Impact of the macroeconomic factors on university budgeting the US and Russia

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Abstract. This paper discusses impact of macroeconomics factor on the university budgeting. Modern developments in the area of data science and machine learning made it possible to utilise automated techniques to address several problems of humankind ranging from genetic engineering and particle physics to sociology and economics. This paper is the first step to create a robust toolkit which will help universities sustain macroeconomic challenges utilising modern predictive analytics techniques.

1. Introduction

Technological progress during last half of the XX century significantly changed labor market all around the world. And therefore universities had to change as well to address to demand and economical realities. At first higher education, which depended heavily on the state, was perceived as a public good. But this belief was no longer valid [1]. Education was noticeably transformed under the pressure of numerous reforms. Economic stress increased the importance of the education system and the demand for quality improvement, which led to the need for greater funding. Higher education had to interact more closely with society and industry to increase the share of funding from the “market” and match the growing demand [2]. Now universities are even more closely related to the economy.

The main objectives of education are primarily knowledge maintenance and transfer. However, with the spread of the knowledge-based economy, universities have acquired new functions, such as technology transfer, building science and technology research parks, creature of incubators, providing consultancy services, etc. [3]. Therefore universities are becoming more and more dependent on the revenue from the sources outside of education and research and university budgeting process is becoming even more complex and sets higher standards for ROI expectations. In this way, budgeting – this is part of the economic cycle [4].

According to one of the definitions, budgeting is the decision on resources repartition among subunits of organization [5]. Frederick S. Hills and Thomas A. Mahoney tried to explain the process of budget allocation in universities. They came to the conclusion that universities as organizations behave according to the theory of coalition. Moreover, the method of allocating funding among subunits depends on the availability of resources. But the central power is more important in times of scarcity, which usually occurs during a crisis [6].
On the other hand, Joseph G. Fisher suggests using budgets for resource allocation that can eliminate budget slack. Moreover, the budget can be used for performance evaluation and this increases subordinate performance and more accurate budgets. Thus, management methods of budgeting, combining planning and control functions, can have a positive effect on the performance of the organization [7]. However, the authors made conclusions based on specific individual organizations and leave room for future research.

Another case study is an overview of budget allocations in one of the state universities in Malaysia. On the basis of mathematical calculations, the authors tried to find the effect of budget allocations for different faculties and subunits of the university. So they want to find a fresh approach to the resource allocation based on the effectiveness of the subunits [8].

Ingo Liefner analyzes various forms of allocation resources and funding affect universities at the macro and micro levels. Private funding plays a more important role in Anglo-American high education system. But in each case, the characteristics of a particular university affect the success of the funding allocation scheme. There are also differences in short-term and long-term results, which must be taken into account [9]. Because of the effect of globalization, the world economy has a significant impact on the development of education [10]. The behavior of organizations can be even the opposite. For example, during the 2008 downturn, companies reduced their expenditure for R & D, as there were fewer resources and it was necessary to survive in the short term. However, some organizations have increased funding for research in the hope of future incomes [11].

However, there may be an inverse relationship between education policy and funding. Alexander L. Darling and Martin D. England studied the financial formula in Ontario and assessed the effectiveness of budget allocation as a public policy tool [12]. The economy and the resulting indicators of education have a mutual impact. The crisis is an unpredictable and dangerous fluctuation of the economic structure, which must affect the education system.

The goal of this paper is to study which factors impact university budgeting in the current economical reality. This is a first step in the research project, which is aiming to use machine learning techniques to create automated university budgeting tool helping institutions of higher education be better prepared to macroeconomic fluctuations and become more sustainable in there development.

2. Methodology and data

The study of financial flows is a convenient tool for analyzing the activities of the organization as well as important mechanism in organizational health forecasting. The advantage of this type of analysis is that it can produce dynamical picture from both qualitative and quantitative points of view. Most of financial data is provided in uniform and easy to normalize format, but even with this in consideration a number of simplifications should be taken in the course of the study.

In this paper we considered two major indicators describing of the US economy: GDP in comparable prices of 2015 in US dollars and the Dow Jones index average for the year. The Dow Jones index reflects the dynamics of entrepreneurial activity. It is more sensitive to macroeconomic fluctuations than GDP. Similar indicators were taken for Russia: GDP in comparable prices in 2015 in Russian rubles and the RTS index average for the year. RTS index is the main indicator of the dynamics of market shares of leading companies in Russia. The above-mentioned indicators provide an opportunity to evaluate the health and dynamics of the economy in the country at the macroeconomic level.

Against the backdrop of the dynamics of macroeconomic indicators, we consider the system of research and development funding. For the US, we used the data provided by American Association for the Advancement of Science (AAAS) [13]. There are a number of federal R&D data series, including research budgets by agency, character and discipline. Most data come from annual AAAS R&D budget reports. Additionally we used data from the National Science Foundation’s National Center for Science and Engineering Statistics [14], and data provided by the White House Office of Management and Budget (OMB) [15]. Total R&D funding and funding by performer among which
federal, industry, university, federally funded R&D centers and nonprofits were taken in 2015 US dollars.

