NATIONAL RESEARCH UNIVERSITY
HIGHER SCHOOL OF ECONOMICS

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DOES TECHNOLOGICAL DEVELOPMENT EXPLAIN HIGHER EDUCATION EXPANSION?

BASIC RESEARCH PROGRAM

WORKING PAPERS

SERIES: EDUCATION

WP BRP 59/EDU/2020

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DOES TECHNOLOGICAL DEVELOPMENT EXPLAIN HIGHER EDUCATION EXPANSION?[3]

Globalisation and the development of technology called forth an expansion and a fundamental transformation of systems of higher education around the world. This research proposes a theoretical model that demonstrates that the growth in higher education enrolment is in response to technological shocks in which either high-skill-biased technologies, technologies replacing middle-skill workers or technologies raising the productivity of high-skill workers, which increases the wage premium of high-skill workers. The authors illustrate the workings of the model using Russian data for 2000–2018, discuss changes in the structure of the labour force, relative wages and enrolment in higher education during the last twenty years.

JEL Classification: I21, I25, I26, O14, O15, O33.

Keywords: educational economics, higher education expansion, demand for schooling, demand for higher education, technologies, economic development.

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[3] This Working Paper is an output of a research project presented at a workshop of Faculty of Economics at HSE University in Nizhny Novgorod. Any opinions or claims contained in this Working Paper do not necessarily reflect the views of HSE University.

1. Introduction

In a rapidly changing world, information and knowledge are becoming the most valuable assets, and the role of higher education is increasingly acknowledged as being an important source of them. The increasing number of applicants to higher education institutions is being followed by an increase in the size of the student body and the number of institutions; there has been a 20% increase in enrolment in tertiary education over the last 20 years worldwide which is four times higher than during the previous 20-year period.

The literature addresses the drivers of this dynamic: technological changes, the intensification of global competition and changing paradigms in society to name a few [Ahmed, 2016], [Kwiek, 2001], [Schofer and Meyer, 2005], [Scott, 2000]. Widely acknowledged ideas of the complementarity between technologies and skills [Goldin and Katz, 1998] and the race between technologies and education [Tinbergen, 1975] allow us to identify innovation as a significant factor in the dynamics of higher education enrolment. It is claimed that innovation increases the wage premium for higher education, enhancing the demand for it. The majority of papers imply that demand for education is equivalent to demand for skilled labour and restrict their argumentation to the analysis of labour market dynamics in response to technological shocks [Blundell, Green, Jin, 2018], [Meyer, Schiopu, 2015]; we argue that technological changes have an influence on the individual application decisions of school leavers.

The paper presents a microeconomic model of the influence of technological development on the demand for higher education that exploits the ideas of changes in the labour market in response to technological shocks [Acemoglu, Autor, 2011]. We assume that these dynamics are transmitted to the expectations of school graduates about their labour market outcomes which are one of the main factors in their university application decisions. The model proposes high-skill-biased technologies, technologies replacing middle-skill workers and technologies raising the productivity of high-skill workers change the relative wages of high-, middle- and low-skill workers leading to a growth in demand for higher education.

The empirical analysis of the dynamics of the labour market in Russia adds value to the research. The dynamics of the shares of groups of workers and their relative wages support the stylized facts given by Acemoglu and Autor [2011], though they do not discuss the situation in developing countries. Our findings could be insightful for such counties, especially the post-Soviet ones, where the level of economic development is close to that of Russia.

The tendencies of the labour market are compared with the numbers enrolled in higher education in Russia in terms of the model. The results provide evidence that either high-skill-biased technologies, technologies replacing middle-skill workers or technologies raising the productivity of high-skill workers affected the Russian labour market 2007–2015, which we claim to be one of the reasons for the growth in the share of youth admitted to higher education institutions. The results are consistent with the dynamics in the other post-Soviet countries, characterized by similar education systems and education policies [Smolentseva, et.al., 2018].

The paper is organised as follows: Section 2 presents a literature review; Section 3 describes the model of the demand for higher education and discusses its dynamics in response to technological shocks; Section 4 estimates the parameters of the model on Russian data; Section 5 concludes.

2. Literature Review

The massification of higher education is defined as an increase in the share of an age cohort at university[4] (see Figure 1). It is usually accompanied by institutional changes, such as growth in the number of universities, their diversification, or changes in educational standards [Altbach, 2008]. Massification occurred in almost all parts of the world during the 1990s.

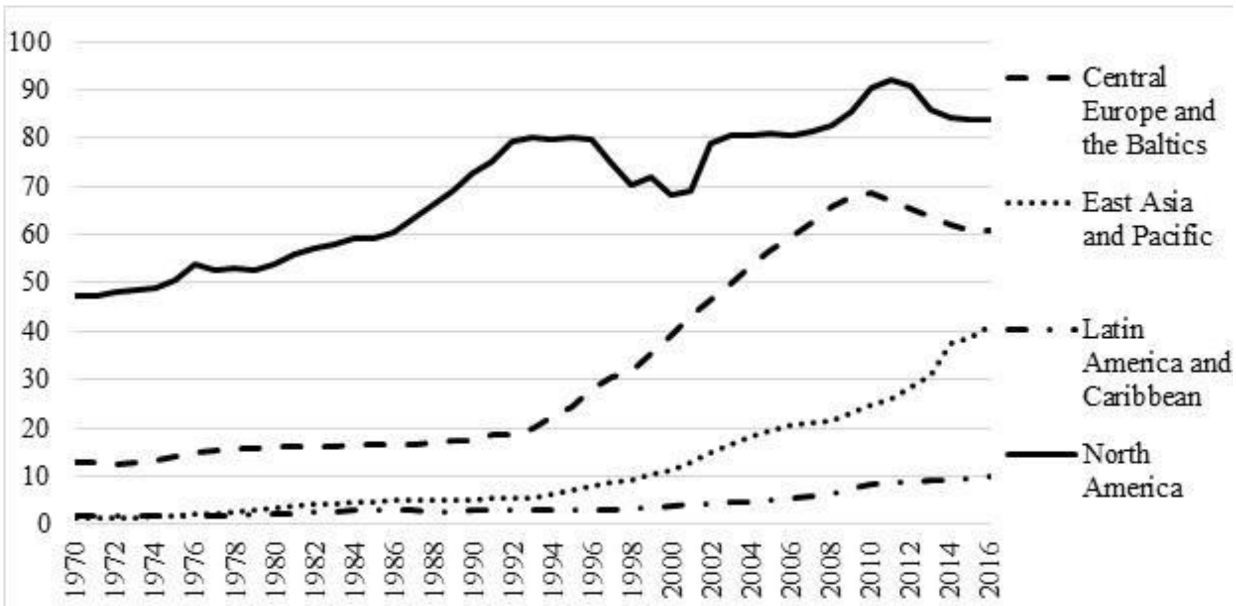

Fig. 1. Dynamics of the enrolment ratio in higher education. Source: World Bank Open Data

The paper contributes to three strands of the literature: that which verifies the drivers of higher education expansion; that which explores the influence of technological changes on the economy

[4] This corresponds to the definition of the enrolment ratio used by the World Bank.

and education systems; and that which empirically illustrates the correlations of employment and wage dynamics with enrolment dynamics.

