National Research University Higher School of Economics

Global competitiveness program

Strategic academic unit

COGNITIVE NEUROSCIENCE: FROM COMPUTATIONAL MODELS TO NEUROTECHNOLOGY

Description

Moscow, 2016

CONTENTS

1. STRATEGIC ACADEMIC UNIT "COGNITIVE NEUROSCIENCE: FROM COMPUTATIONAL MODELS TO NEUROTECHNOLOGY"

1.1 Project summary

Goal: To establish a research and educational center of excellence that integrates cognitive neuroscience and information science in order to construct interdisciplinary models of human behavior and to implement these models in the cutting-edge neurotechnologies.

Main Objectives:

- Developing new interdisciplinary models of normal and pathological behavior, including computational models of perception, communication and decision-making;

- Implementing the achievements of modern cognitive neurosciences, information sciences and cognitive psychology in neurotechnologies for regeneration, preservation and enhancement of human brain resources as well as for integration of human brain with IT and robotic devices;

- Providing research and educational support to the NeuroNet national technological initiative (NTI) in neurotechnology aimed at integrating modern global technologies of life sciences with novel data mining algorithms and robotic devices;

- Launching interdisciplinary post-graduate's and Master's neurotechnology and cognitive neuroscience programs in English that will be competitive on the global education market.

Main Anticipated Deliverables:

− The first Russian research center in neuroeconomics: neurobiological mechanisms of decision-making;

− National platform for integrating interdisciplinary (combining social, economic, cognitive and information sciences) studies of human behavior using hi-tech "neuroimaging" approaches. This initiative will help HSE be a part of the global modern research in bioscience;

− Cutting-edge software for mapping the complex cortical activity in the human brain;

− New brain stimulation protocols for research and diagnostic study of the patients;

− New-generation communicative systems: brain-computer, interfaces integrated with biofeedback algorithms;

− New approaches for prediction of behavior and optimization of decision-making in different social contexts;

− Unified database of the experimental neurophysiological data for interdisciplinary research;

− Launch of the joint Master-Doctoral level tracks in cognitive sciences and neurotechnologies;

− Synchronization of the curricula between Master's programs "Cognitive Sciences and Technologies: From Neuron to Knowledge", https://www.hse.ru/en/ma/cogito/ (Faculty of Social Sciences) and "Data Analysis in Biology and Medicine" (Faculty of Computer Science);

− Recognition of HSE in the international academic community, based on the university's position in top global rankings: HSE should rank in the Top 100 of QS World University Ranking by Faculty in Social Sciences & Management, in the Top 100 of QS World University Ranking by Subject in Economics & Econometrics and in the Top 150 of QS World University Ranking by Subject in Psychology.

Summary of STRA-U's Role and Contribution to the University's Development and Achievement of the Goals and Target Indicators Set by the Global Competitiveness Program

STRA-U shall achieve the following goals:

(1) create an interdisciplinary platform for the researchers from the leading HSE faculties (Social Sciences, Computer Sciences, Economic Sciences, etc.) to conduct interdisciplinary studies of human behavior using modern neuro- and cognitive technologies - thereby adding life sciences to the research agenda of HSE;

(2) increase the number of interdisciplinary publications and citations in journals Q1 and Q2;

(3) develop new research directions (e.g.,neuroeconomics) within the framework of life sciences;

(4) develop a new Cognitive Neuroimaging Research Center focused on the implementation of the NTI NeuroNet.

The CN STRA-U shall become the only international (English-speaking) academic unit in Russia that is dedicated to harnessing the achievements in social, informational and cognitive sciences for the development of neurobiological research and neurotechnologies. It supports the development of HSE as a comprehensive university and should contribute to its academic reputation and brand-building.

In 2015, STRA-U has made a significant contribution into HSE advancement in QS World Rankings By Industry: Social Sciences & Management (161st place, ranks 2nd in Russia after Lomonosov Moscow State University) and in QS World Rankings By Subject: Economics & Econometrics (151-200, the only Russian university).

1.2 Project Fact-sheet

Key STRA-U Subdivisions and Associated Units:

1. Center for Cognition & Decision Making (https://www.hse.ru/en/cdm-centre/), including the Unique Scientific Instrument (USI) "Laboratory for non-invasive brain stimulation, brain activity monitoring and eye –tracking", registered in the RF USI register in January 2016.

2. Neurolinguistics laboratory, School of Philology (https://www.hse.ru/en/neuroling/, headed by Dr. Olga Dragoy),

3.Cognitive psychology laboratory (https://cogres.hse.ru/en/, headed by Dr. Igor Utochkin, Department of Psychology),

4. Laboratory for experimental and behavior economics, ISEF (https://epee.hse.ru/en/, headed by Dr. Alexis Belyanin)

STRA-U Research Adviser: Yuri Shtyrov - specialization: cognitive sciences - HSE / Aarhus University (Denmark) Laboratory Supervisor.
(https://www.hse.ru/en/org/persons/123199881).

STRA-U Academic Leader: Vasily Klucharev, Head of Psychology Department in HSE.
(https://www.hse.ru/en/org/persons/84236477)

Key Educational Programs and their Development

The English-taught Master's program Cognitive Sciences and Technologies: From Neuron to Cognition is central to the STRA-U. It is the only Master's program in cognitive and neurosciences in Russia that is taught fully in English; currently 40 students (including 4 international ones) are enrolled in the program. École Normale Supérieure (Paris, France) and Aarhus University (Aarhus, Denmark) are the key partners of the program. They participate in

the development of the program's curriculum and teaching as well as in the supervision students' projects. The academic supervisor of the program is Dr. Anna Shestakova.

CN STRA-U will take part in the development of the Master's program Data Mining in Biology and Medicine in cooperation with the Faculty of Computer Science. The new program is created in close cooperation with A.N. Belozersky Research Institute of Physico-Chemical Biology MSU; with Institute of N. A. Vavilov Institute of General Genetics RAS and with Leiden University. The program focuses on new methods in biological (genetic, neural, etc.) data analysis and is to be launched in September 2016. The academic supervisor of the program is Mikhail Gelfand. The program plans to enroll 25 students (with 3-5 of them being international) per year and focuses on cognitive sciences, neuroscience and neurotechnology.

By the year of 2020 STRA-U is planning to:

(1) Provide students with more opportunities to attend interdisciplinary courses on Life Sciences by synchronizing the curriculum of the two Master's programs;

(2) Increase the percentage of foreign students in the English-speaking programs up to 25% and sign a partnership agreement with one of the world's leading universities to facilitate double-degree programs;

(3) Develop short modular courses in neurotechnologies targeting practitioners;

(4) Develop in the next three years the Master-Doctoral level track in cooperation with Doctoral School of Psychology (https://psychology.hse.ru/en/), which will allow talented students to enter the post-graduate program. Through optimizing the theoretical curriculum, students will be able to finalize their qualification projects (theses) earlier and will have more time for conducting research. The competitiveness of this track is to be confirmed by the increase in percentage of foreign postgraduates in the English-speaking track up to 25%.

