participating countries. In order to determine the importance of the technologies and their future prospects, i.e. if they are strategic or consolidated technologies, 3 input ziffer graphs were used. For each key technology selected, we present the position of all participating countries and the region in the development and application of the technology. According to these criteria we selected one key technology from 5 biotechnologies, namely KTQ11: biochemical modification of food ingredients, based on removing molecules causing health problems (i.e. gluten, allergens) or food modification for better consumer utilization (i.e. hydrolysed fat component). This technology was selected as key technology in Bulgaria, Croatia, the Czech Republic, and Romania.

In principle, we can identify two main groups of technology. *Consolidated technologies*, refering to those technologies at an advanced stage of development and a good position of the country in the development and/or application of the technology. *Strategic technologies*, refering to those technologies in which the country seems to have a good/excellent position in the development of the technology which is at an early stage of development.

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Figures 7 and 8 indicate that we could not identify KTQ11 as strategic technologies for any of the six countries considered. This may be explained by the size of the country in the region, lack of financial resources for R&D, and the way the agri-food sector is organised. However, w may define this technology as consolidated technology in Hungary and Slovakia.

V. Conclusions

The paper has investigated the likely future impacts of biotechnology on food safety in six Central and Eastern European countries using a key technology survey. Results suggest that CEE countries are laggards in the development and application of biotechnology. We found that experts evaluate rather positively the effects of biotechnology on various types of hazards. Apparently, large differences can be observed among country experts to assess these impacts. We could not identify any biotechnology as strategic technology for all six countries but one of them can be identified as a consolidated technology in Hungary and Slovakia.

It is crucial to prove the relevance of foresight for decision-making: its timing and relevance to major issues faced by societies, as well as the quality of its ‘products’ – reports and policy recommendations – are critical. Only substantive, yet carefully formulated proposals can grab the attention of opinion leaders and decision-makers, and then, in turn, the results are likely to be implemented. Otherwise all the time and efforts of participants put into a programme would be wasted, together with the public money spent to cover organisational and publication costs. The so-called process results – e.g. intensified networking, communication and co-operation among the participants – still might be significant even in this sad case, but they are less visible, and much more difficult to measure. Thus, the chances of a repeated programme – when it would be due again given the changes in the circumstances – are becoming really thin.

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Appendix 1: List of Biotechnologies

- Biochemical modification of food ingredients, based on removing molecules causing health problems (i.e. gluten, allergens) or food modification for better consumer utilization (i.e. hydrolysed fat component)
- Microorganisms with specific metabolic products enriching food with essence elements (fatty acids, amino acids and other biomolecules in a form of native or separated biological structures)
- Specifically bound molecules of medicines incorporated in food, capable of using the protection function of food molecules during digestion, thus ensuring the transport of medicine into target tissue and facilitating regular and more effective use of medicine (especially in case of patients with memory malfunctions)

- Signal bacterial molecules, capable of regulating the microorganism vegetation process (deceleration, acceleration), modify microorganisms metabolic activity (to avoid generation of toxins) or modify sporulation process (initiate or quit)
- Technology of food marked by biological molecules based on a combination of specific molecules that are part of the food, facilitating the identification of food adulteration by other producers as well as find out the food identity (traceability of food) in case all other identifiers and labelling in paper or electronic form have got lost

Tables and figures

Table 1: Basic characteristics of the survey respondents

		Share or respondents (percent)				
		Qualification	Working place			
	Total number	Ph.D	business	government	university or other publicly financed R&D organisation	NGO
Bulgaria	115	39.6	28.6	5.5	61.5	4.4
Croatia	68	42.4	18.6	22.0	52.5	6.8
Czech Republic	75	58.5	22.0	17.1	51.2	9.8
Hungary	53	33.3	39.4	9.1	48.5	3.0
Romania	63	81.6	5.3	5.3	81.6	7.9
Slovakia	60	8.3	77.8	5.6	8.3	8.3
Region	434	43.6	29.9	10.7	53.0	6.4

Figure 1: Current level of development of 'biotechnology' by countries and region