Local political and educational policy changes are often given as reasons for the massification of higher education [Schofer and Meyer, 2005] and these reasons are common for all countries. Technological development and globalisation are the primary drivers of positive demand for higher education [Schofer and Meyer, 2005]. [Telezhkina et al., 2019] say that change in individual countries should also be considered as accompanying the effects of technological development and globalisation. The development of technology creates value for higher education, which develops soft skills by applying these changes. The wage premium for higher education growth causes an increase in the number of applications. Globalisation leads to increased demand for a highly qualified workforce, enhanced competitiveness and, consequently, the wage premium for such workers rises as does the quantity of individuals getting higher education [Beerkens, 2003]. Technological innovations contribute to the growth in the number of international corporations, thus, enhancing globalisation [Narula, 2003]. The idea that knowledge is an asset and that education provides social mobility is also a cause of the massification of higher education.

The necessity to enhance education in order to ensure economic growth in a technologically intensive world is widely acknowledged in the literature [Yeo and Lee, 2020]. [Tinbergen, 1975] described 'the race between education and technology'. Skill-biased technologies lead to an increase in the relative demand for skills which influence wage premiums and cause an increase in the relative supply of skills [Blundell, et.al. 2018], [Meyer and Shiopu, 2015]. The influence of labour market changes, induced by innovation, on individual enrolment decisions receives less attention. [Belskaya and Sabrianova Peter, 2014] emphasize a lack of theoretical and empirical analysis of the growth in number of applicants to universities. The current paper fills this gap, providing a theoretical framework for new technologies leading to the massification of higher education.

Blundell et al. [2018] stress the diversity of effects of innovation on the labour market and education systems worldwide, however, it seems that globalisation is a feature of both. The current paper sheds some light on how different types of technologies have affected relative wages in Russia in the last 20 years and whether we can verify the changes in demand for education, resulting from these dynamics.

Being guided by the correlations between the dynamics of skill supply and the development of technology, we singled out technological innovations as the main source of increasing demand for higher education. The article formulates a microeconomic model to reveal how the types of technological change contributes to increased demand for higher education; it identifies the types of technology that have had a significant influence on the Russian labour market and enrollment in higher education.

3. The model of demand for higher education

The model considers an individual choosing to apply or not to university. We assume that the choice is guided by the comparison of utility in both cases and that the utility function has the form:

$$u_i = I_i + b * L_i \ , \tag{1}$$

where u_i is utility of individual i, I_i is aggregate expected income of individual i, L_i is the consumption of leisure and other goods[5], b is the relative marginal utility of leisure. Since we are interested in the impact of technology on utility, mediated by the labour market, the component of the utility L_i is free of the influence of technological development and is insignificant in the differential calculus of utility under technological shock. Thus, we assume that individuals are guided by the comparison of expected incomes in their university application decisions.

If individual *i* does not enter university, he expects to get job immediately and receive yearly expected wage Ew_i^{NU} which grows at constant rate g_1 each subsequent year till the year of his retirement, *N*. Thus, the discounted cash flow of an individual not going into university is:

$$I_i^{NU} = Ew_i^{NU} + \frac{1}{1+r}(1+g_1)Ew_i^{NU} + \cdots + \frac{1}{(1+r)^N}(1+g_1)^N Ew_i^{NU} \ , \tag{2}$$

where r is the discount rate.

An individual expects to study at university for 4 years to get bachelor's degree and to enter the labour market just after graduation, receiving an expected wage Ew_i^U. He/she will work till

[5] This term may also capture the pleasure of experiencing student life, etc.

year N, and his/her wage will grow at a constant rate, g_2, each year. The discounted income for entering university is:

$$I_i^U = \frac{1}{(1+r)^4} Ew_i^U + \frac{1}{(1+r)^5}(1+g_2)Ew_i^U + \cdots + \frac{1}{(1+r)^N}(1+g_2)^N Ew_i^U \,, \tag{3}$$

Thus, the individual enters university if $I_i^U \geq I_i^{NU}$.

$$\frac{1}{(1+r)^4} Ew_i^U * \frac{1-\left(\frac{1+g_2}{1+r}\right)^{N-4}}{1-\frac{1+g_2}{1+r}} \geq Ew_i^{NU} * \frac{1-\left(\frac{1+g_1}{1+r}\right)^{N}}{1-\frac{1+g_1}{1+r}}, \tag{4}$$

$$C * Ew_i^U \geq Ew_i^{NU}, \tag{5}$$

where $C = \frac{1}{(1+r)^4} * \frac{1-\left(\frac{1+g_2}{1+r}\right)^{N-4}}{1-\frac{1+g_2}{1+r}} / \frac{1-(\frac{1+g_1}{1+r})^{N}}{1-\frac{1+g_1}{1+r}}$.

Following Acemoglu and Autor [2011], we consider low-skill, middle-skill and high-skill workers, signifying the capabilities necessary for performing various tasks, and suppose that the last two of them require higher education. Thus, $Ew_i^U = a_i * w(M) + (1 - a_i) * w(H)$, where a_i is the probability of individual *i* getting a middle-skill job with the wage *w(M)* and $(1 - a_i)$ is the probability of individual *i* getting a high-skill job with the wage *w(H)*. Values of the stochastic variable, a_i, depend on the abilities of individuals. The wage of low-skill workers defines the expected wage for not going to university, $Ew_i^{NU} = w(L)$. Consequently, an individual applies to university if $F \geq 1$ where $F = C * ((1 - a_i) * \frac{w(M)}{w(L)} + a_i * \frac{w(H)}{w(L)})$. The share of individuals with the values of $F \geq 1$ constitute the demand for higher education[6]:

$$D = \int_1^\infty f(F)dF, \tag{6}$$

[6] The value of F might be equal to infinity, if the relative wages approaching infinity, which can be a matter of normalization. For instance, if w(L) is considered to be the minimal paid wage, and is normalized to zero, whereas w(M) and w(H) are defined as the difference between the average wage of medium skilled and high skilled workers and the minimal paid wage, then the relative wages will approach infinity.