For Russia, we used data from Ministry of Education and Science of the Russian Federation summarized in the report that was prepared by the Republican Research Scientific-consulting Center of Expertise [16]. The available indicators for the study are total funding and funding by performer such as federal, industry, university and nonprofits. The data were brought to a comparable way by adjusting for the official value of inflation to the rubles 2015.

Further the university budgets were considered in more details. US data on funding sources for university R&D are collected by the National Science Foundation’s National Center for Science and Engineering Statistics [17]. According to this agency we can name such sources of R&D funding in universities as federal, state and local, universities, industry and other. The values were translated into the prices in 2015 US dollar using the inflation factor. In Russia according to the data from above-mentioned report universities receive funding from higher education institutions, federal, industry and foreign sources, off-budget funds, own funds and funds of private non-profit organizations. The values are also translated into the prices in 2015 Russian rubles using the inflation factor.

For comparison between US and Russia we used the Purchasing power parities (PPPs) index. Purchasing power parities are the rates of currency conversion that equalize the purchasing power of different currencies by eliminating the differences in price levels between countries and we used World Bank Data to normalize the data [18].

To study a data correlation we used simple Paerson correlation coefficient, which is a measure of linear correlation between two variables X and Y. [19] It can be described by simple formula

\[
r = \frac{\sum_{i=1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i-\bar{x})^2} \sqrt{\sum_{i=1}^{n}(y_i-\bar{y})^2}}.
\]

where n is the number of samples, \(x_i, y_i\) are the samples with respect to the index i, \(\bar{x}\) and \(\bar{y}\) are mean values of the sample. And the goal was to find a correlation between both overall university R&D expenditures and macroeconomic indicators as well as such correlation between macroeconomics indicators and various financial sources for R&D activities. This step is necessary to create accurate model, which will forecast optimal university R&D budget based on macroeconomics modeling.

3. Data analysis
First we will consider dynamics of total R&D spending’s, depending on the state of the economy in the country. As we have mentioned before GDP is used as a major indicator of the economic grows. As we can see from the Figures 1 and 2 total R&D spending almost tracking GDP in both Russia and the US (corresponding correlation coefficients are 0.9412 for the US and 0.9779 for Russia). If we consider in more detail each series of values, then it can be seen that the largest deviations between R&D funding and GDP correspond to the economy up and down turns. For instance, during the recession GDP had a local minimum, but at the same the total R&D spending’s have local maximum and vice versa. This can be seen in Figure 1 in 2001 and 2008, and in Figure 2 in 2003 and 2009, although to a lesser extent. It should be noted that although extremes are close to each other, they are not necessary in the exactly same year. Thus, we can conclude that the R&D spending’s are growing accordingly with the growth rate of the economy. The most notable deviation is most likely caused by the recessions of the 2000s and 2008.
Another important indicators of the health of economy are stock market indexes as The Dow Jones for the US RTS for Russia. Stock markets are much more volatile than GDP and thus could be much better macroeconomic indicators. In this scenario we still can see significant correlation between macroeconomic factors and R&D spending’s (Figures 3 and 4, corresponding correlation coefficients are 0.7691 for the US and 0.7423 for Russia).

Nevertheless we can see significant difference in dynamics of R&D funding between the US and Russia if we use PPP index in 2015 US dollars. As we can see from the Figure 5 the US R&D funding grew 1.66 times from 1998 to 2014 while Russian R&D spending is almost flat over the same period of time.

Now let’s look in more detail what are the reasons for fluctuations of R&D spending’s. First, we will compare the most active performer in R&D (the Industry) with Universities contribution.
As we can see from the Figure 6 for US, universities operate in opposition to the industry. The university does not always react quickly to changes and therefore the extremes do not coincide but the main trend can be seen very clear: universities compensate for the lack of industrial R&D spending’s during economy downturns. (Correlation coefficient 0.8571) In Russia the situation is completely different (Figure 7): universities behave the same way as the industry, strengthening the total fluctuations. (Correlation coefficient 0.94) Strong values of the correlation coefficient also support this theory.

As can be seen from the Figure 8 and 9 both Russian and US government are trying to mitigate negative impact of macroeconomic downturns on the university R&D activities. It worth to mention that both in the US as well as in Russia federal government funding remain main source of the university R&D budget. Such funding accounts to about 70% of total university R&D spending emphasizing huge role of the government in the modern science.
4. Conclusion and future work
As we have discussed in the previous chapters we can see a strong correlation between macroeconomic factors and university R&D spending. It worth to note that government and industry financing of R&D activities show opposite behaviors in respect to macroeconomic downturns. Therefore financial diversification could be a key to sustainable financial model of university budgeting. The logical next step would be study of other income sources for the universities such as tuition, endowment, technology transfer etc. and development of the optimal P&L model.

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