Key Research Projects and their Development
1. *Neuroeconomics models of decision-making in various social contexts*

Project supervisors: Boris Gutkin, HSE/Ecole normale supérieur, Vasily Klucharev, HSE, Alexis Belianin, HSE.

HSE has developed the only center of neuroeconomics studies in Russia. CN STRA-U researchers develop neurobiological models of decision-making processes interruptions, for example, a model of nicotine addiction (Gutkin et al, 2006, http://www.ncbi.nlm.nih.gov/pubmed/16415156), as well as models of cross-cultural differences in decision-making processes (Kroger et al, 2015, http://www.sciencedirect.com/science/article/pii/S0167487012001109). The CN STRA-U personnel has developed pioneering models of brain mechanisms of social influence on decision-making processes (Klucharev et al, 2009 http://www.ncbi.nlm.nih.gov/pubmed/19146819; Huber et al, 2015, http://www.ncbi.nlm.nih.gov/pubmed/24974396).

By 2020 we are planning to continue our interdisciplinary projects and to develop neuroeconomics models of:

– neurobiological mechanisms of valuation (processing of subjective values) during binary choices,

– decision-making in social groups in different social contexts (including various forms of social influence),

‒ neurotechnologies aiming to optimize the decision-making processes, to create applications for consumer research.

The most important international partners of CN STRA-U are Ecole normale supérieure (Paris, France), and Charité ‒ Universitätsmedizin Berlin. Russian partners include theHSE Faculty of Computer Science, USI MEG-center of MSPPU, Neurology center of RAS, Kurchatov Institute National Research Center.

2. Dynamic brain connectomics: algorithms, paradigms and tools

Project supervisors: Vadis Nikulin, HSE/Charité ‒ Universitätsmedizin Berlin; Alexey Ossadtchi, HSE.

The CN STRA-U's Connectomics group has developed novel approaches to studying neural network dynamics, which are based on the neural data collected with the help of various technologies, including electroencephalography (EEG), magnetoencephalography (MEG) and functional MEG (fMEG), transcranial magnetic stimulation (TMS), diffusion tensor imaging (DTI), optical imaging (OI) (for example, ref. Greenblatt et al, 2012, http://www.ncbi.nlm.nih.gov/pubmed/22426415 ; Nikulin et al, 2014, http://www.ncbi.nlm.nih.gov/pubmed/24732648).

The project is being implemented in cooperation with the Faculty of Computer Science (HSE), MEG-center of MSPPU (the only magnetoencephalography ‒ MEG - center in Russia) and with the Research Institute of Neurosurgery named for N. N. Burdenko.

By 2020 the CN STRA-U will develop a platform that will be able to support the new generation of brain mapping software focusing on dynamics of neural networks. CN's computer programs and algorithms will be used in neuroimaging of the whole brain and incorporated into most popular hard- and software tools and packages analyzing brain signal obtained with the help of the following methodologies: functional magnetic resonance imaging (fMRI), EEG, MEG, TMS, direct durrent stimulation (tDCS), alternating current stimulation (tACS), etc. Overall, CN STRA-U engines and algorithms will be used in studies of neural networks dynamics underling various cognitive functions and for diagnostics and pre-surgical mapping of the patients.

3. A universal "brain-computer interface with biofeedback" that can be used individually or by a group of individuals

Project supervisors: Mikhail Lebedev, Duke University, USA, Alexey Ossadtchi, HSE.

Academic personnel and partners of CN STRA-U are the national leaders in the field of Neurointerfaces, a modern and rapidly growing technique for the rehabilitation of patients with neurological disorders and for enabling people to operate external devices using their brain activity (Lebedev & Nicolelis 2006, http://www.ncbi.nlm.nih.gov/pubmed/16859758). CN STRA-U actively cooperates with Lobachevsky State University of Nizhni Novgorod in neurointerfaces development (two large joint research grants), having a unique expertise in developing algorithm for the analysis of the brain dynamic signals. The STRA-U specialists have developed new approaches to creating interfaces (Okorokova et al, 2015, Shokur et al, 2013, http://www.ncbi.nlm.nih.gov/pubmed/23980141) and they are planning to develop the universal interface by the year of 2020 that will be able to receive various bioelectrical signals as the input and to generate the "brain-computer" and "biofeedback" signals as the output. It will also enable the users to connect with each other through a neurocomputer network.

By the end of the project we will have a universal interface with the following components:

- Multichannel electromyographic interface for the emulation of handwriting;
- Electroencephalographic (EEG) interface with a biofeedback;
- Multichannel electrocorticographic (ECoG) interface with a biofeedback;
- Interface for transcranial magnetic stimulation (TMS-interface);
- Interface for electric brain stimulation.

Our comprehensive brain-computer interface with standardized protocols will help to make the development of next-generation brain-computer devices more simple and quick as well as allow for the creation of hybrid devices.

The primary partners of the project are Duke University Medicine Center (USA) and Lobachevsky State University of Nizhni Novgorod, which cooperate on developing computational and engineering solutions for the interfaces.

4. *Speech neurotechnology: objective, noninvasive measures of cognitive functions underling normal speech and speech disorders*

Project supervisors: Yury Shtyrov, HSE, Aarhus University, Denmark, Olga Dragoy, HSE.

Project leader Professor Yury Shtyrov is one of the leading experts in the field of neural mechanisms of speech (Pulvermüller &, Shtyrov, 2006, http://www.ncbi.nlm.nih.gov/pubmed/16814448). Pursuing this line of research, CN STRA-U extensively studied normal speech (Shtyrov et al, 2014, http://www.ncbi.nlm.nih.gov/pubmed/24753617), and speech disorders (Laurinavichyute et al, 2014, http://www.ncbi.nlm.nih.gov/pubmed/25281888). The project is particularly focused on further studies of neuronal basis of the speech pathology.

By the year of 2020, we are planning to reveal specific brain mechanisms of different speech pathologies and ways of compensatory reorganization of speech mechanisms in the brain. For this, various MEG-, fMRI- and TMS-based objective noninvasive measures of cognitive functions (attention, lexicon-semantic memory, etc.), optimal protocols for noninvasive mapping of neuronal activity underlying cognition and production of normal speech and impaired speech (for example, in aphasia) will be developed.

Major Russian and foreign project partners are: (1) the Moscow Health Department Speech Pathology Neurorehabilitation Center, which investigates aphatic patients (the center provides Siemens 1.5T Avanto magnetic resonance imaging scanner); (2) the Center of Advanced Studies at the University of Pavia (Italy), in cooperation with which we are developing a new method for the neurovisualisation of language.

5. *Genetic "personalization" of neuroplasticity induced by noninvasive brain stimulation*

Project supervisor: Matteo Feurra, HSE.