If $b_i = C * a_i$ then the decision rule $F \geq 1$ can be rewritten in the form:

$$b_i \geq \frac{1-C*\frac{w(M)}{w(L)}}{\frac{w(H)}{w(L)}-\frac{w(M)}{w(L)}}, \tag{7}$$

Thus, the demand for higher education is equal to:

$$D = \int_{\frac{1-C*\frac{w(M)}{w(L)}}{\frac{w(H)}{w(L)}-\frac{w(M)}{w(L)}}}^{\infty} f(b_i)db_i * Q = [1 - \int_{-\infty}^{G} f(b_i)db_i] * Q, \tag{8}$$

where $G = \frac{1-C*\frac{w(M)}{w(L)}}{\frac{w(H)}{w(L)}-\frac{w(M)}{w(L)}}$, Q is the number of individuals of the corresponding age. If ε is a parameter characterizing the scope of technological shock, then the sign of $\frac{dD}{d\varepsilon}$, characterizing the response of the higher education system to the demand shock, is of primary interest. The derivative of the demand for higher education function is expressed by (9). It is evident that the sign of the derivative depends on the sign of the term $\frac{dG}{d\varepsilon}$ which is equal to (11).

$$\frac{dD}{d\varepsilon} = \frac{dD}{dG} * \frac{dG}{d\varepsilon} = -f(G) * \frac{dG}{d\varepsilon}, \tag{9}$$

$$\frac{dG}{d\varepsilon} = \frac{-C*\frac{d\left(\frac{w(M)}{w(L)}\right)}{d\varepsilon}*\left(\frac{w(H)}{w(L)}-\frac{w(M)}{w(L)}\right)-\left(1-C*\frac{w(M)}{w(L)}\right)*\left(\frac{d\left(\frac{w(H)}{w(L)}\right)}{d\varepsilon}-\frac{d\left(\frac{w(M)}{w(L)}\right)}{d\varepsilon}\right)}{\left(\frac{w(H)}{w(L)}-\frac{w(M)}{w(L)}\right)^2}, \tag{10}$$

$$\frac{dG}{d\varepsilon} = \frac{\left(1-C*\frac{w(H)}{w(L)}\right)*\frac{d\left(\frac{w(M)}{w(L)}\right)}{d\varepsilon}-\left(1-C*\frac{w(M)}{w(L)}\right)*\frac{d\left(\frac{w(H)}{w(L)}\right)}{d\varepsilon}}{\left(\frac{w(H)}{w(L)}-\frac{w(M)}{w(L)}\right)^2}, \tag{11}$$

Consider an economy that produces a unique final good, Y, that involves the production of some intermediate goods, $y(i)$, through performing tasks, i, such that $Y = exp[\int_0^1 lny(i)di]$. Each task has the production function:

$$y(i) = A_L\alpha_L(i)l(i) + A_M\alpha_M(i)m(i) + A_H\alpha_H(i)h(i) + A_K\alpha_K(i)k(i)$$

where the A terms represent factor-augmenting technology, and $\alpha_L(i), \alpha_M(i), \alpha_H(i), \alpha_K(i)$ are the task productivity schedules designating the productivity of low-, medium- and high-skill workers and capital in different tasks, $l(i), m(i), h(i), k(i)$ are the number of low-, medium-, high-skill workers and the capital allocated to task i [Acemoglu and Autor, 2011, p.1121]. Several types of technological innovations[7] may take place:

- skill biased technologies affecting either A_L,A_M or A_H;
- task-replacing technologies;
- productivity changing technologies affecting parameters α_L, α_M or α_H.

Let us analyse the dynamics of demand for higher education in response to changes in relative wages of high-, middle- and low-skill workers as a consequence of the introduction of skill-biased, task-replacing and productivity-raising technologies on workplaces and in production.

Skill-Biased Technologies

Under a *high-skill-biased technological shock*, parameter A_H growth in ε results in an increase of relative wages $\frac{w(H)}{w(L)}$ and $\frac{w(H)}{w(M)}$ and decline of $\frac{w(M)}{w(L)}$ [Acemoglu, Autor 2011]. Thus, $\frac{dD}{d\varepsilon}$ will be positive if the terms in (5) $(1 - C * \frac{w(H)}{w(L)})$ and $(1 - C * \frac{w(M)}{w(L)})$ are positive. A graphical representation and discussion of the condition $\left(1 - C * \frac{w(H)}{w(L)}\right) > 0$ can be found in the Appendix. Estimates of the expressions on Russian data, presented in Section 4, show that the requirement holds for the period 2007–2015 when high-skill-biased technological changes are hypothesised.

Relative wages $\frac{w(H)}{w(L)}$ and $\frac{w(M)}{w(L)}$ both decline in the case of *low-skill-biased technical change* as a result of more tasks being performed by low-skill workers and an increase in their wages. The

[7] For example, the introduction of accounting software can be considered a high-skill-biased technological change, as it requires analytical skills for using it. Thus, calculations, previously performed by hand, by middle skilled workers, are done by high skilled workers with the use of computers in a much shorter time. The electronic catalogue in a library might be a case of low-skill-biased technological change. A highly-educated librarian might now be replaced by an employee with a lower level of education at the circulation desk.

effect of low-skill-biased technological change on the sign of $\frac{dD}{d\varepsilon}$ is ambiguous. If multipliers in the enumerators are of different signs, so that $\left(1 - C * \frac{w(H)}{w(L)}\right) < 0$ and $\left(1 - C * \frac{w(M)}{w(L)}\right) > 0$, then $\frac{dD}{d\varepsilon} < 0$. If the multipliers are of the same sign then it depends on relative values of $\frac{(1-C*\frac{w(H)}{w(L)})}{\left(1-C*\frac{w(M)}{w(L)}\right)}$ and $\frac{\frac{d\left(\frac{w(M)}{w(L)}\right)}{d\varepsilon}}{\frac{d\left(\frac{w(H)}{w(L)}\right)}{d\varepsilon}}$. These conditions also make $\frac{dD}{d\varepsilon}$ positive if *medium-skill-biased technical change* occurs. The relative wage of medium-skill workers increases, whereas that of high-skill workers is also more likely to rise, according to Acemoglu and Autor [2011].

Task-replacing Technologies

Acemoglu and Autor [2011] consider a shock when ε, the share of routine or codifiable tasks, that are primarily performed by medium-skill workers, become economically viable to be performed using machines rather than labour. They propose that this change leads to an expansion of low- and high-skill tasks, so that $\frac{d\left(\frac{w(M)}{w(L)}\right)}{d\varepsilon}$ is negative, while $\frac{d\left(\frac{w(H)}{w(L)}\right)}{d\varepsilon}$ is more likely to be positive. Analyzing (5), it is evident that demand for higher education grows in response to such a shock if the terms $(1 - C * \frac{w(H)}{w(L)})$ and $(1 - C * \frac{w(M)}{w(L)})$ are positive.

Productivity Shock

Acemoglu and Autor [2011] assume the existence of a threshold task $\tilde{I}_H$ so that the productivity of high-skill workers in tasks $[I_H, \tilde{I}_H]$ increases. They stress that this shock initiates similar dynamics in relative wages when technologies replace middle-skill tasks. The shock may also cause an increase of demand for higher education if these conditions hold.

4. Empirical Analysis

This part of research tests the conditions for observing growth in the demand for higher education under high-skill-biased technological change, task-replacing technologies and productivity-raising technologies affecting the high-skill group. We use data from the Russian Longitudinal Monitoring Survey, conducted by HSE University, OOO “Demoskop”, the Carolina

Population Center at the University of North Carolina at Chapel Hill, and the Institute of Sociology of Federal Center of scientific research in Sociology of Russian Academy of Science (http://www.hse.ru/rlms). There are 49,439 observations available in each of the waves 9–27 (2000–2018).