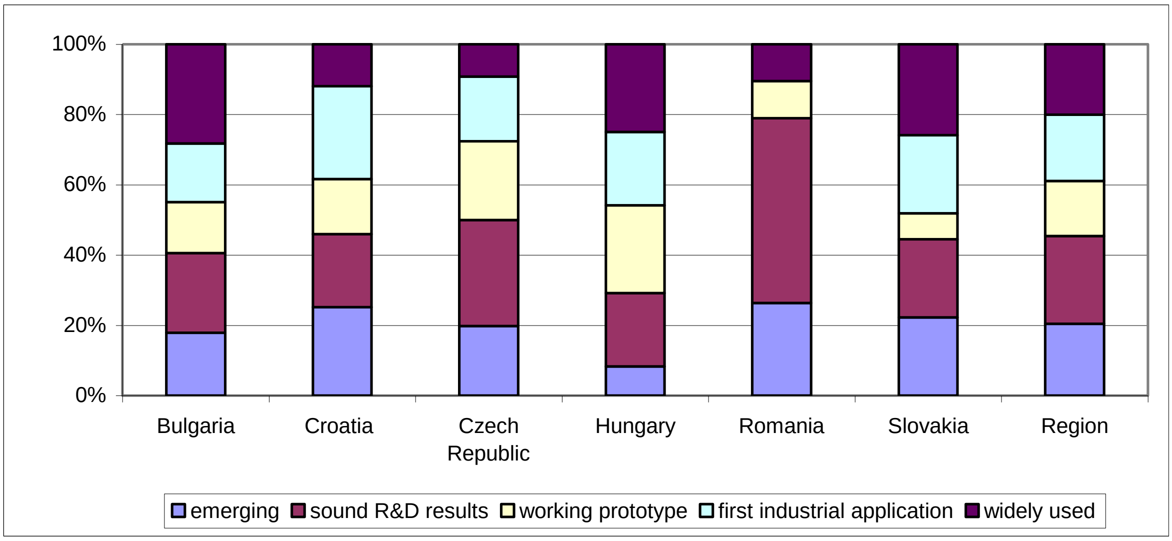

Figure 2: Current position in the development of 'biotechnology' by countries and region

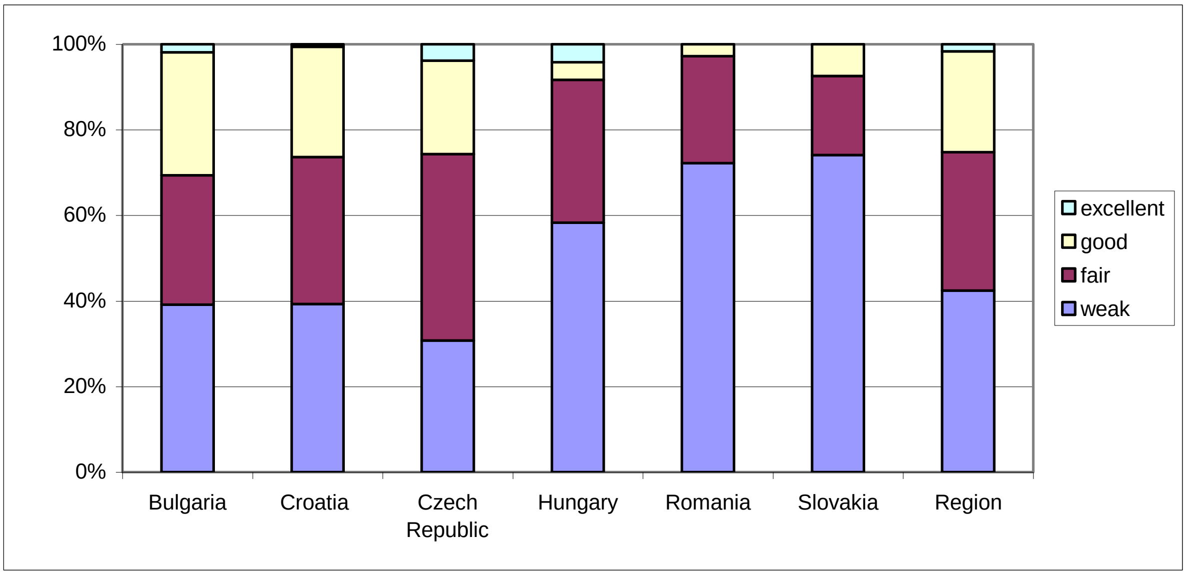

Figure 3: Current position in the application of 'biotechnologies' by countries and region

