NATIONAL RESEARCH UNIVERSITY
HIGHER SCHOOL OF ECONOMICS

Alexandra Savelkaeva, Valentina Poliakova,
Konstantin Fursov

STRUCTURE OF SOCIAL ATTITUDES TO SCIENCE AND TECHNOLOGY: NATIONAL AND INDIVIDUAL DETERMINANTS

BASIC RESEARCH PROGRAM
WORKING PAPERS

SERIES: SCIENCE, TECHNOLOGY AND INNOVATION

WP BRP 52/STI/2015

Alexandra Savelkaeva,[1] Valentina Poliakova[2], Konstantin Fursov[3]

STRUCTURE OF SOCIAL ATTITUDES TO SCIENCE AND TECHNOLOGY: NATIONAL AND INDIVIDUAL DETERMINANTS

Attitudes towards science and technology has been drawing the attention of many researchers focusing their search on specific aspects of public understanding of science, measuring risk perception associated with the development and wider dissemination of new technologies, engagement in decision making about controversial research issues. While some authors prefer to focus on the prevalence of particular attitudes towards S&T, trying to explain the differences between countries by variances in their economic development, others search for specific individual factors underpinning their development like values or beliefs. In our paper, we attempt to bring together these perspectives and comprehensively analyze both individual and national factors that define public opinion on S&T by considering the example of the attitude that characterizes optimistic or pessimistic perception. The method of multilevel regression analysis is used for this purpose. It was shown that inclusion into the model both micro and macro-level indicators is helpful to explain the differences between countries and allow us to better understand the "pure effects" of certain social determinants of public attitudes towards science and technology.

Keywords: Science and society, public opinion on S&T, attitudes to S&T, multilevel regression analysis, individual determinants, national determinants.

JEL classification: C25, O33, O35

[1] Alexandra S. Savelkaeva – BA, Research Assistant, Laboratory for Comparative Studies in Mass Consciousness, National Research University – Higher School of Economics. E-mail: assavelkaeva@edu.hse.ru.

[2] Valentina V. Poliakova – MA, Research Fellow, Institute of Statistical Studies and Economics of Knowledge, National Research University – Higher School of Economics. E-mail: vpoliakova@hse.ru.

[3] Konstantin S. Fursov – PhD, Senior Research Fellow, Laboratory for Economics of Innovation, Institute of Statistical Studies and Economics of Knowledge, National Research University – Higher School of Economics. E-mail: ksfursov@hse.ru.

INTRODUCTION

Attitudes towards science and technology (S&T) is drawing the attention of many researchers focusing their search on specific aspects of the phenomenon. As a result, there are numerous approaches being used to study public understanding of science, measuring risk perception associated with the development and wider dissemination of new technologies, engagement in decision making about controversial research issues. While some authors prefer to focus on the prevalence of particular attitudes towards S&T (Miller 2004, 2012; Shuvalova 2012), trying to explain the differences between countries by variances in their economic development (e.g. see Schramm, 1998), others search for specific factors underpinning their development like values or accumulated social capital (Knack, Keefer, 1997; Dakhli and Clercq 2004; Lebedeva 2010; Simon 2011).

Lacking of attempts to build up a comprehensive model taking into account both micro- and macro-level perspectives prompted us to carry out further research. Our study is aimed at the analysis of people's attitudes towards S&T by searching for the factors shaping them both on an individual and national levels. To achieve this goal, a multilevel regression model was developed to incorporate variables on different hierarchical levels, which allowed us to evaluate their combined impact on the overall perception of science. The method have seen widespread application and continue to be actively used in mathematical modeling in social sciences to understand correspondence between an individual and societal levels in the analysis of complex social phenomena (Hox, 2010).

Here lies the main idea of a multilevel approach to studying social activity – a hierarchical system exists in which individuals are grouped together 'in nests' and there is a significant structural difference between individuals and the groups at different levels in the hierarchy. At each of these hierarchical levels – at the individual level and at the group level – it is possible to identify a corresponding set of variables for subsequent examination.

Taking into account abovementioned features of the multilevel regression modelling, we set ourselves the task to analyse public attitudes to S&T in a cross-country perspective. Our intention was to examine the nature of the individual and group (or country) level factors identified in previous studies and evaluate their combined impact on the overall perception of S&T. therefore the paper is structured as follows. In the next section we will look at the structure of the determinants underpinning social attitudes towards S&T, which we developed based on an analysis of the results of previous studies. We consider the individual level factors shaping attitudes towards S&T to be individual values, social capital, level of religiosity, and a number of socio-demographic characteristics (age, sex, education, income). A country's economic welfare (GDP) and amount of human capital constitute national level factors. We will pay attention to certain restrictions not taken into account by other researchers and will propose in section three our own approach to analysing this structure. In the conclusion we focus on the the results of our research carried out using data from the World Values Survey (WVS) and set out in detail the possible limitations of this research and its practical applicability for future work in the field.

BASIC ASSUMPTIONS

In this paper, attitudes towards S&T are taken to mean a representation of certain construct obtained from several statements selected from World Value Survey 2005 (WVS) and having undergone a prior test for invariance. In other words, we built an index of attitudes to S&T, the meaning of which is revealed through respondents' agreement with the following statements:

1. 'Has the world become better or, conversely, worse thanks to S&T?'