The first step of the analysis involves defining high-, middle-and low-skill tasks in the suggested classification of occupations. Acemoglu and Autor [2011] define non-routine cognitive tasks to be high-skill one; middle skill tasks are routine cognitive or routine manual; low skill tasks are non-routine manual. This gives us the following matching of the classifications (Tab. 1).

Tab.1. Matching the classification of occupations in ISCO-08 by task level

Name of the task group as in Acemoglu and Autor (2011)	Occupation names in ISCO-08
High Skill Tasks (non-routine cognitive)	Managers
	Professionals
	Technicians and Associate Professionals
	Commissioned Armed Forces Officers
Middle Skill Tasks (routine cognitive and routine manual)	Clerical Support Workers
	Craft and Related Trades Workers
	Plant and Machine Operators and Assemblers
	Non-commissioned Armed Forces Officers
Low Skill Tasks (non-routine manual)	Services and Sales Workers
	Skilled Agricultural, Forestry and Fishery Workers
	Elementary Occupations

The next step of the analysis is testing the assumptions of the model of Acemoglu and Autor [2011]. Their model represents the stylized facts of job and wage polarisation. Fig. 2 illustrates the decline of the share of workers performing middle-skill tasks, in the overall labour force, and the growth in the share of workers performing low-skill tasks. They refer to this as job polarisation and express this idea in the 'routinization hypothesis', which states that routine and codifiable tasks of middle-skill workers are being replaced by machines, leading to a decline in the number of workers doing these tasks.

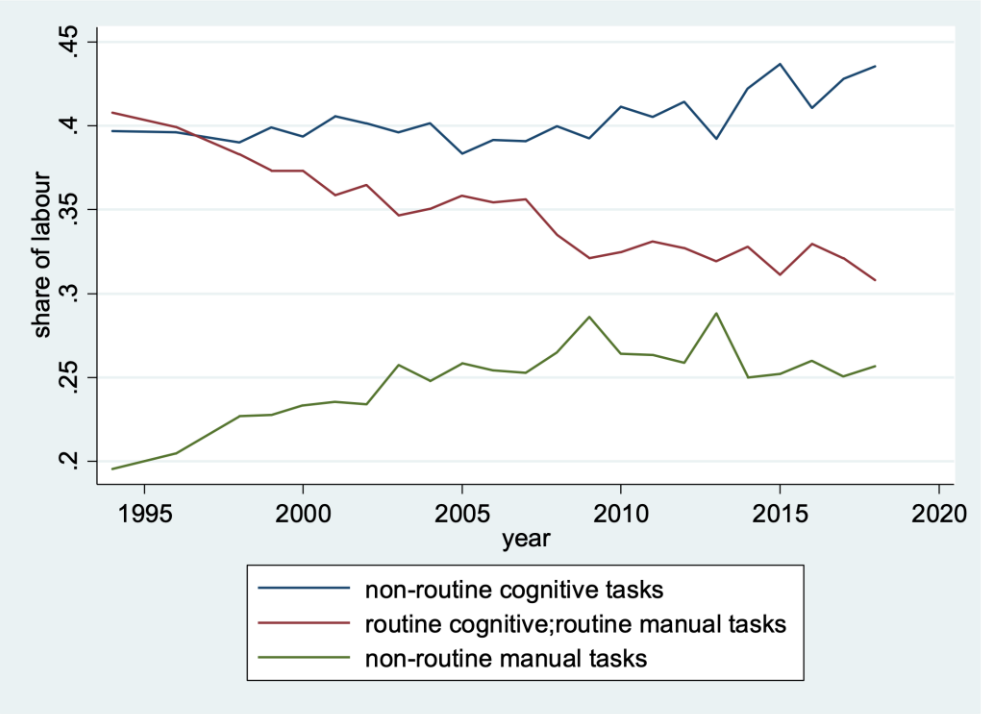

Fig. 2. Dynamics of share of workers performing different tasks in Russia

Fig. 3 illustrates the increasing wage gap between workers performing high-skill and low-skill tasks, which is implied by wage polarisation. It seems that entrepreneurs and other high-income individuals are underrepresented in the sample, which is evident from the statistics that underestimate the average wage of workers performing high-skill tasks. This also may be evidence of the existence of the shadow economy in Russia.

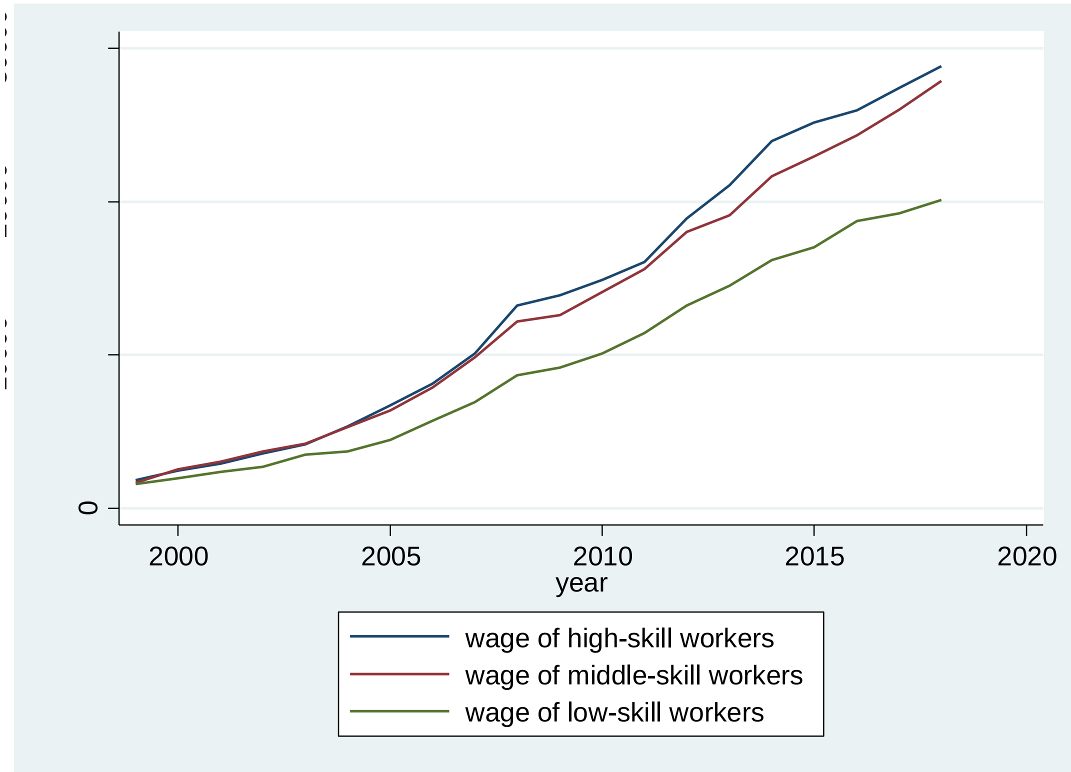

Fig. 3. Dynamics of wages by task level in Russia

Statistics show the in-phase dynamics of relative wages $\frac{w(H)}{w(L)}$ and $\frac{w(M)}{w(L)}$ in the periods 2000–2007 and 2015–2018 and out-of-phase dynamics in 2007–2015 (Fig. 4). It is possible to hypothesise that middle- or low-skill-biased technological changes affected the Russian labour market in 2000–2007 and 2015–2018 and high-skill-biased technological change, technologies replacing middle-skill tasks or productivity-raising technologies affected high-skill workers in 2007–2015.