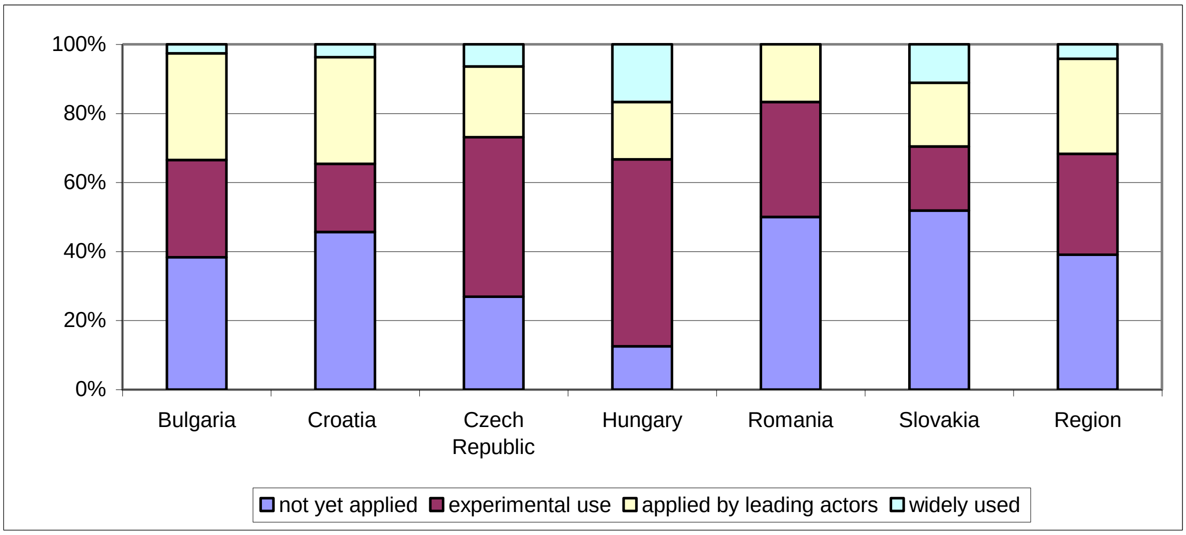

Figure 4: Potential impact of biotechnology on biological hazard

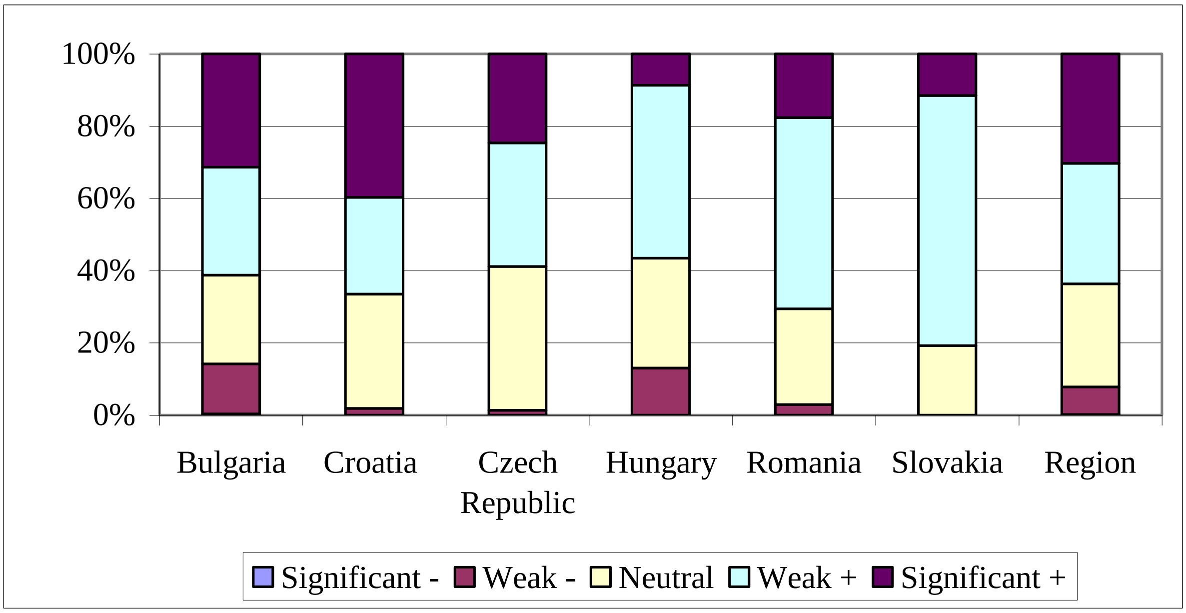

Figure 5: Potential impact of biotechnology on chemical hazards

