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## How to Measure the Local Economic Impact of Universities? Methodological Overview

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Today, the realization that certain economic units, such as universities or other large tertiary educational institutions have an impact on the economy of their region has gained prominence. There is a growing demand for precise studies on the economic impact of such entities, and the issue has attracted considerable attention in the scientific community. The examination of their economic impact is especially interesting when we compare regions with different levels of development, characterized by a successful international university. The different methods used in the literature render comparisons difficult; therefore, our focus is to recommend a method for investigating universities in different countries. In the absence of regional input-output matrices, a multiplier based approach is suggested for the first and second mission (education and research), while the application of a set of indicators is recommended for the third mission (knowledge transfer-related). There are several substantial problems in assessing the economic impact of universities. First, the definition of impact; second, measuring and estimating first-round expenditures and avoiding double-counting; third, estimating the model parameters (e.g. multipliers); fourth, the quantification of third mission activities. In this paper, we clarify theoretical definitions, resolve some contradictions, and consequently, recommend a feasible method considering the circumstances in Hungary.

## Introduction

In the modern globalized world, there is even stronger competition to obtain highly qualified workforce and create economically potent intellectual capital. The presence of a university *in a given territorial unit*<sup>1</sup> can create value in many ways: One type of value can be measured relatively easily, while for other types of values, we face several challenges. The first question we address is how universities affect the economy; then, we ask on what scale we can measure direct and indirect effects that would not be present if there was no university. The advantages of education primarily emerge in the long term, assuming graduates settle in the same place where they attended university. The results from research can also be sources of competitiveness, as long as they are utilized by the local economy. However, their impact is greatly influenced by the local context, hence some professional measurement methodologies may present general elements, but others may include context-specific features.

Our research question is as follows: *What methodological alternatives exist to measure the impact of universities on local economies? Which method is suitable for Hungary, and to what extent?*

The goals of this study are to review systematically such methodologies, to highlight the limits of the related literature, and to improve the measurement of the impact of universities.

This study is organized as follows: In the first chapter, we explore the literature on universities, mainly focusing on their advancement, their types, and their potential connections with the local industry and the government. In the second chapter, we address the diverse classifications of regional effects of universities, and we attempt to create a unified system of definitions. In the third chapter, we review both international and Hungarian empirical benchmarks, and we examine the methodologies used to quantify the economic impact of universities on local economy. The fourth chapter focuses on methodological suggestions, based on the limitations we identified in the previous chapters.

## Function and mission of universities

According to Wissema (2009), universities advance from one generation to the other. Nowadays, most higher education institutions have the characteristics of second generation universities, and many are transitioning into third generation universities. While the main purpose of second-generation universities is education and research, the commitment of third generation universities includes the third mission: creating and maintaining partnerships with economic actors outside the university, absorbing the existing knowledge. The enhancement of a region's competitiveness can be

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<sup>1</sup> Universities may create value all over the world, but we are only interested in local impacts. The definition of 'local' will be discussed later in this paper.

expected from third generation universities, in which the third mission has a central role, besides education and research (Lukovics 2010).

However, it is important to emphasize that today's higher education institutions are far more heterogeneous than the theoretical systematization in Wissema (2009) suggests. The order lines are not so sharp and obvious, but a number of third generation characteristics are present in today's higher education institutions.

Pawlowski (2009) writes about the 'fourth generation' universities, and examines their impact on local development. Second and third generation universities also influence their environment, but the purpose of fourth generation universities is to expedite significant changes in the environment, responding to the needs of a knowledge-based economy.

Lukovics and Zuti (2014) proposed a systematic classification of the four generations of universities (Table 1). The authors described the essence of the fourth generation universities as follows: both society and the economy are in a phase of globalization, and intensively use information technologies, where the strategic approach is a key feature. Besides discussing the three primary missions, the conscious and future-oriented development of the local economy is present as well.

Table 1

#### Characteristics of first, second, third and fourth generation universities

Aspect	First generation universities	Second generation universities	Third generation universities	Fourth generation universities
Goal	Education	Education and research	Education, research, and utilization of knowledge	Education, research, Research & Development & Innovation, utilization of knowledge, and proactive economic development
Role	Protection of truth	The cognition of nature	Creation of value added	Local economic accelerator, strategy determination
Output	Professionals	Professionals and scientists	Professionals, scientists, and entrepreneurs	Professionals, scientists, entrepreneurs, and competitive local economy
Language	Latin	National	English	Multilingual (national and English)
Management	Chancellor	Part-time scientists	Professional management	Professional management and local experts

*Source:* Based on Lukovics–Zuti 2013 and Lukovics–Zuti 2014.