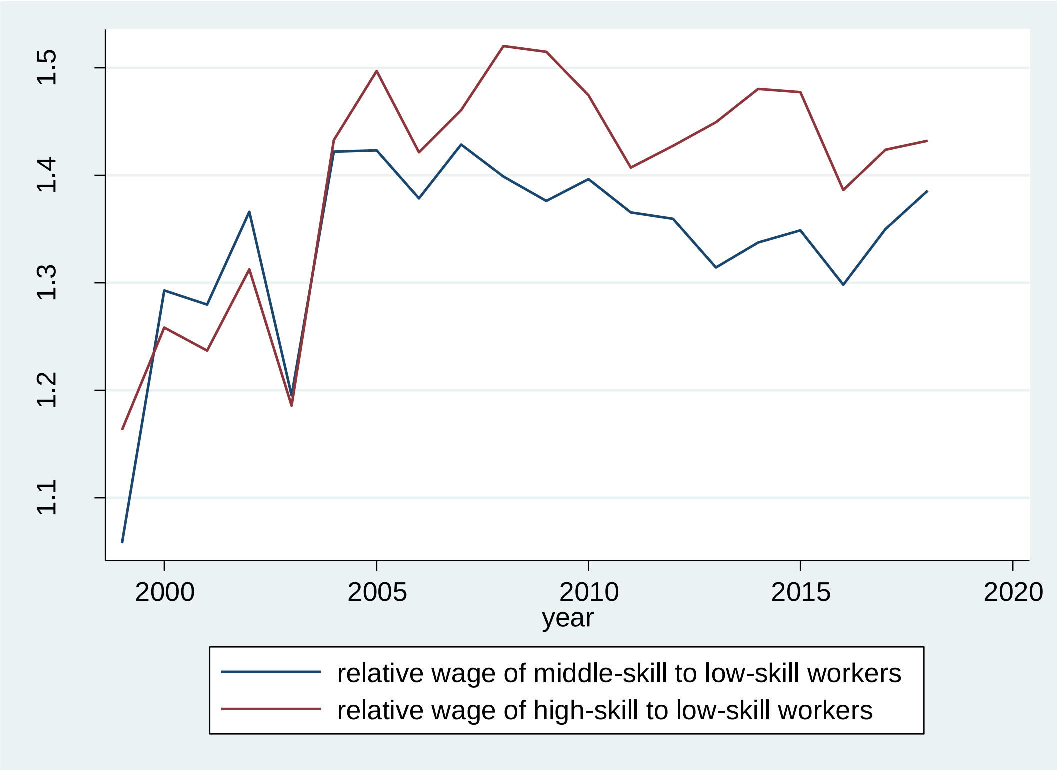

Fig. 4. Dynamics of relative wages high-, middle- and low-skill workers

Once the basic assumptions of the model are met, then it is possible to employ the results for the analysis of the demand for higher education.

For the first period, the dominance of growing patterns in the dynamics of both $\frac{w(H)}{w(L)}$ and $\frac{w(M)}{w(L)}$ illustrate the spread of middle-skill-biased technologies, which contribute to the growth in demand for higher education (see Section 3). The dynamics of the education system in Russia at the beginning of the 2000s have to be considered in the context of the development of the market economy, which is why the transmission of labour market tendencies to the education system may not be efficient. The empirical analysis of demand for higher education in Russia is analysed below.

Having verified the influence of high-skill-biased technological changes, medium-skill task-replacing technology and high-skill productivity-raising technologies on the relative average wages of Russian workers, it seems reasonable to check the conditions for the growth in demand for higher education in response to these kinds of shocks. It seems obvious that the condition $\left(1 - C * \frac{w(H)}{w(L)}\right) > 0$ is more restrictive than $\left(1 - C * \frac{w(M)}{w(L)}\right) > 0$ as $\frac{w(H)}{w(L)} > \frac{w(M)}{w(L)}$. Thus, it is necessary to estimate the annuity coefficient:

$$C = \frac{1}{(1+r)^4} * \frac{\frac{1-\left(\frac{1+g_2}{1+r}\right)^{N-4}}{1-\frac{1+g_2}{1+r}}}{\frac{1-\left(\frac{1+g_1}{1+r}\right)^{N}}{1-\frac{1+g_1}{1+r}}}, \tag{12}$$

and the average value of $\frac{w(H)}{w(L)}$ on the data. Having distributed individuals in different occupations by groups performing high-, middle- and low-skill tasks with the use of Tab.1, we get the data on relative wage $\frac{w(H)}{w(L)}$. Estimates of the yearly wage growth rates for individuals who do not have higher education (g_1) and those who do (g_2) are calculated as the average rate of wage growth in low-skill workers and the average growth rate of middle- and high-skill workers with the use of Tab. 1. Only growth rates lower than 0.5 and higher than (-0.5) are counted while estimating the parameters. Other cases are attributed to special occasions such as a change of workplace, becoming self-employed, etc. or errors. We approximate the discount factor, r, with the rate of inflation in the previous year for the period 2000–2014 and with the average of previous rate of inflation and the inflation target for each year after 2014, when inflation targeting was announced in Russia. The average working age, N, is set to 42 because less than 50% of people continue working after the age of 60, so that we observe a significant decrease in labour force participation after this threshold, whereas those who do not get higher education start working at approximately the age of 18. We assume individuals study for 5 years in 2000–2013, transforming the formula of annuity coefficient, so that $C = \frac{1}{(1+r)^5} * \frac{1-\left(\frac{1+g_2}{1+r}\right)^{N-5}}{1-\frac{1+g_2}{1+r}} / \frac{1-(\frac{1+g_1}{1+r})^N}{1-\frac{1+g_1}{1+r}}$. The point is that, before joining the Bologna process, there was a 5-year system higher education and a 4-year system of vocational education[8] though there are more than twice as many students of the former than the latter. After the transformations started, there were still universities with 5-year educational programs, whereas the others were already providing 4-year bachelor's and 2-years master's degrees. We calculated the weighted average year of getting higher education with the use of data published in ROSSTAT statistical compilation "Rossijskij statisticheskij ezhegodnik" [Russian statistical yearbook]. Mean values of the parameter estimates are presented in Tab. 2.

[8] For Russia, we analyze the tendency of growth of enrolment in both vocational education and higher education institutions, and aggregate the data on both of them.