The most recent studies of Professor Feurra's group have shown that methods of noninvasive brain stimulation (NIBS) can have a significant effect on the efficiency of the neuronal networks on physiological and behavioral levels, including improvement of cognitive capacity, called the "neuroenhancement" effect (Santarnecchi et al, 2013, http://www.ncbi.nlm.nih.gov/pubmed/23891115; Feurra et al, 2011, http://www.ncbi.nlm.nih.gov/pubmed/21865459). These and others studies of CN STRA-U demonstrate a relationship between single nucleotide polymorphisms (SNP) and the effectiveness of NIBS protocols (Shpektor et al, 2015, http://www.ncbi.nlm.nih.gov/pubmed/26441642). The project focuses on the development of

new genetic "personalized" protocols of brain stimulation for pre-surgical brain mapping, for rehabilitation and for new methods of strengthening cognitive functions using NIBS. The project will result in the development of cutting-edge algorithms of genetic personalization of neuroplasticity effects for noninvasive brain stimulation.

Considering strong variability of patients' sensitivity to brain stimulation, our understanding of genetic mechanisms underlying brain plasticity induced by NIBS will help to develop new methods to select most the effective NIBS and choose optimal stimulation protocol, i.e. to personalize brain stimulation.

The primary partners for this project – Goldsmiths, University of London, Tomsk National Research University and Psychological Institute of the Russian Educational Academy – will perform genetic analysis for differences "candidate" single nucleotide polymorphisms (SNP) that can underlie individual differences in neuroplasticity evoked by NIBS.

Links between research and educational programs:

Students in the Master's program Cognitive Sciences and Technologies: From Neuron to Cognition' run their qualification projects within CN STRA-U research labs. The Doctoral School of Psychology is the key educational program for the training of CN STRA-U junior researchers, and their research topics are closely related to those of STRA-U.

Key external parties who benefit from STRA-U activities

CN STRA-U focuses on research and innovation and its beneficiaries can be grouped into three clusters by the end result:

1. Training of junior researchers for Post-Graduate and PhD Schools:

- Institute for Translational Medicine (St. Petersburg State University, St. Petersburg);

- Scientific Center for Neurology of Russian Academy of Science, Moscow;

- Academician N. N. Burdenko Research Institute of Neurosurgery, Moscow;

- MEG-center of MSUPE, Moscow, etc.

2. Research and Educational Support of the National Technological Initiative (NTI) "NeuroNet".

3. Innovation products:

- Health Ministry of the Russian Federation;

- Medical institutions and health facilities;

- Yandex, Neurotrend Co, Moscow, etc.

STRA-U Infrastructure

Laboratory equipment and facitilies used by STRA-U:

1. Unique Scientific Instrument (USI, https://www.hse.ru/en/cdm-centre/facilities) - Laboratory for Non-invasive brain stimulation, brain activity monitoring and eye-tracking: a unique instrument is used for studying cognitive processes with the help of transcranial magnetic stimulation and direct (alternating) current brain stimulation with simultaneous recording of the brain activity, vegetative activity (electromyography, galvanic skin response, heart rate, respiration rate) and of saccadic movement. The essential equipment of USI currently consists of:

1) 2 transcranial magnetic stimulators- MagVenture X100 and R30 (for transcranial magnetic stimulation);

2) Locolite brain navigation system

3) 4 EEG modules (Brain Poducts DC); module of EXG (Brain Products);

4) External sensors: of breathing, of heart rate, of galvanic skin response, of temperature, three dimensional accelerometers (2 items);

5)   BrainStim transcranial electric stimulation system; StarStim transcranial electric stimulation system with possibility to record EEG (8 channels);

6)   Eye movements tracking systems SMI HiSpeed 1250 and Eyelink 1000 Plus, SR Research, (2 items), etc.

Approximate cost of the equipment at the moment is 2 million EUR.

2.   The research is conducted in cooperation with the USI MEG-center of MSUPE - owner of an only Rissian magnetoencephalography instrument for recording brain activity and with RAS SC "Neurology", Moscow Health Department Center of speech pathology and neurorehabilitation, Academician N. N. Burdenko Research Institute of Neurosurgery, Kurchatov Institute National Research Center with usage of its magnetic resonance imaging scanner with 1.5-3.0T of power.

Approximate cost of each equipment piece at the moment is 2-3 million euros.

Current STRA-U Personnel Composition: Average number of academic personnel *per year* − 28, average age of academic personnel - 39, share of academic personnel holding an academic title – 59%.

Key academic personnel profiles can be found in sections Key Research Projects and Their Development and STRA-U Structure and Management System of this Project Fact-Sheet.

Academic Personnel Development:

- Annual recruitment of PostDocs on the international labor-market (within the framework of HSE's strategic development program);

- Recruitment of leading faculty members/researchers (up to 5 people) on the international academic market in the field of cognitive neuroscience in the framework of the HSE Advanced Studies program;

- Further development of weekly trainings and seminars (including trainings in the following non-invasive brain stimulating methods - TMS, TDCS, TACS and multichannel EEG training);

- Annual schools: "Active and passive methods of the brain mapping" (http://brainmappingschool.neurobiotech.ru/en), "Summer neurolinguistic school" (https://www.hse.ru/neuroling/summer_school/), "Theoretical and practical problems of cognitive psychology".

For more information regarding development of the personnel please see section 2.5.

CN STRA-U Structure and Management System

STRA-U "Cognitive Neurosciences: From Models to Neurotechnologies" fall into the second type of STRA-U HSE. The information about the STRA-U structure, planned organizational changes, CN STRA-U level of autonomy, and the STRA-U governance bodies' functions is provided in sections 2.1, 2.2, and 2.6.

STRA-U Governing Board (Heads of Key CN STRA-U Units):

1. **Alexis V. Belianin**, HSE, International Institute of Economics and Finance, Associate Professor; HSE, Experimental and Behavioral Laboratory, Laboratory Supervisor https://www.hse.ru/en/org/persons/131721.

2. **Olga Dragoy**, HSE, Humanities Department, School of Philology, Associate Professor; HSE, Neurolinguistics Scientific-Educational Laboratory, Laboratory Supervisor https://www.hse.ru/en/staff/dragoy.

3. **Igor S. Utochkin**, HSE, Social Studies Department, Psychology Department, Associate Professor; HSE, Cognitive Studies Scientific-Educational Laboratory, Laboratory Supervisor, https://www.hse.ru/en/staff/utochkin.

4. **Anna Shestakova**, HSE, Neuroeconomics and Cognitive Studies Center, Director, https://www.hse.ru/en/org/persons/96086247.

STRA-U International Expert Committee:

1. Risto Ilmoniemi, Professor, Aalto University, http://www.aka.fi/en/about-us/scientists-behind-the-research/academyprofessors/ilmoniemi-risto1/.