2. 'S&T make our life simpler and healthier',

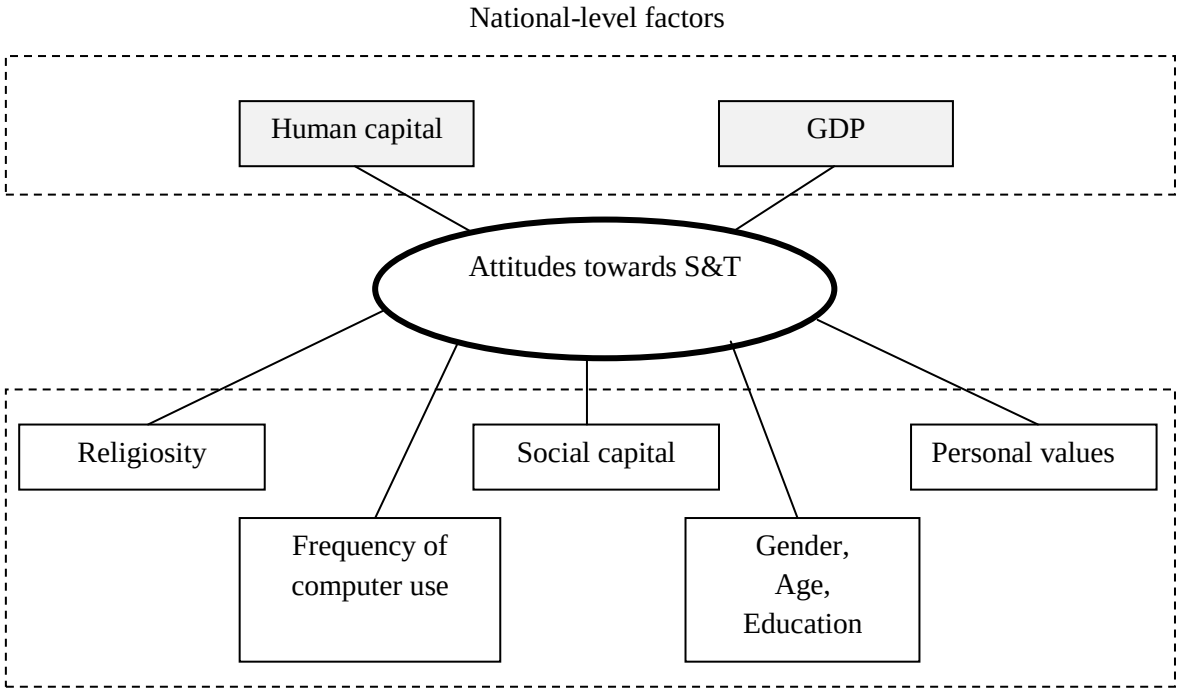
3. Thanks to S&T, more opportunities are opening up for future generations'.

The invariance test showed variance for only three of the eight variables used to build the combined index. We recognize that our index does not reflect all components of people's attitudes towards S&T, which can be explained by the inadequate questions in the WVS itself and can be listed among the limitations of this research. However, the measurement tool that we have developed is valid and can be used for a cross-country analysis.

Structure of factors shaping attitudes towards S&T

Within the framework of this research we consider both micro (individual level) and macro (country level) factors that may influence on the attitudes towards S&T. Individual level factors are understood to be personal appearances and views of respondents, unlike group level factors, which are mainly characteristics of the economic and social environment (Figure 1).

Figure 1 – Structure of factors shaping attitudes towards S&T



Personal values

Researchers have recognized that differences in basic cultural values determine the way in which innovations are perceived (Lebedeva, 2010) and that the relationship between values/attitudes varies from one country to another and has its own specific nature in each society, without however losing certain common universal traits inherent in all cultures simultaneously. For example, Russians with a positive attitude towards science and a high innovativeness index demonstrate visible significance in the following values: *Independence, Stimulation, Power*, and *Achievement*[4], while those with a negative attitude have *Tradition* as a marked value. For Canadians, the situation is entirely different: a higher innovativeness index comes from a devotion to the values of *Independence* and *Stimulation*, while a lower index is linked to the high value of *Power*. Positive attitudes towards S&T among the Chinese are only associated with an affinity for the value *Stimulation*. In other words, successful S&T development is associated in Russia with powerful, active and independent behavior while in China, for whom these values

[4] Here and further, we use the terminology and structure of values introduced in (Shwartz and Bilsky, 1987, 1990).

are entirely untypical, positive attitude to S&T is correlated with desire for diversification and the sensation of a well-rounded life.

Social capital

The notion of social capital has been reviewed on various occasions. However, there are still several carefully studied definitions in literature. First, Putnam and colleagues (1994), following the original definition of Granovetter (1973), pointed out the utmost significance of weak ties within family groups, and then referring to Coleman (1988) attributed an important role to the level of interpersonal trust and behaviour norms consistent with a sense of civil duty. We, therefore, consider trust, moral and ethical behaviour norms, and 'associative' activity in society (i.e. the ability of individuals to join different groups and organizations) to be components of social capital.

In their study of social drivers of economic behavior Knack and Keefer (1997) has shown that trust and cooperation between members of society leads to active economic growth. However, the role of 'associative' activity is low in this case; joining groups and organizations does not make the economy more prosperous. This conclusion is not particularly surprising: many scholars have remarked upon the contradictory impact of associative activity on economic development. Putnam (1994) linked economic prosperity in northern Italy to the large number of associations instilling citizens with customs such as cooperation, solidarity and civic-mindedness, while Olson (1982) noted that horizontal associations can harm growth because many of them occur in the context of 'interest groups' lobbying for specific views, thus imposing disproportionate expenses on the government.

In later studies (Dakhli, Clercq, 2004) it has been shown that the level of interpersonal trust has a positive impact on innovative development of a country, while participation in social organizations influences only funding for innovative projects. This comes as no surprise as far as active participation in life of a local community may go against the interests of the greater society as a whole. Consequently, by intensifying an individual's association with these interests and his or her hostility towards other groups in society, such communities tend to increase their 'in-group' cooperation and reduce the success of interaction on a country level, which may lead to a slowdown in innovative development. At the same time, adherence to norms somewhat contradicts the idea of innovation as this involves the introduction of new, risky methods of action which may go against the prevalent standards of behavior in society.

The level of trust is positively linked to economic development indicators such as GDP (Schramm, 2008). Moreover, Western European countries are characterized by higher levels of trust than economies of Eastern Europ. Trust has a direct impact on GDP as well as a mediated impact – through the level of cooperation and interaction between individuals in terms of scientific research, which consolidates the process of introducing innovations, which in turn contributes to economic growth. The German example adopted by the authors showed that the low level of trust in the GDR ('East Germany') compared with the FRG ('West Germany') was the result of the specific power regime in East Germany which intensified anonymity in society. In turn, this reduced the level of trust by maintaining the authoritative hierarchical structure and ruling out any opportunities for cooperation and free exchange of information between individuals.