Tab. 2. Estimates of the parameters of the model

Parameter	Notation	Estimate
Wage of high skilled workers in relation to wage of low skilled workers, mean value	$\frac{w(H)}{w(L)}$	1.42
Yearly wage growth rate of individuals without higher education degree, mean value	g_1	0.08
Yearly wage growth rate of individuals with higher education degree, mean value	g_2	0.081
Discount-factor, mean value	r	0.1
Working age	N	42
Annuity coefficient, mean value	C	0.61

Fig. 5 presents the annuity coefficient, calculated on individual data in each year, and the dynamics of $\frac{w(L)}{w(H)}$. The condition of $\left(1 - C * \frac{w(H)}{w(L)}\right) > 0$ requires the annuity coefficient being lower than $\frac{w(L)}{w(H)}$.

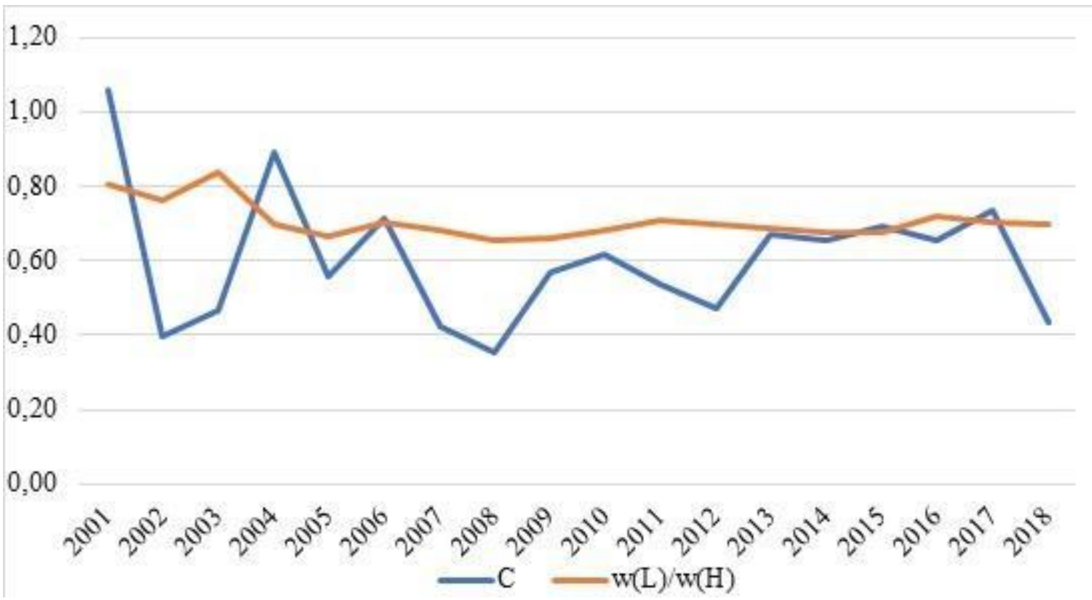

Fig. 5. Comparison of annuity coefficient and relative wage of low and high skilled workers

It seems the result of the comparison of the estimate of coefficient C and $\frac{w(L)}{w(H)}$ support the hypothesis about the periods of technological change in Russia, stated earlier. In particular, the growth in demand for higher education holds for 2007–2015, when we observe the dynamics of relative wages under high-skill-biased technological shock, medium-task replacing technologies or productivity-raising technologies affecting high-skill workers. However, the condition $\left(1 - C * \frac{w(H)}{w(L)}\right) > 0$ is regularly violated in the periods 2000–2006 and 2015–2018 which means these types of technologies no longer explain the growth in the demand for higher education. If we observe such a tendency, then it is driven by other factors. Returning to Figure 4, the observed pro-cyclical dynamics of relative wages with a positive trend in 2015–2018 suggests the influence of middle-skill-biased technologies in the Russian labour market produces an increase in applications to higher education institutions.

Providing empirical evidence of the dynamics of the demand for higher education is a tricky task: “the majority of economic studies have used enrolments as a measure of demand, this can be problematic because the enrolment decision is affected by both the demand from students and the supply from institutions. In some instances, however, enrolment figures can be reasonably interpreted as demand [Toutkoushian, Paulsen, 2016] if the postsecondary option being examined is at an aggregate level (such as enrolments in any college or in 4-year colleges), then changes in enrolments most likely are due to changes in demand and not supply because most students with a predisposition to college could find some place to enroll” [Toutkoushian, Paulsen, 2016, p.189]. We employ this argument to reveal the dynamics of the demand for higher education in Russia. Education policy changed in 2009 so that the secondary school leaving exam (USE) became compulsory for all school students and enhanced access to higher education: school graduates became able to apply to up to 5 universities with their USE results. Thus, the enrolment rate is an even better proxy for demand for higher education after 2009 than it was before.

The model of the demand for higher education, described in Section 4, suggests we would observe growth in the number of individuals getting higher education in 2007–2018 in Russia with reference to high-skill-biased, medium-task replacing or high-skill productivity-raising technologies affecting the labour market in 2007–2015 and middle-skill-biased technologies in 2015–2018. We avoid the analysis of the influence of innovation on the labour market and the system of higher education in 2000–2007 because the market economy was at an early stage of development in Russia and there might be some distortions in the interpretation and understanding of the labour market signals by economic agents.

To analyse the dynamics of the demand for higher education in Russia, we consider the data on enrolment and the number of higher education institutions compiled with the use of “Rossijskij statisticheskij ezhegodnik” [Russian statistical yearbook] and “Indikatory obrazovaniya” [Indicators of education].

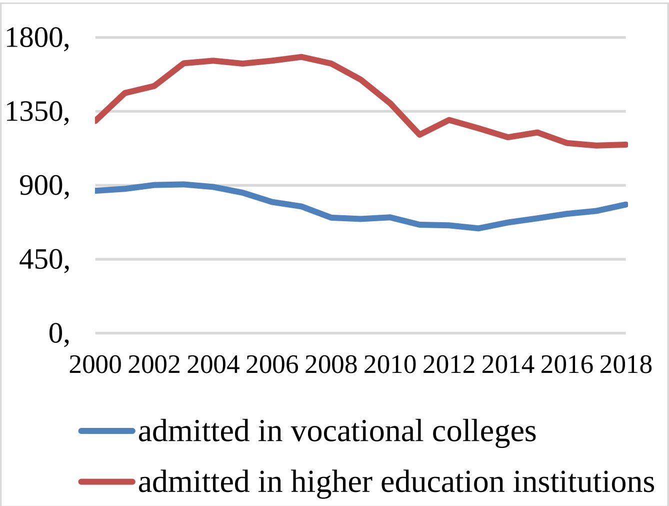

Fig. 6. The number of individuals enrolled on educational programs in vocational colleges and higher education institutions in Russia (in thousands).