Universities can be considered both catalyst and engine of the economy; they create strategic aims, operate in a multilingual environment, and require professional management and experts with experience in economic development.

To be able to measure the impact of universities on the economy, first, we need to define the types of activities we would like to measure. One possible way is addressing their missions, whose definitions and limits are surveyed in the following paragraphs.

Regarding the first mission of universities, Jaeger and Kopper (2013, pp. 3) provide a proper definition: *'the dissemination and diffusion of knowledge via tertiary education'*. These activities include BA/BSc, MA/MSc, PhD programs, contents of the program portfolio, and student mobility programs.

The second mission of universities covers all university-initiated and research-focused activities connected to basic research and researcher mobility programs. Jaeger and Kopper (2013, pp. 3.) define this as *'the generation and accumulation of knowledge'*; suggesting that even though knowledge is created within the second mission, it can spread to the first mission.

The third mission of universities includes *'all activities concerned with the generation, use, application and exploitation of knowledge and other university capabilities outside academic environments'* (Molas-Gallart and Castro-Martínez 2007, pp. 322.).

According to Bajmócy (2011, pp. 130), the third mission is *'the direct contact of universities with the economic and social actors. The fostering of the socially significant impact of university output'*. From these definitions, we can clarify that the third mission is closely connected to the business-related activities of universities.

The impact of the first and second mission can be measured with relative ease, as the necessary data can be obtained upon request. Despite this, in case of the second mission, we may face challenges, as the definition of the word 'research' is on the borderline between the second and third mission. Regarding the second mission, we refer to research activities that are initiated by the university and cannot be connected to an outside client. If research is initiated by an outside client but conducted within the university, it must be connected to the third mission. From this perspective, quantifying separately the economic impact of each mission is very challenging, as universities generally do not have information systems that could handle this categorization (Zuti–Lukovics 2014).

Another concern is that a number of studies identify the third mission with the third generation of universities, as if they were synonyms. Even though these two concepts are not the same, there is some overlap. Third generation universities offer more than simply adding the third mission to a second-generation university. Wissema (2009) provides a detailed comparison of first, second and third generation university characteristics.

The orientation of third generation universities is global, meaning that, if second generation universities are primarily active on local markets, third generation

universities are characterized by an international presence. These institutions compete to obtain the best teachers, researchers, and students. This is a pillar of their development; however, it is not mandatory for second-generation universities that are only expanding towards third mission activities.

International second generation universities and third generation universities can be considered global institutions. One of their important characteristics is that the common language of all their lectures is English. The third mission of universities can be hardly attached to this third generation characteristic, as this mainly affects the education pillar, while they do not affect the execution of third mission activities, such as local, social, and economic actions.

In summary, despite the potential for third mission activities in a certain university, that institution cannot be considered a third generation university in all cases. A third generation university offers much more than the expansion of education and research with the third mission. The presence of third mission activities is necessary for a third-generation university; however, it is not a sufficient condition.

### **Net and gross; direct, indirect, induced, and catalytic effects**

Johnson (1994) argues for the division of local and non-local impacts (it is better a choice on which territorial level we identify impacts (see Chapter 4 for details), and direct and indirect impacts; further, he refers to various negative impacts of universities, and the necessity of a net approach. For instance, individuals could spend more if the government did not tax them for the expenditure of universities. The double net question arises in the form of ‘Where live people taxed for the expenditures of the university?’ The question of gross or net impacts can be analysed from several perspectives. Generally, a gross impact is easier to define and compute, as calculation of net impact requires answering questions such as follows:

- In absence of university, where would its staff work, and in which occupation?
- In absence of university, where would students pursue their studies (if at all)?
- In absence of university, how large the level of knowledge in the local economy would be? To what extent is it different from the current situation?
- In absence of university, would house prices be lower and by how much?

Further, these questions are linked to the territorial level we chose to focus on. The impact we are interested in can be observed when new universities are investigated: most academic staff is from other (national) universities, while non-academic staff can be hired locally. Local house prices change slowly, and only complex comparative analysis, such as panel regression analysis, can detect the impact of universities (Varga 2001).