2. Alexander Sack, Head of Laboratory, Maastricht University, http://www.maastrichtuniversity.nl/web/Profile/a.sack.htm.

3. Ale Smidts, Professor, Erasmus University Rotterdam, https://www.rsm.nl/people/ale-smidts/.

4. Friedemann Pulvermüller, Head of Laboratory, Freie Universität Berlin, http://www.geisteswissenschaften.fu-berlin.de/we04/institut/mitarbeiter/pulvermuller/index.html.

5. Etienne Koechlin, Professor, Ecole Normale Supérieure de Paris, http://www.paris-neuroscience.fr/en/etienne-koechlin.

6. Tatyana Strogonova, Head of Laboratory, State University of Psychology and Education, Moscow, http://megmoscow.ru/staff/detail.php?ID=43.

1.3 Performance Indicators of Strategic Academic Unit

№	Indicator	2015 actual	2016 plan	2020 plan
1.	Position in broad field (specific subject) rankings (ARWU, THE, QS) as university KPI for which the STRA-U is valuable (according to the "roadmap" of the relevant university)			
1.1.	QS «Social Sciences & Management» by faculty	161		51-100
1.2.	QS «Psychology» by subject	-		101-150
1.3.	QS «Economics & Econometrics» by subject	151-200		51-100
2.	Number of publications in the Web of Science per one faculty member of the STRA-U	2,85	3,25	6,28
3.	Number of publications in Scopus per one faculty member of the STRA-U	2,85	3,51	5,56
4.	Average citation index per one faculty member of the STRA-U calculated on the basis of the total number of publications indexed by the Web of Science	4,55	5,66	15,87
5.	Average citation index per one faculty member of the STRA-U calculated on the basis of the total number of publications indexed by Scopus	5,09	6,33	14,53
6.	Percentage of international faculty in the STRA-U's team including Russian citizens with PhDs from foreign universities	46,7%	50,3%	86,4%
7.	Percentage of international students enrolled in higher education degree programs provided by the STRA-U (including CIS students)	14,3%	12,5%	28,6%
8.	Average Unified State Examination (USE) grade for students enrolled in full-time federal funded Bachelor and Specialist-level programs delivered by the STRA-U	Master's programs only		
9.	Percentage of the STRA-U's income from non-budgetary (non-government) sources	29%	no less than 29%	no less than 36%

1.4 Quantitative characteristics of the STRA-U's development

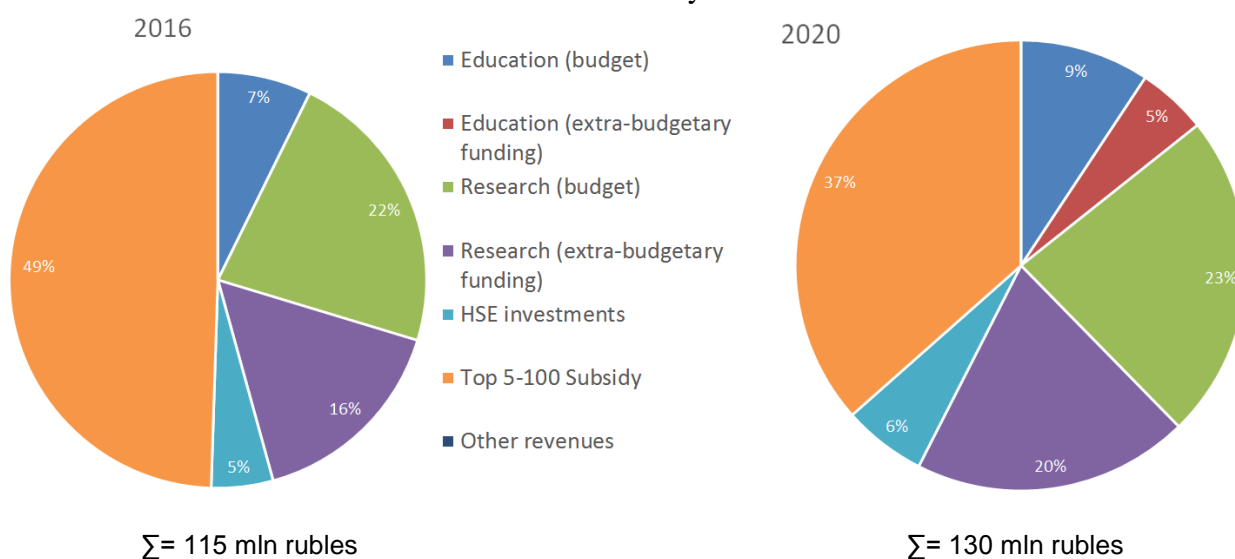| №	Indicator	2015 actual	2016 plan	2020 plan
1.	Number of higher education degree programs with international professional or public accreditation delivered by the STRA-U	0	0	1
2.	Number of higher education degree programs delivered by the STRA-U entirely in a foreign language	1	1	1
3.	Number of higher education dual degree programs delivered by the STRA-U	0	0	0
4.	Percentage of the STRA-U's students involved in R&D of this unit and enrolled in higher education degree programs provided by this unit, among the total number of students enrolled in the STRA-U's higher education degree programs	5,41%	6%	6%
5.	Percentage of the STRA-U's students enrolled in higher education degree programs among the total number of students enrolled in higher education degree programs of the relevant university	0,36%	0,38%	0,42%
5a.	Same for Bachelor-level programs (Specialist-level)	0%	0%	0%
5b.	Same for Master's programs	1%	1%	1%
5c.	Same for Ph.D. programs	6%	6%	6%
6.	Percentage of the STRA-U's faculty members who authored publications indexed by Scopus or the Web of Science among the total number of faculty of the STRA-U	52%	59%	90%
7.	Percentage of the STRA-U's employees among the total number of employees of the relevant university	1,4%	1,4%	1,4%
8.	Number of intellectual deliverables/intellectual products (IP) created by the STRA-U's employees	0,00	1,00	1,00
9.	Source-Normalized Impact per Paper (SNIP) of journals indexed in Scopus where the articles authored by the STRA-U's faculty members were published in the reporting year	1,293	1,31	1,40

1.5 Financial Model

STRA-U budgets are managed by the university and heads of participating units; they are financed from the following three sources:

1. Government-funded education and research projects. STRA-U contribution to the government projects in 2016-2020 is expected to be about 4 % for research. In the framework of the state assignment for educational services, the STRA-U provides training to 61 students (in state-funded places).

2. Funding from **external sources** (extra-budgetary revenues) derived from fee-based educational services, research and expert review projects in the interests of the government and corporate clients, donations and other special purpose contributions. The share of the STRA-U's extra-budgetary revenues is expected to be no less than 36 % in 2020. Funding from external sources is one of the KPIs of the STRA-U's units heads.