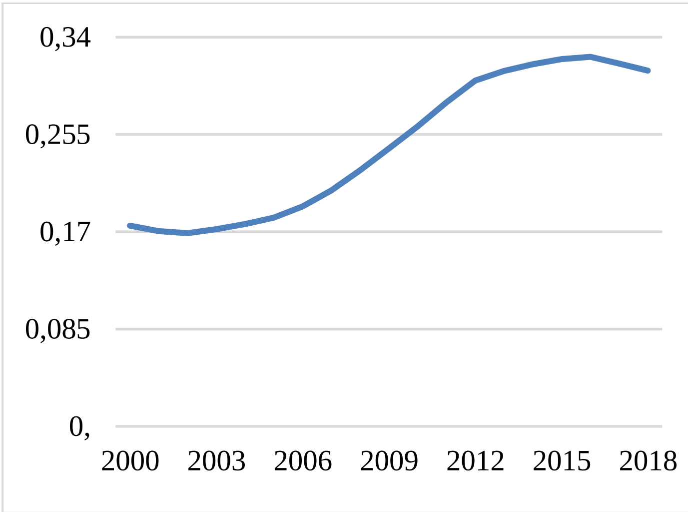

Fig. 7. Share of individuals admitted to colleges and universities in the number of youth of the corresponding age cohort

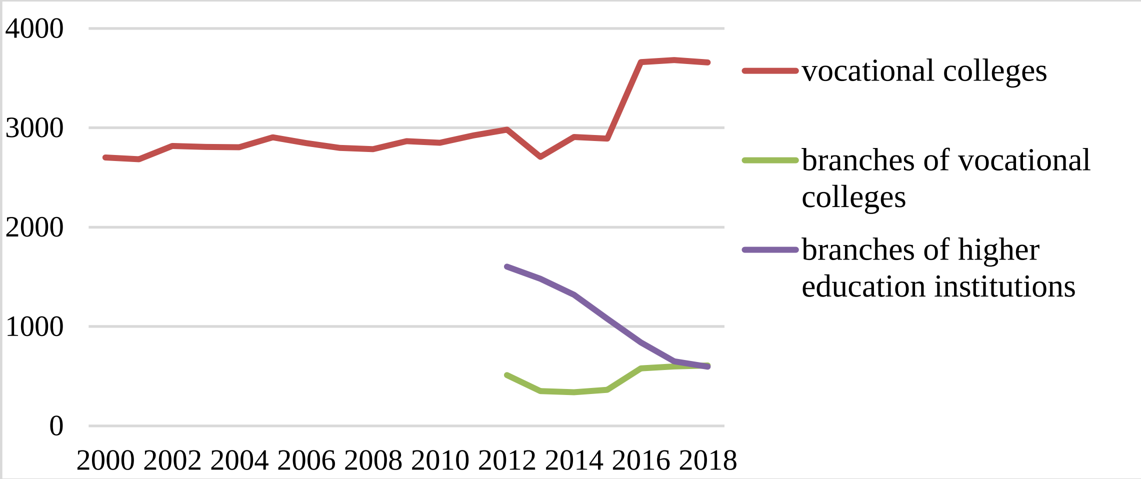

Fig. 8. The number of vocational colleges, higher education institutions and their branches in Russia.

Fig. 6 illustrates a moderately decreasing pattern in the post-secondary enrolment in 2007–2013 and growth of 30% in 2013–2018. The latter can be attributed to the 30% rise in the number of vocational colleges and their branches which is primarily an increase in the number of state colleges rather than private ones (Fig. 8). The number of individuals admitted to universities strictly decreased in 2007–2011; the quantity of university entrants fluctuated slightly, 2011–2018, around the level of 1.2 million individuals (Fig. 6). An abrupt fall in the number of higher education institutions and their branches after 2009 suggests that the level of university enrolment was preserved due to increasing demand for higher education. Thus, we would argue that there was a 4-year lag on labour market changes in reaction to the demand for higher education. The results are supported by the numbers of individuals admitted to institutions of higher education relative to the number of the corresponding age cohort (15–19 years) (Fig. 7). An increase in the value of the parameter in 2007–2015 is a result of both the reform introducing the USE, increasing access to higher education, and the labour market trends discussed previously.

5. Conclusion

Increased higher education enrolment in almost all countries the world over, which is known as massification, means the understanding of the drivers and consequences of the phenomenon and education policy need to be revised. Globalisation and technological development are widely acknowledged as reasons for higher education expansion [Ahmed, 2016], [Altbach, 2008], [Kwiek, 2001], [Schofer and Meyer, 2005], [Scott, 2000]. Market globalisation is the tendency to overcome national boarders, which influences countries, societies, companies, and individuals. As a result, the global markets for goods and services, and international corporations appear to lead the increasing demand for a highly qualified workforce, which increases the returns to and demand for higher education. The development of technology and their incorporation into production, finance and management enhanced these labour market trends. It is suggested that technological innovations stimulate globalisation, for instance, making international collaboration easier.

The hypothesis under consideration is that changes in the labour market structure in response to the introduction of technological innovations contribute to an increase in the demand for higher education. This idea, announced by Tinbergen [1975] and Goldin and Katz [1998], is enriched by a microeconomic model describing the influence of wage premium changes on individual university application decisions, presented in the current paper. We provide evidence for the increasing number of applicants in response to high-skill-biased technologies, task-replacing technologies and productivity-raising technologies affecting high-skill workers.

The result is suggestive in terms of forecasting the future dynamics of enrolment in higher education: compelled remote work is expected to force workers of some occupations to work from home on a more regular basis [Dingel and Neiman, 2020], which might decrease the share of middle-skill and low-skill workers even further, increasing the wage gap between high-, middle- and low-skill workers. These processes might accentuate the value of knowledge even more and stimulate individuals to get higher education of good quality.

The paper identifies the effects of either high-skill-biased technological shock, task-replacing technologies or productivity-raising technologies using data from the Russian labour market, 2007–2015, and illustrates the feasibility of technologies leading to a positive demand shock for the higher education market. The authors verify the increased demand for higher education in Russia in the period and suggest the existence of a 4-year lag in the reaction of the enrolment rate to changes in relative wages and the composition of the labour force. The peculiarities of the dynamics of the shares of workers by skills and relative wages, the features of the higher education system and education policies are similar among post-Soviet countries [Smolentseva, et.al., 2018] and to developing economies which makes the research insightful for those countries.

The model of the influence of technological development on the demand for higher education, mediated by the labour market, presented in the paper, does not account for the dynamics of the supply of higher education which restricts the interpretation of the results and their empirical verification. This is because the scope of government regulation of the higher education system varies significantly in countries worldwide; some post-Soviet countries, including Russia, exhibit a lot of government influence on the structure of higher education system.