Education and scientific literacy

Education is an important determinant of attitudes towards S&T on account of its positive relation to scientific literacy. More educated people are inclined to have a more positive perception of S&T (Shuvalova, 2012). However, the heterogeneity of countries in Europe and globally in terms of their attitudes towards science and the level of scientific literacy today has

been proven in a number of studies (Eurobarometer, 2005). On the one hand, there are invariant socio-psychological mechanisms that shape the structure of the relationship between awareness and attitude towards science. From this perspective, of course, the differences are minimal and the relationship should be the same for any society. On the other hand, we cannot ignore the social, political and cultural differences between EU-states when discussions touch on the relationship between scientific knowledge and attitudes. A cross-cultural model that puts forward some interesting conclusions was developed by (Allum et al., 2008). First, variation between countries has been recorded through a correlative relationship between indicators of scientific literacy and attitude towards S&T. Second, this variation can be explained by differences in national and regional socio-economic conditions.

Here we encounter some common ground with the so called 'deficit model' of science and society interactions (Sturgis, Allum, 2004), whereby attitudes towards science are directly related to the level of scientific literacy. A lack of knowledge among the population of modern Europe and America[5] leads to growth in scepticism and mistrust in science. The main hypothesis of the 'deficit model' is that there is a positive linear relationship between scientific knowledge and attitudes towards science.

Under the 'contextual model', attitudes towards science are shaped by several components: knowledge of scientifically approved facts and understanding of the ways science brings its results into daily life institutionally embed scientific knowledge in culture. The main hypothesis of the 'contextual model' is that deeper understanding of the relationship between political and financial institutions and science breaks up linear dependence between scientific literacy and attitudes towards science.

The results of a study based on data collected in the United Kingdom (Wynne, 1991) confirmed that as scientific literacy grows, attitudes towards science also improve (deficit model). However, increasing the awareness of the institutional structure only intensifies the positive trend of attitudes towards science. Moreover, the higher level of scientific literacy and in-depth understanding of the institutional structure of society and the interaction between science and other social institutions only improve attitudes towards S&T.

Gender and age

Gender differences in attitudes towards science can now be regarded as a proven fact, but the reasons for these differences, according to some researchers (Qin, Brown, 2007), need to be sought out in the various demographic characteristics of men and women – thus, religiosity and level of education act as important mediators between gender affiliation and attitudes towards S&T. Aside from this, it has been suggested that gender-specific life views among men and women, formed during socialization, constitute the context in which knowledge about new technologies is embedded. As a man's anxiety for his own financial welfare increases, he is increasingly likely to view the role of science in a pessimistic light, and even increased knowledge of scientific achievements does not help to improve his attitude.

Religiosity

A lack of understanding of the essence of scientific research is the most widespread phenomenon in a complicated differentiated world, information on which is forever growing and is becoming ever more difficult to systematize. Therefore, it is inevitable that individuals will turn to other systems in their everyday experience to make sense of scientific developments and achievements – religious faiths, prejudices, subjective assessments, intuitive opinions, all of which grow from

[5] As shown in (Sturgis, Allum, 2004), only one quarter of Europeans is scientifically literate.

interpersonal interaction and the exchange of opinions and knowledge. As such, religiosity has been recognized as one of the key factors in shaping social opinion about science (Liu, Priest, 2009). Moreover, as religious involvement increases, an individual's opinion regarding scientific achievements starts to be more influenced by the surrounding environment. In addition, as the intensity of involvement in religious ceremonies grows, so too the fears expressed by respondents about stem-cell research intensify. As a result, people who do not attend religious services or do it occasionally share more optimistic attitudes towards scientific progress compared than those who attend them on a regular manner.

Economic development and industrialization

A societal level of economic development is a strong factor determining transnational differences in attitudes towards S&T. As shown in (Allum et al., 2008) when one society transitions from an industrial to a post-industrial stage, the forms of interaction between the lay public and science changes. Thus, at the industrial stage of economic development, the sciences are idealized. People attribute to science a key role in the economy and society and accordingly, the more the public is kept informed about S&T matters, the more their attitudes tie in with this belief. In postindustrial societies, the sciences are seen as a 'matter-of-course' phenomenon and the knowledge and understanding from science become more and more specialized. Despite the fact that science still helps society to flourish, individuals are inclined to view it with greater suspicion and scepticism; the cultural stereotypes of the role of science is lacking. Researchers have found a curvilinear dependence between attitudes towards science based on scientific literacy and gross domestic product (GDP). Correlation is seen at a low level in both economically developed and developing countries. The highest correlation is seen in the intermediate group of European economies with an average level of development – i.e. industrial.

Human capital

The concept of human capital is linked to an individual's knowledge and skills acquired during learning, endowing the person with the ability to make their own contribution to the economic development of society (Dakhli, De Clercq, 2004). On a country level, a positive relationship has been observed between the amount of human capital and innovativeness – indeed, different forms of capital can easily be converted into economic gains (Bourdieu, 1986). Generally, the idea is that more educated individuals are capable to making a bigger contribution to social development and intensifying innovative development.

In empirical studies, a specialized index is often used as the variable reflecting human capital - the Human Development Index (HDI), which incorporates life expectancy, quality of life and education (Dakhli, De Clercq, 2004). A positive correlation has been discovered between HDI and several indicators reflecting a country's innovativeness – the number of patent applications submitted, spending on scientific research, and high-tech exports. Thus, human capital is in fact an important catalyst of innovation and has a positive effect on innovation activity of a country.

HYPOTHESES

In our study, we are combining both individual and national level factors outlined above into a single model in attempt to answer the question, which of the factors actually shaping attitudes towards S&T in a cross-cultural perspective?

To solve the task we need first to trace the nature of the relationship between views about science, personal values and social characteristics of individuals, and second, having justified the

assumption regarding the existence of such dependencies within selected sample of countries, include macro-level indicators to bring light on possible differences between them.

Research hypotheses to be tested in the model:

A. Individual values have a significant impact on attitudes towards S&T. In particular, with the data available, we can assume that in situations, where the intensity of the novelty and risk values is high, attitudes towards S&T will be more positive and similarly where the intensity of the safety value is high, attitudes towards S&T will be more negative.

B. Components of social capital is expected to have a mixed impact on attitudes towards S&T, i.e. a high level of trust between people will improve positive attitudes towards S&T will improve. At the same time both involvement in social organizations and disapproval of various forms of deviant behavior may worsen attitudes towards S&T.