3. **HSE special purpose funds** provided to STRA-U units for development (academic development funds, centralized HSE programs such as Academic Fund, Fund of Educational Innovations, etc., acquisition of special research and laboratory equipment, inviting international faculty and researchers, etc., including funds of the subsidy under Global Competitiveness Program).

Planned STRA-U's sctructure and revenues dynamics:

2016

- Education (budget)
- Education (extra-budgetary funding)
- Research (budget)
- Research (extra-budgetary funding)
- HSE investments
- Top 5-100 Subsidy
- Other revenues

∑= 115 mln rubles

2020

∑= 130 mln rubles

The growth in the STRA-U revenues in the period of up to 2020 will be achieved thanks to the increase in the number of students in fee-based programs.

STRA-U units will continue to actively participate in research grant programs of Russian funds (the Russian Science Foundation, international projects of the Russian Foundation for Basic Research, etc.) in top priority fields of research in natural sciences (cognitive neurobiology and cognitive psychology, neuroeconomics, neurotechnologies, etc.), as well as in the international research grant programs in partnership with the leading Russian universities and research centers (Tempus, Erasmus, etc.). At the moment, the STRA-U participates in two RSF projects in the STRA-U main fields of research (30 mln. rubles). The STRA-U is also involved in the work under the government contracts together with the Lobachevsky Nizhny Novgorod State University (45 mln rubles).

Total increase in the STRA-U revenues in 2020 versus 2016 will be no less than 15%. In case of improvements in the international market situation, the revenues may multiply.

STRA-U expenditures include personnel salaries (68-72%) and other operating expenses (teaching and research process, academic mobility, acquisition of information, etc.).

General and administrative expenses are centrally managed by HSE. All premises, dormitories, IT infractructure and administrative services are provided by the university.

The STRA-U's financial stability is achieved through the combination of revenues from all types of its operations and HSE investments – through centralized academic development instruments (programs and projects). HSE is ready to provide additional resourses to the STRA-U by reallocating HSE's centralized funds if nccessary.

1.6 Schedule (Roadmap) for controlled changes

No.	Objectives	Year				
		2016	2017	2018	2019	2020
	1. Organizational changes					
1.1.	STRA-U organizational structure has been established, including the team, management, collegiate and executive bodies	X				
1.2.	Project teams have been set up, and required information resources for their operations have been defined	X	X	X	X	X
	2. Required changes and deliverables in education					
2.1.	Student academic mobility programs, student exchange programs	X	X	X	X	X
2.2.	Promotion of undergraduate and the Master's programs on the global market, arranging international students' admission to Master's programs	X	X	X	X	X
2.3.	Synchronizing two Master's programs: Cognitive Sciences and Technologies: From Neuron to Cognition and Data Analysis in Biology and Medicine		X	X		
2.4.	Harmonizing the transition from Master's program to doctoral program in Neurotechnology (unified trajectory)			X	X	X
2.5.	Agreements with new international partners for Master's programs implementation			X	X	X
	3. 3. Changes and results of the research and technical activities					
3.1.	Running applied projects in key academic fields	X	X	X	X	X
3.2.	International recruitment of scholars on a competitive basis	X		X		X
3.3.	Simplifying access to the Unique Scientific Instrument (USI)	X	X			
3.4.	Weekly training sessions (including training in TMS, TDCS, TACS brain stimulation, multi-channel EEG)	X	X			
3.5.	Unified Experimental and Neurophysiologic Data Repository	X	X			
3.6.	New brain stimulation protocols	X	X	X	X	X
3.7.	New generation of software for mapping the dynamic cortical activity in the human brain	X	X	X	X	X

3.8.	New approaches to optimizing decision-making processes	X	X	X	X	X
3.9.	New speech neurology techniques	X	X	X	X	X
3.10.	New generation in communication technologies: brain-computer interface	X	X	X	X	X
3.12.	Regular evaluation of STRA-U research activities by the International Advisory Board	X	X	X	X	X
3.13.	Developing research infrastructure	X	X	X	X	X
	4. 4. General changes and results, including at the University's level					
4.1.	Facilitating the HSE achievement of leading positions in the education and research at the regional and global level, evidenced by the promotion in global rankings	X	X	X	X	X
4.2.	Reducing dependence on the state budget financing				X	X

2. TRANSFORMING THE UNIVERSITY BY ESTABLISHING THE BREAKTHROUGH AREAS ACROSS STRATEGIC ACADEMIC UNITS

2.1 Organizational Transformation of the University

HSE is in the process of systemic transformations, first launched by the university in 2010, and aims to create centers of excellence and to disseminate the experiences of these centers throughout the university.

In the first stage of transformation, the university established 10 international laboratories lead by the prominent foreign researchers. The development of international laboratories in economic, social, computer, and mathematical sciences has contributed to overcoming the long-term isolation of Russian social and economic sciences and enabled HSE to join the global network-based research market and strengthen the university's position as the center of advanced research in select areas of expertise. As a result of the university concentrating its resources on the development of those areas, the number of research publications in the international databases Web of Science and Scopus has grown five times over the last five years. Globally renowned scientists such as Nobel Laureate Eric Maskin, Fields Medal Winner Andrei Okounkov have joined the university. The number of international laboratories grew to 22 in 2015 and these research centers have enabled the university to integrate the new academic culture into more traditional forms through the creation of faculties and moving further to the next transformation stage.

The second stage in the transformation of the university's organizational model is the transition from highly specialized faculties and academic departments, designed with the primary purpose of teaching, to the model of mega-faculties, or large research and education units conducting research (including multidisciplinary research) and faculty training in broad areas of expertise: economic sciences, social sciences, business and management, humanities, computer and engineering sciences, mathematics, law, communications and design and urban studies. The integration process was completed in 2015 when 21 faculties and division networks were replaced with 10 mega-faculties. The former faculties and academic departments became departments and schools, and mega-faculties were merged with previously independent HSE research units to conduct basic and applied research and focus on expert analytical work and consulting. The new organizational model is currently finalizing its operating mechanisms.

The university merger of interrelated fields of expertise encourages the development of promising research areas at the intersection of sciences and ensures the principle of crossdisciplinary interaction in research and teaching. This contributes to the rapid development of the mega-faculties' educational programs built into the framework of new fast-growing areas of expertise that are implemented by research scientists, key employers, international experts; students become involved in real scientific research projects while still in the training. Such integration is provided by research units, departments and schools within the mega-faculties.

The conversion ensures an integrated approach to mega-faculties-based management and the development of all areas of the university's expertise, including higher education and continuing education, basic and applied research, innovation, expert analytical work and consulting. International laboratories still act as the drivers of research, set standards for other research teams and play an important role in graduate and postgraduate education. Regular evaluation of laboratories' performances by internationally recognized experts constitutes the basis for decision-making on the laboratories' existence. Mega-faculty management is based on the principles of academic self-governance, which is implemented at all levels of decision making.