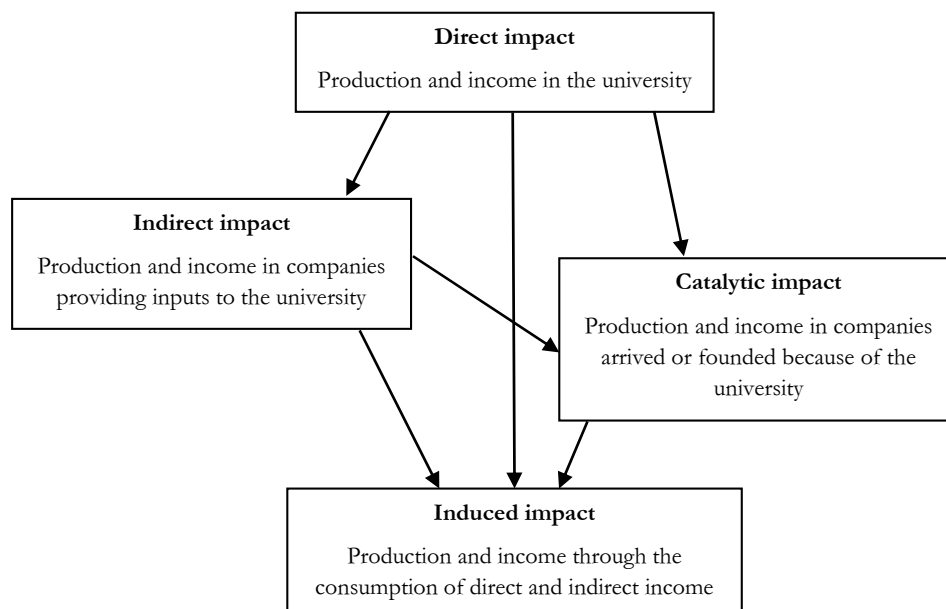
The classification of the type of economic impacts depends on how the impact is related to the activity of universities, and it varies significantly in the literature. We can find twofold, threefold, and fourfold classifications, with contradictory names

and contents. Our aim is to show the absence of a widely accepted classification in the studies focusing on the economic impact of universities.

A common feature is the separation of direct and indirect impacts, where direct impacts include the expenditure on staff and students. In larger classifications, we find induced impacts (Klophaus 2008), and catalytic impacts (Lukovics–Dusek (2014a) and Lukovics–Dusek (2014b) for university-related research; Dusek–Lukovics (2011) for business services). Figure 1 shows the modified version of these classifications for universities.

Figure 1

### Direct, indirect, induced, and catalytic effects



*Source:* own construction.

In this figure:

- Direct impact: output, income and workplaces created on-site, owing to the investments and operations of the university;
- Indirect impact: income and employment generated in the companies providing inputs for the university;
- Induced impact: income and employment subject to the multiplier effect of spending such incomes;
- Catalytic impact: productivity growth achieved through the operation of the university, income, and employment created through the companies settling because of the university, and spending of the visitors arriving in the area because of the university.

The contradictory and, sometimes, misleading mélange of the existing classifications of the economic impact of universities is shown in Table 2, by juxtaposing the classification proposed by Garrido-Yserte and Gallo-Rivera (2010) and the alternative proposed by the French school, as in Gagnol-Héraud (2001) and Baslé-Le Boulch (1999). The former is quoted more than 70 times in similar studies, while the French literature uses the latter as standard.

Table 2

### Regional/local economic impacts of universities

Impact	Meaning	
	<i>Garrido-Yserte-Gallo-Rivera</i>	<i>Gagnol-Héraud</i>
Direct	related to the local expenditures of the university, staff and students of the university	consumption of the university, staff and students of the university
Indirect	multiplied income (each euro spent in the location by the university community (university, staff and students) generates indirect transactions in the location linked to businesses that do not have a direct relation to the university	impact through education of the work-power, development of synergies of R&D with regional enterprises
Induced	the expenditures of the people that visit the university, the effects upon financial institutions, the effects upon property value, and the impact upon location of new companies and so on	multiplier effect

*Source:* Garrido-Yserte and Gallo-Rivera (2010) and the Gagnol-Héraud (2001).

In this confusion, we chose to use induced impact for all the effects generated by the multiplication process. In the Lukovics-Dusek classification, the separation of direct and indirect impacts is artificial: we separate personal expenses from the purchase of assets and from investments. The rationale for this can be the local analysis: on-site created income is always local, even though not necessary locally spent, like in the case of professors who spend only 4-8 hours a week in the university town. Adding the special situation of students, we consider *primary impact* the sum of the local parts of direct and indirect impacts in Figure 1. The *catalytic impact* of Lukovics-Dusek, the indirect impact of Gagnol-Héraud and the induced impact of Garrido-Yserte and Gallo-Rivera have almost the same content. While it is not widespread in the literature, the catalytic expression better describes the content of this category.