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Appendix A

High-skill-biased technological changes, task replacing technologies and productivity rising technologies for high-skill workers constitute the major part of technological shocks affecting economies today, and, that is why, D. Acemoglu, D. Autor also put much attention to them in their analysis in [Acemoglu and Autor 2011]. If these types of innovations are concerned then it is necessary to evaluate whether the conditions of $\left(1 - C * \frac{w(H)}{w(L)}\right) > 0$ and $\left(1 - C * \frac{w(M)}{w(L)}\right) > 0$, ensuring growth of university applications, are feasible. It is evident that the former one is more restrictive than the latter. That is why, it is given primary attention from the point of feasibility analysis. Fig. A.1-A.3 present surfaces of the values of annuity coefficient, C, resulting from different values of the parameters r and g_1 in the interval [0; 0,1][9] calculated with the use of formula (6). Maximum working age is approximated by 42, if an individual starts working at 18 and the career ends at 60 years old[10]. The Figures A.1-A.3 illustrate the influence of increasing difference between growth rates g_1 and g_2 on the feasibility region of the inequality. The lines in bold set the plane of points with the values of $C = \frac{w(L)}{w(H)}$, so that the points on the surface $C(r, g_1)$ below the line of intersection of them are the solution of the inequality $\left(1 - C * \frac{w(H)}{w(L)}\right) > 0$. The relative wage of low-skill workers to high-skill workers are approximated by 0,7 that is the average value of the parameter received on the data of RLMS on the period 2001-2018. It seems evident that the lower the difference between wage growth rates of individuals with diploma and without it, the greater the range of discount rates and growth rates that satisfy the condition. Nevertheless, it seems evident, there is the threshold value of $(g_2 - g_1)$ for each of the values of $\frac{w(L)}{w(H)}$ such that further increase of the difference gets the feasible region being empty.

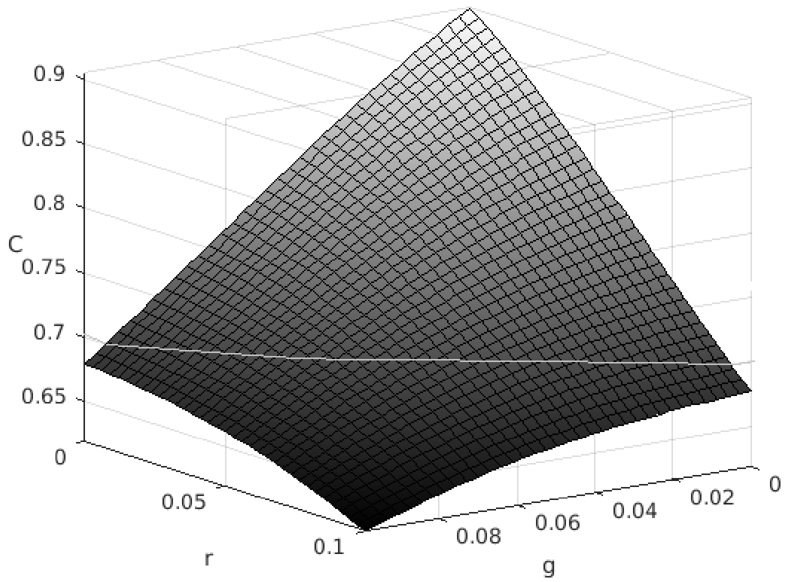

Figure A.1. The surface of the function $C(r, g_1)$, $(g_2 - g_1) = 0$

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[9] It seems reasonable to assume wage growth rate of those, without higher education, and discount rate are positive and less than 10% a year. One might suggest, discount rates, greater than the value, reflect substantial risks, that economic agents face, and can take place in unstable economies, that are beyond the scope of the study. High wage growth rates may happen in economies with high inflation that is not a common situation.

[10] Another explanation of the assumption of maximum working age is that individuals might be prone to change their job after the age of 60, in order to rearrange work-life balance. This might result in structural break in the model of individual wage formation. That is why is seems reasonable not to account for the period after 60 years old while considering individual wage profiles.

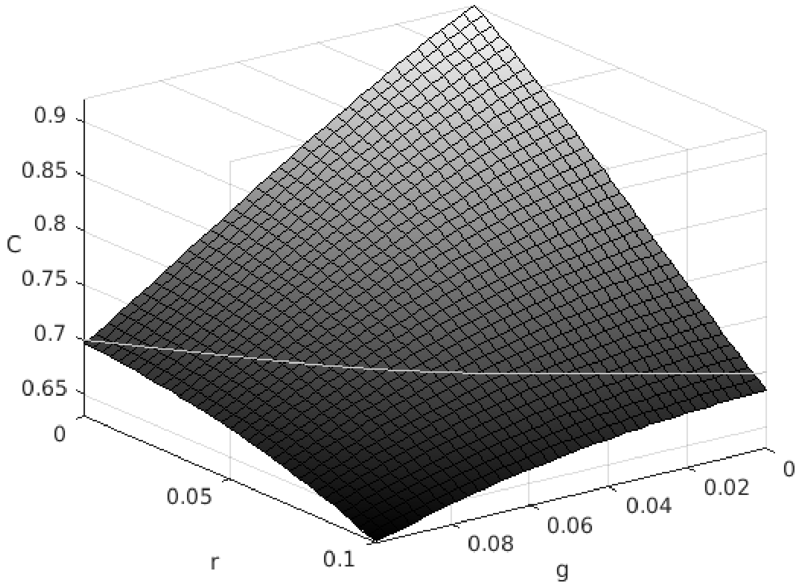

Figure A.2. The surface of the function $C(r, g_1)$, $(g_2 - g_1) = 0{,}001$

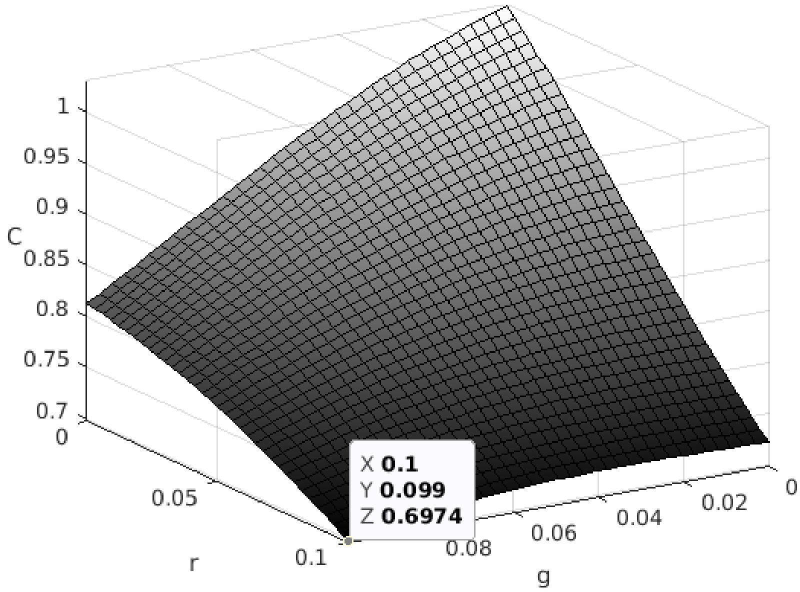

Figure A.3. The surface of the function $C(r, g_1)$, $(g_2 - g_1) = 0{,}007$

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