In 2015, the right to managing independently financial resources and the responsibility for achieving planned results (KPIs for the mega-faculties' deans are set) were delegated to the mega-faculties. This significantly simplified the decision-making process, allowed more specific considerations on account of individual disciplines and enhanced their development. Currently, almost 50% of resources from the university-wide academic development fund (scholarships for

academic mobility of faculty members, researchers and students, conferences, etc.) are managed by the mega-faculties. The mega-faculties' academic development funds are competitively distributed in accordance with the decision of mega-faculties' governing bodies, composed of researchers and instructors. The mega-faculties' academic and financial autonomy will be further increased; resources will be managed and decisions made based on KPIs.

The university is currently in the third stage of its transformation: HSE continues to improve the mega-faculties and establish better conditions for their development through the individual research and education units under these new interdisciplinary centers of excellence. The centers use the mega-faculties' infrastructure, human and other resources and have become growth points for promising areas where the university intends to enter the global market. Successes have been achieved in some subject areas as evidenced by high quality publications in the leading journals (See sections below).

2.2 Strategic Academic Units

The mega-faculties and research units (including international laboratories) are used to establish large areas of expertise with interdisciplinary connections: Strategic Academic Units (STRA-Us). There are two types of STRA-Us – international consortia and centers of excellence, which are currently being formed based on the following criteria:

1)   Research must be consistent with the global research agenda and international research networks;

2)   Research must be relevant to Russia's geopolitical interests and/or sectoral priorities;

3)   STRA-Us must serve as expert analytical centers for the development of public policy in the economic and social sectors, education, science and technology forecasting and state-building; each STRA-U should make a significant contribution to the development of Russian economy;

4)   Educational programs are implemented at various levels (undergraduate, specialist, graduate and post-graduate programs).

The first type of STRA-Us includes major consortia that address the university's existing core areas. They are recognized internationally (reflected in their international rankings), and have a high capacity for further dynamic development. These consortia are formed from one or more mega-faculties and academic units of the university, which implement educational programs at all levels and their research has been integrated or is capable of being integrated into the global research agenda:

– Economics and Management (QS Economics & Econometrics – 151-200, QS Development Studies – 51-100, QS Social Science & Management – 161[1]);

– Challenges for Social Development (QS Development Studies – 51-100; QS Sociology – 151-200; QS Social Sciences & Management – 161);

– Mathematics, Computer Science and Information Technology: scalable mathematical methods (QS Mathematics и QS Computer Science & Information Systems – 400+, ranks 6th in Russia);

– Humanities Consortium "Humanus" (QS Philosophy – 151-200, QS Arts & Humanities – 289).

The second type of STRA-Us includes centers of excellence: individual structural units that have been created as new growth points in relatively narrow and promising interdisciplinary areas of research and education and are integrated into the global research agenda and implement

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[1] HSE position in QS World University Rankings 2015 (by subject and by industry) are given in brackets. This position has been secured thanks to the contribution of the respective STRA-U.

Master's and doctoral educational programs. In the long run, these units are capable of growing into new research and educational areas:

– Foresight and Science, Technology and Innovation Studies (QS Development Studies – 51-100; QS Social Sciences & Management – 161);

– Cognitive Neuroscience: from Computational Models to Neurotechnology (QS Economics & Econometrics – 151-200; QS Social Science & Management – 161);

– Education and Human Development in changing world (QS Sociology – 151-200; QS Social Science & Management – 161);

– Urban and Transportation policy: guiding urban transformation from industrial to digital age (QS Development Studies – 51-100; QS Social Sciences & Management – 161).

Not included in STRA-Us are key HSE faculties such as World Economy and International Affairs, Law, and Communications, Media and Design, as well as the Department of Foreign Languages, because these units are currently focused mainly on the Russian market.

Strategic Academic Unit Management

Each Strategic Academic Unit is managed by:

– the research adviser, a leading scholar in the STRA-U area, well known by the international academic community, whose main functions are to establish the STRA-U research and education agenda and strategies, help enhance STRA-U leadership within the international academic community and engage STRA-U leading experts in relevant fields;

– the leader, a famous academic and experienced research and/or education administrator whose main functions are to ensure achievement of STRA-U goals, coordinate reseach and education communication among the divisions within STRA-U and make personnel and financial decisions.

STRA-U is managed by the Management Board, which makes programmatic and resource decisions on each of the STRA-U's tasks delivery and ensures monitoring of STRA-U's tasks delivery.

Some STRA-Us have already established International Expert Committees and others will establish them by the end of 2016. International Expert Committees will conduct external evaluations of STRA-U research and educational activities and provide recommendations regarding STRA-U development strategy. They will also promote international partnerships and the integration of STRA-U researchers in international research networks.

The university's management practices have been tested within the mega-faculties model and have proved to be viable and effective. They will also be used in the next stage of the university development within STRA-U's framework (see more details in respective sections of each STRA-U fact-sheet).

The scheme of interaction between STRA-Us and other units that haven't been integrated as a STRA-U yet is defined in the following figure.