C. As religiosity increases, negative attitudes towards S&T become more pronounced.

D. Women will have a more pronounced negative attitude towards S&T compared with men.

E. Young people are inclined to assess the effects of S&T developments more optimistically compared with older people.

F. As the level of education increases, attitudes towards S&T will improve.

G. As an individual's income increases, the individual's attitudes towards S&T will improve.

H. More frequent use of a personal computer (as an indicator of an individual's interaction with technology) will be positively associated with perceptions of S&T.

I. A higher human capital value will go hand-in-hand with more positive attitudes towards S&T.

J. In countries with higher GDP, the population's attitudes towards S&T will be more positive compared with countries with lower welfare.

DATA SOURCES AND METHOD

Data for this survey are driven from the Wave 5 of World Value Survey covering 32 countries with a certain number of individuals surveyed to provide representative samples.[6] Data is hierarchically grouped that allows using multilevel regression modeling. It is entirely reasonable to suggest that attitudes towards S&T might depend on different factors in different countries. In some countries, social capital may produce a significant effect, while in others its role may be modest. A single-level model cannot take into account differences between countries, because various effects would be multiplied.

Multilevel regression analysis method used to test the above-mentioned assumptions allows us to trace the combined impact of selected factors in the form of sets of variables included in the analysis on each of the hierarchical (individual and national) levels. Moreover, the use of the multilevel regression method is essential for a number of reasons. It allows us to avoid any errors occurring from applying the standard multiple regression method to variables on different hierarchical levels.

First, it solves the problem of taking into account statistical errors arising during aggregation, when a portion of the information is lost when transitioning from a large number of elements to a small number (for example, researchers try to calculate the average level of income for a country by using data on the individual income of respondents). Similarly, it helps to prevent systematic bias during disaggregation, when a variable value is ascribed to multiple elements from a small

[6] Detailed information of the 5th Wave of the WVS could be found at: http://www.worldvaluessurvey.org/WVSDocumentationWV5.jsp, descriptions of natonal samples available at: http://www.worldvaluessurvey.org/WVSContents.jsp

number of elements on a higher level (for example, the average score on a scale is given to each student).

The used sample includes the number of elements measured at national level. However, the inclusion of a large number of disaggregated elements in the sample leads us to establish the significance of tests, which disprove the null hypothesis far more frequently than assumed according to the nominal alpha-level. To evaluate the scale of the statistical error dispersion of variables should also be compared at different levels.

Moreover, we should not interpret data and apply conclusions to a higher or lower level than that for which the conclusions were made. This error is called the ecological fallacy (when we interpret aggregate data on an individual level) or the atomistic fallacy (when we draw conclusions at a higher level based on an analysis of a lower level – conclusions should not be made about a group when there is high individual heterogeneity). Thus, a key objective of the multilevel regression analysis is to define the direct effects of individual and group level variables on the variable being explained, and to ascertain whether group level variables really serve as a mediator for the relationships encountered on an individual level. If a group level variable mediates individual level variables and the relationships between them, this will be shown in the interactions between variables on different hierarchical levels.

In our case, individual attitudes within a country cannot be entirely independent – people within a country are 'closer to one another' than compared with those from different countries. This can be shaped by a number of common characteristics, including culture, history, similar social and economic environment. Therefore, the average correlation between variables for a group of fellow citizens (intra-class correlation) will be higher than the correlation for citizens of several countries simultaneously. However, standard statistical tests are entirely based on the independence of observations assumption. If this assumption (as in our case) is incorrect, any evaluations of standard errors will be so low that the results will be recognized as statistically significant even though they are not.

DISCUSSION

The results obtained in building our model of the dependence of attitudes towards S&T on individual and national level factors are provided in Table 1. The main descriptive statistics could be found in Table A in the Appendix. By building up a number of models we obtained an overview of the nature of this dependence and quantitative assessments of the scale of the effects, and were also able to evaluate the quality of the models and their correlation with reality.

We build several regression models, gradually including variables on different hierarchical levels. The so-called 'null model' serves as a model for comparison with all quality indicators for subsequent models. Model 1 involves individual level factors as described above: personal values, social capital, religiosity, sex, age, education, respondent's income, and frequency of computer use. The subsequent 2, 3 and 4 sequentially incorporate macro-indicators (national level factors): GDP for the period (2000-2005), the HDI human capital index, and the square of GDP values for 2000.

The gradual inclusion of these variables in the analysis and the construction of several models is justified on several grounds. First, we were able to trace the quality of the model when each variable came to be included in the model. Second, we managed to avoid the problem of multicollinearity between variables, which could have interfered in our assessment of the effects.

With the inclusion of additional variables in the new model the deviation figure falls, which suggests that as the 'complexity' of the model increases. The deviation fell by only 17% when the model was built solely using the religiosity figure, in the financial model (when macro-level figures were included) the deviation fell by 52%.

Table 1

Multilevel regression models

	Average	Hypothesis	Model 0	Model 1	Model 2	Model 3a	Model 3b	Model 3c	**Model 4**	**Model 5**	Model 6
				religion	social capital	independence value	risk and novelty value	safety value	**GDP (growth, 2000-2005)**	**HDI**	**GDP (2000)**
						values					
Intercept			6.9	6.7	7.2	7.2	7.2	7.2	6.2	8.8	7.2
COUNTRY LEVEL:											
GDP (2000-2005, $)	57.2	+							0.02		
GDP per capita (current $)	10154	-									-0.00009
GDP per capita (current $)^2	$2.3610 E^8$	-									0.000
Human Development Index	0.72	-								-2.4	
Trust (% of population inclined to trust 'others')	0.28	+							0.8	1.1	1.7
INDIVIDUAL LEVEL:											
Values											
independence value	0.2	-				-0.02			-0.02	-0.02	-0.02
risk and novelty value	-0.9	-					-0.02				
safety value	0.5	-						-0.03			
Social capital											
civic cooperation	2.41				-0.1	-0.08	-0.09	-0.09	-0.1	-0.1	-0.1
involvement in social organizations	0.15	+			-0.12	-0.14	-0.12	-0.15	-0.08	-0.08	-0.08
level of trust (mistrust)	0.28	+			-0.11	-0.11	-0.11	-0.11	-0.11	-0.12	-0.11
sex (fem.)	0.47	+		-0.12	-0.18	-0.19	-0.19	-0.17	-0.19	-0.19	-0.19
age^2	2175	+-		0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
age	43.4	+-		-0.01	-0.01	-0.01	-0.02	-0.01	-0.01	-0.01	-0.01
education - secondary	0.72	+		0.09	0.19	0.17	0.18	0.19	0.18	0.18	0.18
education - higher	0.21	+		0.18	0.24	0.24	0.24	0.24	0.25	0.24	0.24
income second level	0.09	+		-0.03	-0.07	-0.06	-0.05	-0.05	-0.06	-0.04	-0.04
income 3	0.12			-0.04	-0.03	-0.03	-0.03	-0.02	-0.03	-0.03	-0.03
income 4	0.13			-0.05	-0.08	-0.08	-0.08	-0.07	-0.08	-0.08	-0.08