## Benchmark examples

The analysis of the eight benchmark examples show that various methodologies are available for measuring the economic impact of universities. In other words, we cannot talk about a unified methodology. We compare the eight examples considering eight aspects, demonstrating that the methodologies are quite different, despite the presence of some common features.

Difficulties emerged because the available data were quite different, in many ways, such as their reference period. To be able to compare the different methods, we created two specific indicators, using data regarding the total impact, total number of students and regional GDP, expressed in USD. These results must be interpreted carefully, due to the previously mentioned measurement limits (Molnár–Zuti 2015).

The eight universities were: Izmir University of Economics (Turkey), Pennsylvania State University (USA), University of Alcalá (Spain), University of Portsmouth (United Kingdom), Valencia Public Universities (Spain), South Dakota Public University (USA), Xavier University (USA) and the Kodolányi János University of Applied Sciences (Hungary). The reference periods vary significantly: we can find studies focusing on the period 1994–1995, while others focus on 2009, or 2012. We aimed at analysing examples on a global scale.

The universities were compared based on their sample size, source of data, applied methodology, applied multiplier, impact per student, rate of university impact regarding regional GDP.

All studies used a survey to obtain student related information, especially on their consumption habits. We were unable to acquire data for three institutions, while in all other cases the number of students participating in the questionnaire is between 125 and 2038. The Kodolányi János University of Applied Sciences had a sample of 125 (Kotosz 2013a), the Izmir University of Economics had a sample of 200 students, while the Valencia Public University and the South Dakota Public University interviewed 2000 and 2038 students, respectively. For most examined universities, all data were part of university databases, university documents, and financial statements, besides the questionnaires. The basis for the quantification of the impact was different, but the most commonly used was the input-output model. The ACE model, the Ryan ‘shortcut’ method, the REMI model, the RIMS-II model and the models of Huggins and Cooke (1997), Elliot et al. (1988) and Dusek (2003) were also used. Next, we provide a brief introduction of these models.

Garrido-Yserte and Gallo-Rivera (2010) divided the methodologies that are capable of measuring economic impacts into 2 groups: direct and indirect methods. The ACE (American Council of Education Method) is considered a direct estimation method. With this method, the impact is estimated by detailed primary information, gathered from local agents. The ACE method (also known as Caffrey-Isaacs method) was created in the 1970s, with the purpose of enabling the measurement of local

economic impacts. The authors differentiate three types of economic impacts: impact on local enterprises, impact on local individuals, and impact on local public administration.

The Ryan ‘shortcut’ model uses secondary, indirect information for the estimation, and it is an adaptation of the ACE model by Ryan–Malgieri (1992). Ryan simplified the model of Caffrey and Isaacs, using local, regional, and national sources instead of questionnaires (Garrido-Yserte and Gallo-Rivera 2010).

The REMI method is a dynamic input-output model to estimate the forecasted values of the economy, using a mix of times series analysis and general equilibrium modelling. For the South Dakota Public University, this tool was used to analyse the current state of the economy, and assess the economic structure in the absence of the university. The difference between these two values measures the impact generated by the institution (Allgurn 2010).

The RIMS-II model is a regional input-output model. With this method, we can quantify both direct and indirect effects. In order to progress with the calculations, the authors needed to gather data from several areas. They needed data regarding the students, their spending habits, where they lived before they went to university and which higher education institutions they would have chosen, if the analysed university did not exist. In addition, they also needed data regarding the budget of the institution, including both the income and the expenditure side. In case of some higher education institutions, the larger income comes from tuition fees, events, industrial contracts, and state or local government benefits. The authors highlight the importance of the multiplier effect, which depends on the territorial scope and the rate of local consumption. Based on their experience, indirect effects can increase the impact on local economy by 50 to 100% (Blackwell et al. 2002).

The model of Huggins and Cooke (1997) analysed the connections between the expenditure structure of the university and its region. This study used a sophisticated version of the models previously applied by Bleaney et al. (1992) and Armstrong et al. (1994).

The applied methodology of D’Allegro and Paff (2010) is based on the model of Elliot et al. (1988), which is a modified version of the model of Caffrey and Isaacs (1971), differentiating the impact of local and non-local students. They estimate the economic impact through three steps: first, they calculate the direct spending; second, they estimate the indirect and induced effects with a multiplier, and finally, they sum the direct and indirect effects. This final number represents the estimated economic impact of the university.