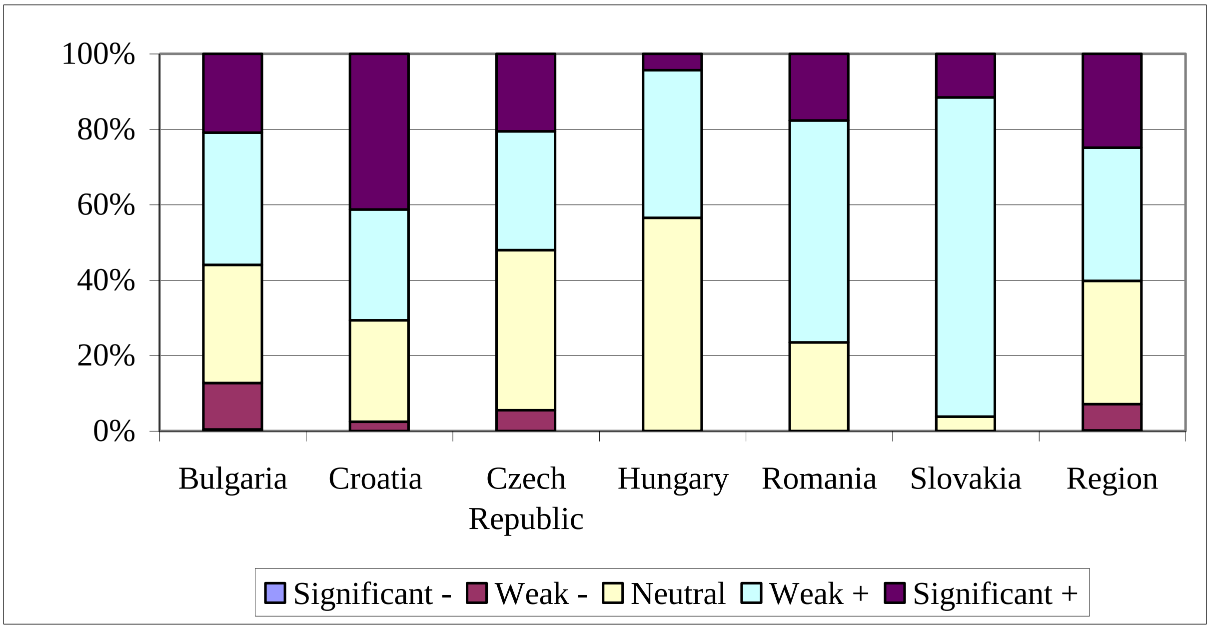

Figure 6: Potential impact of biotechnology on physical hazards

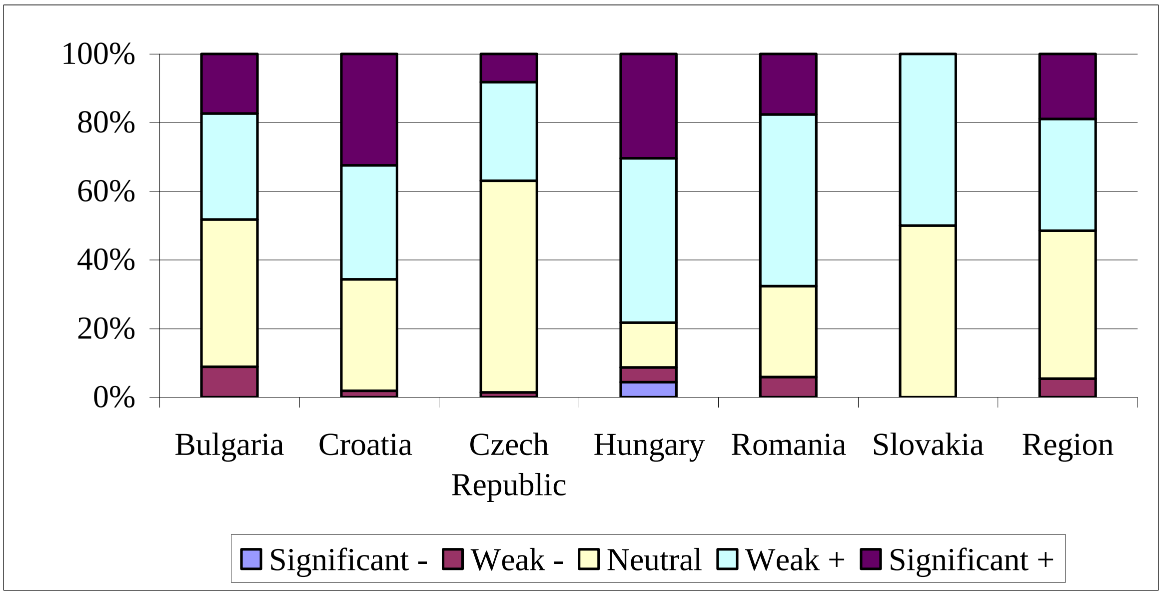

Figure 7: Current level of KTQ11 development versus current