	Average	Hypothesis	Model 0	Model 1	Model 2	Model 3a	Model 3b	Model 3c	**Model 4**	**Model 5**	Model 6
income 5	0.18			0.02	0.05	0.06	0.05	0.05	0.06	0.04	0.04
income 6	0.12			0.16	0.14	0.14	0.15	0.15	0.14	0.13	0.13
income 7	0.09			0.23	0.23	0.25	0.24	0.24	0.25	0.23	0.24
income 8	0.06			0.28	0.28	0.30	0.29	0.30	0.30	0.27	0.39
income 9	0.03			0.35	0.35	0.37	0.36	0.36	0.37	0.33	0.37
income 10th level	0.03			0.53	0.50	0.52	0.52	0.50	0.52	0.48	0.51
frequency of computer use	1.79	+		0.09	0.09	0.09	0.08	0.08	0.09	0.09	0.09
visits to religious services	4.22	+		0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.02
ICC			0.14	0.13	0.14	0.12	0.12	0.12	0.07	0.10	0.07
R square (Level 1)			-	0.3%	9%	9%	9%	9%	9%	9%	9%
R square (Level 2)			-	-	-	-	-	-	61%	41%	60%
Deviance			148285	123139	72238	71313	71586	71684	71303	71308	71300
Deviance reduction (%)			-	16.96	51.2	51.9	51.7	51.6	51.9	51.9	51.8
n = individuals			37425	10,414	37109	25852	25852	25852	25852	25852	25852
var ind (residual)			3.0	3.0	2.8	2.8	2.8	2.8	2.8	2.8	2.8
var country level (random intercept)			0.5	0.5	0.4	0.4	0.4	0.4	0.2	0.3	0.2
Degrees of Freedom			2	18	23	24	24	24	26	26	27
* 0.67 - coefficient insignificant											

When we look at the scale of the effects of the various factors in each of the models, it becomes clear that they are virtually equal, and therefore, by also taking into account the model quality figure, we opt for the more complete following model every time. So on an individual level, we can immediately set about interpreting the model containing the effects of religiosity, social capital, values and a number of socio-demographic characteristics simultaneously.

Personal values

We hypothesized that a person whose values of independence and risk-novelty are high is likely to have a favourable attitude towards S&T, while as the importance of safety increases, attitudes for him or her will worsen. The results of the analysis do not corroborate this assumption. We can see (models 3a-3c) that the regression coefficients with each of the three values are negative. Attitudes towards S&T worsen by 0.002 while the importance of the independence, risk-novelty and safety values increase. This result is unexpected and goes against both the results of previous studies and the basic hypotheses of this research.

We conjectured that the negative coefficients with the individual values are linked solely to the specifics of the data used. We attempted to introduce into the model aggregate value indices

which comprise several judgements simultaneously, however this also did not lead to the desired result – both the 'openness to changes' (risk-novelty, independence, wealth) and the 'conservatism' index (tradition, adherence to norms) only worsened attitudes towards S&T. The weak negative correlation in the majority of countries between the independence, risk-novelty and safety values and attitudes towards S&T as well as certain components of these attitudes (assessments of the benefits of science for future generations, agreement with the view that science makes life simpler and healthier, opinion of the role of sciences for humanity generally) also point to the lack of error on our part both in selecting variables and building the indices.

The problem perhaps lies in the data itself. Specifically, there is a certain 'reaction model' among respondents answering questions about values. It is particularly noteworthy that the actual questions about values were taken from the approach initially proposed in (Schwartz and Bilsky 1987, 1990), however actually used list of judgements was incomplete, which does not allow us to build up 'fully-fledged' value indices as was initially suggested in this method. The apparent shortcomings of the WVS-5 data are therefore clear.

However, this result may show that 'the openness to changes' is indeed not an essential condition of optimistic perception of S&T. It is possible that such mindset assumes more critical (not necessarily pessimistic) attitude to the influence of S&T. This fact requires further study.

Social capital

We managed to come closer to the expected result in terms of the impact of certain social capital components on attitudes towards S&T. Thus, on the individual level of the analysis, membership of the category of people inclined not to trust others leads to the deterioration of attitudes to S&T by 0.11. We can therefore assert the positive significant impact of interpersonal trust on these attitudes, which is in line with the conclusions of previous studies (Lebedeva, 2009; Dakhli, Clercq, 2004). Although they were geared towards searching for determinants of positive attitudes towards innovative activity, the conclusions made by the researchers can logically be applied to our research. In fact, as trust increases the attitudes towards S&T are getting improved. This could be explained by the favourable conditions that are created in dialogue with others to exchange information, experience and knowledge as well as the intensification of the feeling of solidarity between people. Attitudes towards innovation a positive impact not only on innovation activity, but also on public perception of science in general. That is to say that perception of advantages brought by scientific progress (beneficial for future generations, improving the world as a whole, creating conditions for an easier and healthier life) is more easily spread in societies with higher level of trust between individuals.

As for the second component of social capital – involvement in social organizations – as expected, we recorded a negative effect. As the number of organizations that an individual is a member of increases, his or her attitude towards science deteriorates. In fact, this result was predictable. As previously noted in (Knack, Keefer, 1997), the two effects of engagement in social organizations on the amount of social capital were observed. On the one hand, the trust within small associations intensifies, fostering skills such as interaction in their members and establishing behaviour in such a way that an individual can blend in with a group as successfully as possible. In this case, an increase in social capital leads to observable positive effects, including even improvements to a country's economic position (Putnam, 1994). On the other hand, the excessive number of small local organizations and the membership of an individual in such organizations can be a stimulus for clashes between interests and the advocacy of their own interests. As a result, the level of trust reduces, as well as the level of solidarity between individuals, and identification with a particular group intensifies hostility. According to our conclusions, attitudes towards S&T are worsening (from 0.12 to 0.15 in models incorporating

various individual values: 3a, 3b or 3c), which logically ties in with the conclusions regarding the role of trust in these attitudes.