Most calculations use Keynesian-type of multipliers, including output and employment multipliers. The multipliers range from 1.4 to 2.39 in different studies. In some cases, the multiplier is not a number, but an interval (e.g. 1.24–1.73).

One of the indicators used in most studies is the impact per student. The results differ significantly, and they need to be handled carefully because of the different

reference periods. The impact per student in case of universities in the United States was generally higher (Xavier University, 10,153 USD; Pennsylvania State University, 23,695 USD; South Dakota Public University, 59,800 USD) compared with Western European universities (University of Portsmouth, 3,440 USD; University of Alcalá, 15,574 USD; Valencia Public University, 29,961 USD), while the lowest impact was reported in the Eastern regions (Kodolányi János University of Applied Sciences, 4,453 USD; Izmir University of Economics, 7,096 USD).

The institutional share of regional GDP reveals the significance of the university impact in the region. The Kodolányi János University of Applied Sciences has a value of 0.1%, and the University of Alcalá has a value of 0.12%. The Valencia Public University has the highest share (3%), while the University of Portsmouth has the lowest (0.02%), with the Izmir University of Economics (0.03%). Based on these results, there are significant differences in the impact of universities, but this measure is very sensitive to the territorial scope.

### Measuring limits in Hungary

Higher education in Hungary went through significant changes in the 1990s, which had an overall impact on the entire Hungarian society. *Since the regime change, the number of students has risen significantly*, and has nearly quadrupled. This tendency was noticeable both in the OECD and in the EU countries. However, in Hungary, *after the 2005/2006 academic year, the number of students began to decrease*. In 2008 data, Hungary lags behind all the examined countries in number of state-funded students per one million inhabitants. While this number corresponded to 21,324 in Hungary, we observe 24,639 students in Germany, 28,974 in Austria and 38,409 in Norway (Harsányi–Vincze 2012).

In recent years, the decrease in headcount, due to the contraction in the number of births, has affected the higher education sector: while in 2010 the number of 18-year-old was around 126,000, according to Hungarian Central Statistical Office data, in 2015 this number dropped to 105,000, decreasing by 20% in a few years. This trend has substantially decreased and in subsequent years will further decrease the demand for Hungarian higher education, at least in this age group.

When we mention local or regional impacts, a more precise definition of the territorial scope is necessary. In most cases, this choice has serious consequences, not only on the possible set of applicable methods, but also on the results. The literature shows many examples of Hungarian (Mezei 2006, Kollár 2011, Nemes Nagy 2009, Székely 2013) and international (Armstrong–Taylor 2000, Arthur 1990, Blair–Caroll 2009, Bryden 2010) studies where this question is analysed. Sometimes, regional areas are considered (Pálné Kovács 2003), or functional urban areas (Lengyel–Szakálné Kanó 2012, Lengyel–Rechnitzer 2004, Bajmócy 2011, Székely 2011). The territorial levels used in impact studies are of the sub-local, local, regional, and national levels.

For universities, the sub-local level is generally not meaningful, as universities are often multi-campus institutions, jeopardized in their hometowns. The local level is useful for single-town universities, or only for local impacts, for example, when a mayor commissions a study (Kotosz 2013b). Generally, choosing the functional urban area is theoretically more efficient; however, when the key figures are based on sample surveys, this delimitation causes problems in gathering correct answers, as people generally do not know the boundaries of their functional urban area. Administrative regions (at NUTS3 or NUTS2 level) are often used for their simplicity and availability of the necessary statistical data and information. In the United States, state level studies are common. The state level allows the adaptation of input-output based models, as the essential matrices are available at this level. Up-to-date, regional (NUTS2, but preferably NUTS3 level) sectorial input-output matrices (West-Jackson 1998) in Europe are not available, with the exception of large, regional, econometric models (Varga et al. 2014).

In Hungary, both local and regional level impact studies are feasible, but in absence of a widespread secondary background dataset, a mixture of ACE-type (direct) model and local Keynesian multiplier estimation is recommended (Kotosz 2014). These types of models, with adequately estimated flows and parameters, may achieve accurate results on short-term impacts: direct, indirect, and most induced impacts. The main shortcoming of this model type is the impossibility of estimating a significant part of the catalytic impacts, externalities, worker productivity changes, and local welfare effects of R&D activities (Garrido-Iserte-Gallo-Rivera 2010).