position of the region in the application of the KTQ11

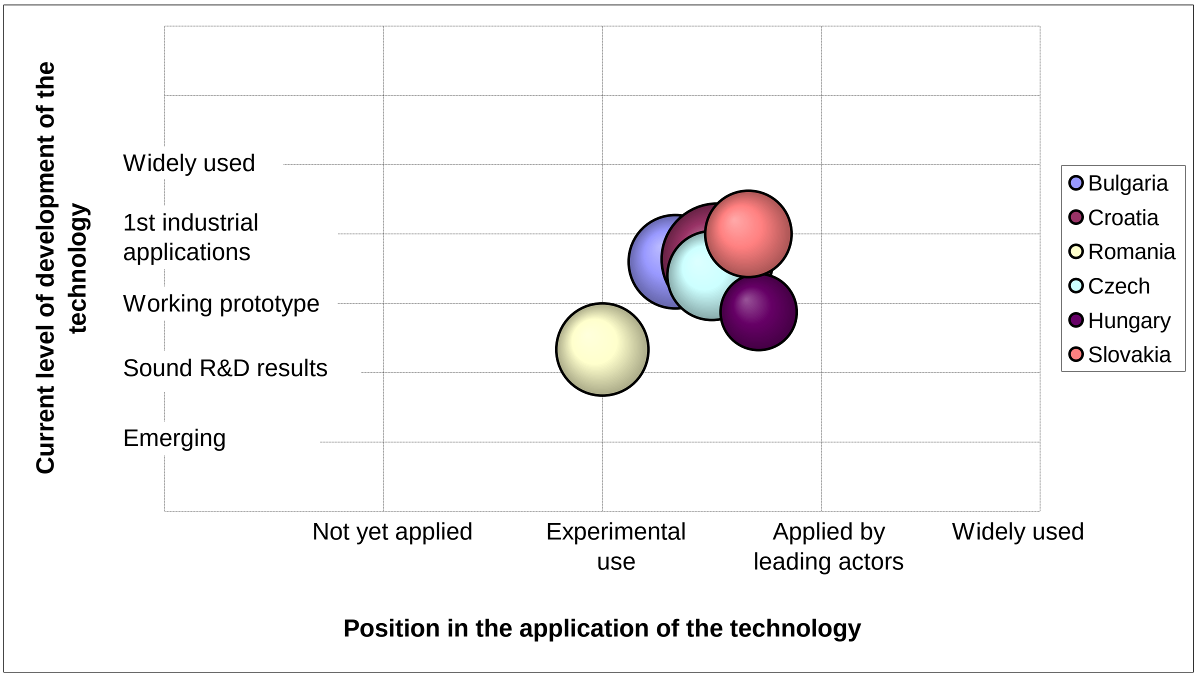

Figure 8: Current level of KTQ 11 development versus current position of the region in the development of the KTQ 11