Finally, the third component of social capital – the strength of public behaviour norms (or the level of disapproval of various forms of deviant behaviour – bribes, fare-dodging, tax evasion, benefit fraud) – as expected, have a significant negative impact on attitudes. In other words, as disapproval of such forms of deviant behaviour increase by one unit, social capital reduces, and attitudes towards S&T worsen by 0.08. This conclusion is also very much in line with the conclusions of previous studies (Knack, Keefer, 1997; Dakhli, Clercq, 2004). In fact, all of the forms of behaviour that we used in our analysis are strategies of so-called 'deviants', who strive to derive gain from using publicly accessible resources without paying. People's ability to cooperate is precisely their disapproval of and determination to eradicate such forms of behaviour. Growth in cooperation is a guarantor of growth in social capital. The result from our research directly points to a positive relationship between the strength of public behaviour norms (disapproval) and attitudes towards S&T.

Thus, we have successfully confirmed the complex, divergent influence of different components of social capital on people's attitudes towards S&T. All of this again confirms the heterogeneity of this concept and requires additional efforts on the part of researchers to conceptualize it and search for indicators which could be sufficiently reliable that their effects can be reproduced so that the concept of 'social capital' can be firmly characterized.

Religiosity

The next determinant of attitudes to S&T taken into consideration was religiosity, which we measured as the frequency of attending religious services. The effect was as follows: the less frequently an individual visits such institutions, the more positive his or her attitudes towards S&T will be. This fully corroborates our hypothesis and goes in line with previous findings. Moreover, our data also confirms that there is a clear contradiction between religious views and science. In particular, the remark about the negative role of religion in acceptance of development of experimental research provided in (Liu, Priest, 2009) has been justified. Moreover, our data confirms the assertion that religious and traditional beliefs are hardly making the way for scientific knowledge and actively disapproving it.

Frequency of computer use

In addition to this, the model also included indicators such as the frequency of computer use. We consider this to be an indicator of 'technology skills' in an individual and the regular or irregular interaction of an individual with technology can have an impact on his or her attitude towards S&T. In fact, as computer use increases attitudes towards S&T increase by 0.09.

Gender and age

As expected, the attitudes of women towards science is more skeptical compared with men's. Therefore, being a woman leads to a reduction in the intensity of attitudes by 0.19. This result is entirely provides evidence for the previously made assumptions that women are more sensitive to risk (Flynn et al., 1994; Greenberg and Schneider, 1995; Gustafson, 1998; Qin and Brown, 2007). We also managed to establish the direct negative impact of age on attitudes to S&T. However, the formulated hypothesis was only corroborated in part. Thus, initially, the inclusion of the age variable in the model pointed to a positive effect on attitudes. But the inclusion of age squared in the model, with a view to removing the likelihood of curvilinear dependence, pointed to the existence of this dependence. Therefore, the effect of age, according to our data, is actually

negative, while the effect of age squared is positive. In other words, this means that when young people move into the 'adult' category, their skepticism regarding the role of technology actually increases, and when they move from the adult category into the elderly category, these sentiments become less pronounced.

Perhaps there is a need to look for the reason in the specific nature of the world views held by different generations. Younger generations are renowned for greater openness to new things and their active uptake of various gadgets, while conservatism increases with age and everything new is viewed more critically. The increased optimism towards scientific and technological progress among the elderly could be linked to the fact that the socialization of those among the older generations took place in a period of large numbers of household appliances and consumer electronics, mass media, growth in the level of public literacy, space exploration and men in space, which could help to embed a scientific map of the world.

Education and financial position

More educated and more well-to-do individuals show greater enthusiasm for scientific and technological developments. A higher education improves these attitudes by 0.24. As we move up the income ladder, with each sequential level the attitudes of the respondents in the corresponding group become more and more positive – in the end, people at the highest level have a attitude which is 0.5 units more intense than those at the lowest level occupying the first rung of the income ladder.

Our conclusions in this regard are in line with the views of other researchers (Miller, 2004) who put forward the 'deficit model' discussed above. In fact, we discovered a direct significant tie between education and attitudes towards science. More informed individuals without 'knowledge gaps' are less inclined to hold irrational beliefs and replace a lack of understanding of scientific facts with religious beliefs, for example. Although the database that we used did not have any variables reflecting the level of scientific literacy in a form which could be used to test the hypothesis in the 'contextual model', we are still guided by the assumption that there is a close link between scientific literacy and level of education.

These were the effects of the determinants shaping attitudes towards S&T on an individual level. However, in our view, it was also extremely important to assess the impact of factors that shape countries in terms of the intensity of attitudes on a macro-level. In order to do this, we introduced several macro-economic indicators into the model: GDP growth over the period 2000 to 2005 and the human capital indicator (the human development index – HDI). It was assumed that these indicators and the vector of public opinion regarding S&T would show some correlation. Human capital (HC) is an indicator made up of several components: level of education, life expectancy, and quality of life. Taking into account the results of previous studies (Dakhli, De Clercq, 2004) showing positive relationships between HC and innovation development of a country (measured through the number of patents issued and spendings on R&D), we presumed that the situation would be similar with public attitudes towards science.

Human capital

Model 5 (cf. Table 4) with the HDI index introduced on a country level predicts not an improvement, but rather a worsening of attitudes towards S&T that disproves our initial hypothesis. Thus, as HC grows, the value of the corresponding index falls by 2.4 points. High HC level is coupled with a more critical assessment of the effects of S&T development.