STRATEGIC UNITS INTERACTIONS
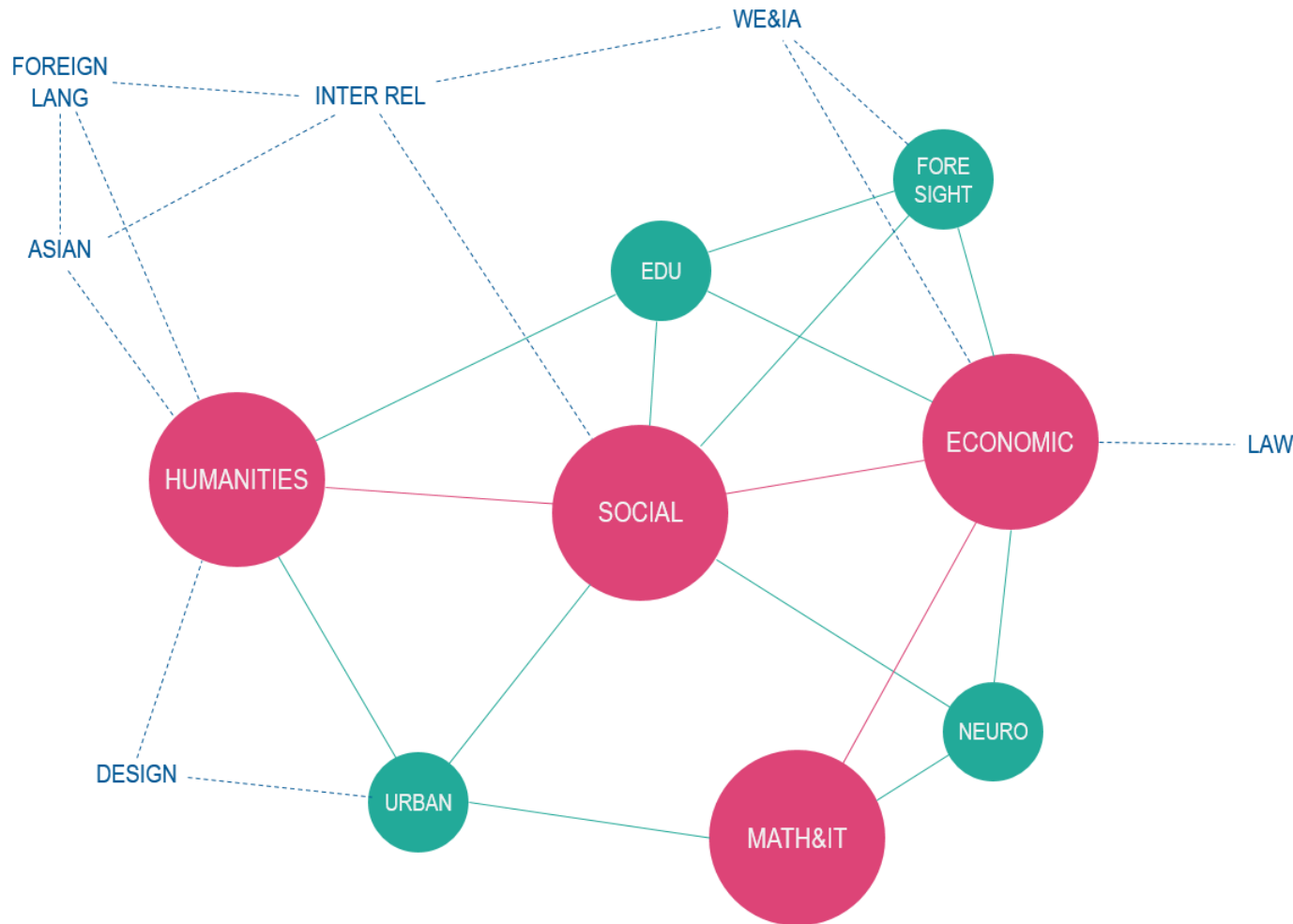
StraU's of I type
CONSORTIUMS

>**ECONOMIC**< ECONOMICS AND MANAGMENT >
>**SOCIAL**< CHALLENGES FOR SOCIAL DEVELOPMENT >
>**MATH&IT**< MATHEMATICS, COMPUTER SCIENCE AND INFORMATION >
>**HUMANITIES**< SCHOOLS AND INSTITUTES CONSORTIUM «HUMANUS» >

StraU's of II type
CENTERS OF EXCELLENCE

>**FORESIGHT**< FORESIGHT AND SCIENCE, TECHNOLOGY AND INNOVATION STUDIES >
>**NEURO**< COGNITIVE NEUROSCIENCE: FROM COMPUTATIONAL MODELS TO NEUROTECHNOLOGY >
>**EDU**< EDUCATIONAND HUMAN DEVELOPMENT >
>**URBAN**< URBAN AND TRANSPORTATION POLICY: GUIDING URBAN >

OTHER UNITS

20

2.3 Research and innovation activities
Research and science project areas are described in detail in each STRA-U Fact-sheet.

HSE strategy for basic research sets rigorous requirements for research quality, and personnel incentives are aimed at facilitating research in the most cutting-edge areas and topical fields. This has caused a significant growth in the number of quality publications. Articles by HSE faculty and researchers are published in top international journals, including Review of Economics and Statistics, Acta Mathematica, Journal of Personality and Social Psychology, The Lancet, IEEE Transactions on Pattern Analysis and Machine Intelligence, Nature Genetics, Journal of Political Economy, Physical Review Letters, American Economic Review, Behavioral and Brain Sciences, Journal of Materials Processing Technology, Annals of Statistics, Communications in Mathematical Physics.

The university has robust research and innovation cooperation with major Russian and foreign companies and organizations which are not only customers of research and consulting projects but also partners in implementation of customized educational programs of mainstream and continuing education. The demand for the university's research is evidenced by steady growth in R&D total revenues, which is currently almost 40%. HSE has partnership relations with such major companies as Gazprom, Rosatom, Rosneft, Novatek, Gazprom Neft, Alrosa, Norilsk Nickel, Aeroflot, Rosgeologiya, Nissan, Sibur, Gazprombank, Lukoil, Transneft, Yandex and others. HSE is constantly expanding the network of joint departments (currently - 40) established in cooperation with leading research and science centers, global consulting companies, ICT companies, analytical centers, and others.

The university's innovative activities are designed to provide diverse forms of communication with project teams which include undergraduate, graduate and post-graduate students, professors and research scientists. Those activities range from annual competitions of business plans for innovative projects to supporting the start-ups at various stages of maturity. A prominent place in the Russian innovation ecosystem is taken by the HSE's Business Incubator which provides coaching and advisory services to student teams; the Innovation Center which provides organizational support to the spin-off companies, and Prototyping Center that provides an experimental platform for technological projects and boasts state-of-the-art equipment.

According to UBi Global rating, in 2015, HSE Buisness Incubator ranked 14 among global university busness incubators (sole university business incubator in Russia to rank in global Top-25).

2.4 New organizational model for the education process
Establishing mega-faculties through the merger of academic units has enabled the implementation of a university-wide organizational and management model for the education process on the basis of "academic adviser - academic council - student office". In spite of a wide variety of programs, the quality of the education process and outcomes is ensured by general principles incorporated in the unique educational standards aimed at a higher level of complexity.

The implementation of undergraduate programs is based on a model that provides for:
− a limited number of courses (no more than five) to be studied by a student in any given semester, at least half of which are electives;
− a fixed part of the program within which a student works on projects and research papers primarily in actual research departments at the university;
− select clusters of courses (minors) available to all students (20 ECTS in two years);
− independent assessment of students' knowledge of the English language at the end of the second year through the process of international exams, and mandatory study of at least two major courses in English;
− mandatory preliminary thesis defense in English.

The implementation of graduate programs is based on the following model:
- no more than 12 courses to be studied by students over two years;
- two professional "core" disciplines (the second disciplines is to be selected by the academic program management and by the students themselves);
- research and independent work must constitute at least 70% of the load;
- opportunity for first-year students to select courses from the general pool of disciplines with broad humanities, social science and economic focus (MagoLego).

HSE's educational programs are focused on the international market: the share of foreign students is currently 7.5%; 18% of disciplines are taught in English; 15 programs in the current academical year and 20 programs in the new academic year will be fully focused on English-speaking students; 43 (29%) educational programs are implemented in partnership with leading foreign (41) and Russian universities (2). HSE is actively involved in the work of universities' consortium representing massive on-line courses on Coursera international platform: in 2015, over half a million students from 195 countries, representing 5% of all Coursera students, signed up for 36 HSE's online courses taught in Russian and English.