An analysis of the developmental history of the model of communication between science and society allows us to clarify and explain the obtained result. As science started to be reported more and more in the media (Rödder, 2009) and information on the risks of scientific and

technological progress and the negative effects of using certain technologies (for example, nuclear weapons and energy) started to spread, a certain 'crisis of trust' in the sciences was noted (House of Lords, 2000; Miller, 2001). In this context, a number of countries which had achieved a relatively high educational and economic level of modernization (for instance, UK, Germany, USA, etc.) started to develop a practice of dialogue between the population and the sciences and involve the population in the production and dissemination of scientific knowledge (Bauer, Allum and Miller, 2007; Bucchi, 2008; Bucchi and Nessini, 2008). This explains the more critical (or rather, more aware) public view on the possible impact of scientific and technological developments on society on a national level in countries with higher human capital indicators. At the same time, this does not void our results, which show that, on an individual level, education is still linked to a higher level of belief in the sciences, as education accustoms certain individuals to the sciences and fosters a more positive opinion about science generally.

GDP

The level of economic development is in fact a significant factor explaining the differentiation of countries in terms of their perception of S&T. Ii is clearly seen from the results of modeling that GDP growth for the period 2000 to 2005 has a clear significant relationship with the public attitudes towards S&T. In other words, the level of economic welfare of a coutry is positively associated with the its citizens' assessments of the impact of S&T. Taking into account the results of previous studies, which established a curvilinear dependence between a country's level of welfare and attitudes towards science (Allum, Sturgis, 2004, Tabourazi, Brunton-Smith, 2008), we considered it necessary to test an additional hypothesis: that perhaps there is not a simple linear, but rather complex dependence of a higher order. However, the introduction of GDP for 2000 into the equation and the square of this figure did not corroborate this hypothesis. The significance of the coefficients with these figures (cf. Model 6) does not allow us to assert that they are determinants of attitudes towards S&T. Our data do not point to any curvilinear dependence between public attitudes in different countries and their welfare. Thus, the postulation of a linear dependence between GDP growth for 2000-2005 and attitudes towards S&T needs to be limited, although the lack of impact from absolute GDP figures for 2000 on attitudes requires additional study.

CONCLUSION

In this work, we set ourselves the task to analyse a set of predictors of attitudes towards S&T, which vary from optimism and full acceptance to guarded and critical perceptions of their impact on everyday life. Unlike previous studies, we proposed studying their combined impact on an individual and national level. For this, we used a multilevel regression analysis method.

We defined a list of determinants shaping attitudes towards S&T and commented on certain global trends taking place in the world with the help of introducing macro-indicators into our analysis. The results of multiple regression modeling showed that it is worthwhile to look both at individual level determinants and to introduce into the model macro-level indicators that partially explain the differences between countries and allow us to better understand the impact of certain parameters on the phenomenon being analysed. Moreover, the introduction of additional layers of characteristics allows us to clarify the impact of certain variables on perceptions of S&T.

Some findings were unexpected. Firstly, the analysis has not confirmed the positive influence of the independence, risk-novelty and safety values on perception of S&T. Secondly, it was shown that the dependence between age and the optimism for S&T is curvilinear. If we compare young and adult people we fix the reduction of optimism for S&T, while comparing 'adult' and elderly

categories the trend is weakening. Third, the high level of human capital at the country level is associated with a more critical (instead of expected optimistic) estimation of the effects of S&T. This empirically supports the claims of contextual theory of public opinion on S&T and some other theories to modify the approach to measuring this phenomenon.

The work done and the results obtained clearly demonstrate the applicability of a multilevel regression analysis method to solve problems of this nature. Such an approach is likely to be used for the analysis of "pure effects" of social factors on public attitudes towards S&T as far as it takes into account and allows to grade economic and cultural differences between countries. At a national level such a model could be used to analyze regional and other effects. Of course, we do not insist upon the completeness of our model and suggest that the number of factors could be increased. Nevertheless, we were still able to obtain important results which have enabled us to identify the existence of different models of interaction between science and society and to deepen our understanding of the ways in which public opinion is shaped on S&T in different social and institutional contexts.

Appendix

Table A

Descriptive statistics of independent variables

		N	Mean	Std. Deviation
organisation	AV_MEMB	25852	0.15	0.21
trust (yes/no)	TRUST	40341	0.28	0.45
macrotrust (%)	MACROTRUST	41953	0.28	0.18
strength of norms	AV_NORMS	39387	2.41	1.77
sex	GNDR	41910	0.47	0.50
age	AGE	41847	43.4	16.9
income: lowest level	inc_cat1	41953	0.08	0.27
	inc_cat2	41953	0.09	0.29
	inc_cat3	41953	0.12	0.33
	inc_cat4	41953	0.13	0.34
	inc_cat5	41953	0.18	0.38
	inc_cat6	41953	0.12	0.33
	inc_cat7	41953	0.09	0.29
	inc_cat8	41953	0.06	0.24
	inc_cat9	41953	0.03	0.16
income: highest level	inc_cat10	41953	0.03	0.17
education: none	ed_cat1	41953	0.06	0.24
education: primary or secondary	ed_cat2	41953	0.72	0.45
education: higher	ed_cat3	41953	0.21	0.41
new value	VAL_NEW	40608	0.2	1.1
risk value	VAL_RISK	40714	-0.9	1.3
safety value	AV_SAFE	39580	0.5	0, 1
GDP growth	GDP_2000_2005	41953	57.2	12.6
human capital	HDI_2000	41953	0.72	0.16

Table B

Dependent variable average value

country	attitude towards S&T (average)
Cyprus	4.25
Uruguay	6.04
Morocco	6.36
Japan	6.38
Zambia	6.49
Thailand	6.67
Chile	6.68
Trinidad and Tobago	6.76
Burkina Faso	6.78
Brazil	6.78
Slovenia	6.78
Malaysia	6.79
North Korea	6.82
Ukraine	6.83
Finland	6.83
Australia	6.88
Spain	6.90
Mexico	6.95
Bulgaria	7.00
Norway	7.04
USA	7.06
Moldova	7.07
Serbia	7.07
Sweden	7.13
Canada	7.15
Georgia	7.17
Poland	7.37
Germany	7.37
Romania	7.49
Turkey	8.26
China	8.35
Vietnam	8.54
In the sample:	6.94

Acknowledgments

The research leading to these results has received funding from the Basic Research Program at the National Research University Higher School of Economics.

The financial support from the Government of the Russian Federation within the framework of the Basic Research Program at the National Research University Higher School of Economics and within the framework of implementation of the 5-100 Programme Roadmap of the National Research University Higher School of Economics is acknowledged.

References:

1. Allum, N., Sturgis, P., Tabourazi, D. and Brunton-Smith, I. (2008). Science Knowledge and Attitudes across Cultures: A Meta-Analysis. Public Understanding of Science 17(1), 35–54.
2. Bauer, M. W., Allum, N., and Miller, S. (2007). What can we learn from 25 years of PUS survey research? Liberating and expanding the agenda. Public understanding of science, 16(1), 79-95.
3. Bucchi M., Nessini F. (2008). Science and Public Participation. In E.J. Hackett, O. Amsterdamska, M.E. Lynch, J. Wajcman (eds) Handbook of S&T Studies. Third Edition. MIT, 449-472
4. Bucchi, M. (2008). Of deficits, deviations and dialogues: Theories of public communication of science. In Bucchi, M. and Trench, B. (Eds.) Handbook of public communication of S&T. Routledge, 57-76.
5. Coleman, J. S. (1988). Social Capital in the Creation of Human Capital. American Journal of Sociology, 94, 95–120.
6. Dakhli, M., and De Clercq, D. (2004). Human capital, social capital, and innovation: a multi-country study. Entrepreneurship and regional development, 16(2), 107-128.
7. Flynn, J., Slovic, P., and Mertz, C. K. (1994). Gender, race, and perception of environmental health risks. Risk analysis, 14(6), 1101-1108.
8. Granovetter, M. S. (1973). The strength of weak ties. The American Journal of Sociology. Vol. 78. Issue 6, 1360-1380.
9. Greenberg, M. R., and Schneider, D. F. (1995). Gender differences in risk perception: Effects differ in stressed vs. non-stressed environments. Risk Analysis, 15(4), 503-511.
10. Gustafsod, P. E. (1998). Gender Differences in risk perception: Theoretical and methodological erspectives. Risk analysis, 18(6), 805-811.
11. House of Lords Select Committee on S&T (2000). Science and Society, 3rd Report. London: HMSO.
12. Hox, J. J. (2010). Multilevel Analysis: Techniques and Applications. Routledge.
13. Inglehart, R. (1997). Postmodern: changing values and changing society. (Postmodern: menaushiesya cennosti i izmenyushhiesya obshhestva). Polis, 4, 6-32.
14. Knack, S. and Keefer, P. (1997). Does social capital have an economic payoff? A cross-country investigation. The Quarterly Journal of Economics, 1251–1288.
15. Lebedeva, N. (2010). Values and attitudes to innovation of Russian, Canadian and Chinese students (Cennosti i otnoshenie k innovaciam rossiiskih, kanadskih i kitaiskih studentov). Psychology in Economics and Management (Psihologia v ekonomike i upravlenii), (6), 59-68.
16. Lebedeva, N. (2011). Social and cultural factors of creativity and innovation: cross-cultural approach (Sociokulturnye faktory kreativnosti i innovacij: kross-kulturnyj podhod). In.: Culture and Economic Behavior (Kultura i ekonomicheskoe povedenie) / Eds.: Lebedeva N., Tatarko A. M.: MAKS Press, 481-520.
17. Liu, H. and Priest, S. (2009). Understanding public support for stem cell research: media communication, interpersonal communication and trust in key actors. Public Understanding of Science, 18(6), 704-718.

18. Miller, J. D. (2004). Public understanding of, and attitudes toward, scientific research: What we know and what we need to know. Public Understanding of Science, 13(3), 273-294.
19. Miller, J. D. and Inglehart, R. (2012). Public attitudes toward S&T. In Bainbridge, W. S. (Ed.) Leadership in S&T: A reference handbook. Sage Publications, 298-306.
20. Miller, S. (2001). Public Understanding at the Crossroads. Public Understanding of Science, 10 (1), 115–120.
21. Olson M. The Rise and Decline of Nations. New Haven, CT: Yale University Press, 1982.
22. Pardo, R. and Calvo, F. (2002). Attitudes toward science among the European public: a methodological analysis. Public understanding of science, 11(2), 155-195.
23. Putnam, R. D., Leonardi, R. and Nanetti, R. Y. (1994). Making democracy work: Civic traditions in modern Italy. Princeton university press.
24. Qin, W., & Brown, J. L. (2007). Public reactions to information about genetically engineered foods: effects of information formats and male/female differences. Public Understanding of Science, 16(4), 471-488.
25. Rödder, S. (2009). Reassessing the concept of a medialization of science: A story from the "book of life". Public Understanding of Science, 18(4), 452-463.
26. Schramm M. Trust, distrust and innovations. Business and Universities in a divided Germany (1949-90) // Institute for European History Technische Universität Chemnitz, URL: [gla.ac.uk›media/media_168233_en.pdf]
27. Schwartz S.H., Bilsky W. (1987) Toward a Universal Psychological Structure of Human Values // Journal of Personality and Social Psychology. Vol. 53.
28. Schwartz S.H., Bilsky W. (1990) Toward a Theory of the Universal Content and Structure of Values: Extensions and Cross Cultural Replications// Journal of Personality and Social Psychology. Vol. 58.
29. Shuvalova, R. (2012). Stakeholders in the field of science and innovation: the "new" stakeholders or "old" technocrats? (Zainteresovannye gruppy v sfere nauki i innovacij: «novye» stejkholdery ili «starye» tehnokraty?) Sociology of S&T (Sociologia nauki i tehnologij), 3(3), 73-96.
30. Simon, R. M. (2011). Gendered contexts: Masculinity, knowledge, and attitudes toward biotechnology. Public understanding of science, 20(3), 334–346.
31. Special EUROBAROMETER 224 (2005). Europeans, S&T. European Commission Report. URL: [http://ec.europa.eu/public_opinion/archives/ebs/ebs_224_report_en.pdf]
32. Sturgis, P. and Allum, N. (2004). Science in society: re-evaluating the deficit model of public attitudes. Public understanding of science, 13(1), 55-74.
33. Wynne, B. (1991). Knowledge in Context. Science, Technology, and Human Values, 16(1), 111–121.

Konstantin Fursov
PhD, Senior Research Fellow, Laboratory for Economics of Innovation, Institute of Statistical Studies and Economics of Knowledge, National Research University – Higher School of Economics. E-mail: ksfursov@hse.ru.