2.5 Development of Academic Personnel

Academic personnel development within the new STRA-U framework will be provided by the instruments of academic development and through competitive procedures established in HSE in recent years and described in detail in the Roadmap of the Program for Enhancing HSE Competitiveness of the second stage.

The main instrument for attracting international experts is the international recruitment strategy, which has been in place at HSE since 2010. The ruble devaluation has significantly restricted Russian universities' capacity to compete as employers in the global academic market; therefore, specialist recruitment on the international market in 2016 will change: most cited scientists in high demand by strategic academic units will be selected through the international recruitment procedure. Foreign researchers will be engaged in scientific projects under short-term contracts and remote work contracts. Particular emphasis will be placed on engaging talented young scientists in international research projects through the postdoctoral research fellow program, which will be enhanced starting from 2016.

Mandatory engagement of faculty members in research and involvement of researchers in the educational process is guaranteed by the single contract with academic personnel implemented by HSE in 2015. Faculty members' teaching load is alleviated by teaching assistants, who are selected from among the best students and thus get a chance to start their academic career. Personnel rotation and academic faculty selection is performed through creating competitive academic environment - an open competition for academic faculty positions is held annually and attracts many external candidates. The competition procedure involves the multi-stage selection of candidates: evaluation of research, professional level, interviews, and open lectures. The selection is carried out by expert subject committees, mega-faculties' personnel, and the personnel committee of the HSE Academic Council. The open procedure and similar evaluation criteria for HSE professors and external candidates provide conditions for the selection of the best specialists to be employed by the university on a full-time basis. They meet the university's requirements focused on the global market: HSE academic faculty was renewed approximately by one third in 2013.

The merit-based personnel selection system is supported by a wide range of incentives that provide for professional development and the opportunity to select the optimum academic path for each faculty member. The instruments include stipends for publications at the international level, contributions to the university's reputation, teaching courses in English, development of new teaching methods and training courses, individual and collective research and academic mobility scholarships, international partnership development scholarships, comprehensive professional development program which includes internships and PhD

education at foreign universities and academic English courses at Academic Writing Center. All of these procedures are carried out on a competitive basis.

HSE strives to create an English language-driven professional environment and to ensure the smooth integration of international students, faculty members and researchers into the university academic life. HSE has established special administrative units that provide guidance to international students and academic personnel in all aspects of the HSE experience (including medical insurance, social support, etc.). The university has created English language information resources and hires program coordinators with fluent English. In the coming years, the number of administrative personnel with English proficiency will be increased, and international faculty members will receive comprehensive information about what is occurring during their employment at HSE.

HSE's target personnel development model suggests that by 2020 at least 60% of academic personnel will be scientists (included in the global academic networks), about 20% will be the leaders of the Russian professional market, and the remaining 20% will be engaged only in teaching (mostly teaching foreign languages). It is also planned that 90% of full-time HSE faculty members will be able to teach and conduct research in foreign languages.

2.6 Financial sustainability and resource allocation for the establishment and development of Strategic Academic Units

Resources for the Program of Enhancing Competitiveness and the university's financial sustainability in general are secured primarily through revenue from core activities (all types of educational services, research and expert and consulting activities). In aggregate, HSE revenues in 2016[2] will exceed 14 billion rubles ($190M), which is higher than the revenue in 2012 by 44%. The university earns about 40% of the funds or 6 billion rubles per year ($80M) in the open market: in terms of extra-budgetary revenue, HSE is among top three Russian universities. Global Competiveness Program program funding constitutes only 6.5% to the university's revenue.

In the years leading up to 2020, HSE will increase its overall revenue by 31% compared to 2015, mainly through extra-budgetary income, of which 70% will come from for-profit educational services, and 20% from applied R&D and consulting services. Overall, by the end of the period the share of extra-budgetary income will increase to up to 44%.

Resources for the implementation of the HSE Roadmap will be gathered by combining centralized incentive mechanisms and increasing the financial autonomy of the units. HSE makes target investments of more than a quarter of its income into the university's development projects. The share of funds managed at the level of research and educational units and their consortia is, on average, more than 50%.

The university's financial model is actually replicated within STRA-Us: the units' financial sustainability is achieved through a combination of revenues from all types of activities and diversification of sources of their financing. The tasks of resource allocation to the units within STRA-Us are reflected both in their budget structure, and in the KPI system of their leaders (see Section 2.1).

Key risks for the financial sustainability of the university and its units in the period of up to 2020 are mostly related to negative economic conditions:

1) the devaluation of the ruble caused a significant reduction in the competitiveness of Russian universities as employers in the international academic labor market; paying competitive salaries becomes increasingly difficult, especially when trying to maintain fair balance between Russian and foreign academics;

2) the devaluation has also resulted in the significant increase of other university costs that depend on currency exchange rates, such as international academic mobility, access to foreign sources of information, purchase of equipment, etc.

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[2] Excluding state capital investments

3) reduction of Federal Budget expenditures for 2015-2017 significantly restricts the university's income growth potential, both in education and in research.

The key measures taken by HSE to address those risks are:

- cutting operational and administrative costs (in 2016, operational costs were cut by 15%, administrative personnel costs were cut by 10%, etc.);

- reducing full-time employment of foreign personnel in favor of short-term and remote contracts, without compromising the requirements related to cooperation with Russian personnel and publication activity levels;

- stricter internal requirements related to the efficient utilization of resources: allocation of funds for research projects that foster academic personnel allowances; implementation of economic standards for educational programs and personnel schedule and workload; and introducing indicators for attracting external resources into managers' KPI systems;

- reducing (and closing) administrative and research units and educational programs that do not meet academic criteria of productive efficiency (in particular, in 2014-2015, the Master's programs portfolio was optimised, and a number of academic departments were reorganized).

Information on HSE-Moscow total revenues and expenses in 2015-2020 are given in the table below (mln rubles):

mln rubles

(excluding state capital investments)	2015	2016	2020
REVENUES	13150	13880	16197
Educational services	**7 127**	**8 228**	**10 375**
State assignment for educational services	4 703	5 352	6 176
Fee-based educational services – Higher education	1 331	1 652	2 311
Fee-based educational services – Continuing education	632	695	1 240
Pre-university education	168	301	386
Subsidy for the scholarship fund	293	228	262
Research and Development	**2 577**	**2 568**	**3 000**
State assignment for research	888	862	1 000
Applied research and development	1 690	1 705	2 000
Other revenues (special purpose subsidies, donations, other revenues)	**817**	**1 102**	**1 016**
Funding under 5-100 Program (special purpose subsidy)	**930**	**930**	**930**
EXPENSES	12 099	12 903	15 304
Program and project expenses	**3 109**	**3 364**	**3 969**
Current operating expenses	**7 961**	**7 920**	**9 960**
Special purpose expenses (scholarships, major repairs, taxes)	**1 029**	**1 293**	**961**
Reserves	**283**	**325**	**414**
BALANCE (end of period)	**1 052**	**977**	**893**