While a partial set of third mission activities are included in the above recommended estimation method, these activities are particularly interesting from a methodological point of view.

Many universities try to deal with potential methods to measure and quantify third mission activities. Laredo (2007), Molas-Gallart et al. (2002), Polt et al. (2001) attempt to quantify the impact of the third mission. Laredo (2007) introduces a study from 2004–2006 that tries to create a framework for research activities, differentiating each of the eight dimensions of the third mission with a specific indicator. Molas-Gallart et al. (2002) categorized third mission activities into twelve groups, based on the activities of universities. They created a list of indicators and highlighted the need for better measures. Polt et al. (2001) also created a set of indicators for nine target areas. However, Lengyel (2009) argues for the primary use of cluster mapping.

Assigning specific and quantifiable indicators to the dimensions of third mission activities is challenging. These indicators have a theoretical use, and their practical applicability is questionable. In addition, some indicators measure in currency, while some others rely on different measurement units: a neat comparison is impossible, and we are not able to create a final and transparent measure (Molnár 2015).

In connection with the measurements of the University of Szeged, the VIR (EIS, Executive Information System) have collected suitable data since 2011. The third

mission is present in five specific goals and nine indicators (IFT, 2012). Most of these indicators can be related to both the second and third mission, not allowing the authors to disentangle the impact of third mission activities (Molnár 2015).

Table 3

### Suggested third generation indicators

Target area / Activity	Suggested indicators
Technology transfer	Income realized by the university from the utilization of intellectual capital
	Number of joint research contracts with innovative companies
	Number/regional rate of innovation-oriented companies created at the university
Counselling	Number of economic development strategies created
	Number of enterprises resorting to counselling services
Spin-offs and start-ups	Percentage of university spin-off/start-up companies in the agglomeration
	The number of spin-offs/start-ups per 1000 university staff
	The number of spin-offs/start-ups created in the last 5 years
	The revenue of spin-offs/start-ups
	The number of employees of the spin-offs/start-ups in the last 5 years
	The number of enterprises created by students or graduates of the last 5 years
University – Industry – Government relations	Number of industrial R+D connections
	Number of R+D actors
	Number of joint projects carried on by university and industry in the last 5 years
	Percentage of innovative companies (as a share of all companies) cooperating with the university
	Percentage of industry-financed university R+D activities
Commercialization of academic facilities	Revenue from rent (e. g. laboratories)
	Number of public events organized by the university
Enhancement of the social engagement of the university	Number of cultural events
	Number of internal visitors
	Number of external visitors
	Number of press releases in a given time period (university staff, researchers in regional and national media)
	Number of university events promoting social responsibility (e. g. green programs)
	Number of dissemination programs (science to general public)

Source: Based on Molnár (2015, pp. 41).

Molnár (2015) made an effort to systematize a possible third mission indicator framework, based on the experiences of the University of Szeged and previous theories exposed in the international literature. The author grouped the third mission activities of universities into six categories, based on domestic and international benchmarks: technology transfer, counselling, spin-offs and start-ups, university-industry-government relations, commercialism and utilization of university property, and the enhancement of the social engagement of the university. All categories have a number of indicators, some of which are creations of the author, while others have been already used in the international literature. Table 3 summarizes such indicators.

It is important to emphasize that only some indicators provide a currency measure, while others represent a simple number, without a definite unit of measurement. Therefore, until now, the creation of a uniform measure has not been successful. (Molnár 2015). Repeated measurements would allow us to follow potential changes of intensity in third mission activities.

In summary, a number of complex methodological opportunities are available to measure the impact of universities and third mission activities. In addition, we can create a systematized collection of indicators that can help us in such measurements (Molnár 2015). However, even though the commonly used methods are capable of measuring third mission activities in the short term, generally including them in the direct or indirect impacts, the measurement of the long-term impacts, such as the catalytic impact, remains challenging.

## Conclusion

In our paper, we presented an overview of the methodological possibilities of measurement of the local economic impact of higher education institutions. To achieve this goal, first, we mapped the functions of universities, to see which activities should be considered in the calculations. The roles of universities are changing and broadening; new functions and missions have increasing impacts that can be captured only in the long run. Short-run impacts are often already included in computations made for first and second missions, as expenditures cannot be separated. In the second part of this study, we showed that the estimation of gross impacts is more straightforward than net ones, as the latter needs more sophisticated primary data. We also addressed some contradictions in the definition of direct, indirect, induced, and catalytic impacts, and offered a framework for further analysis. In the third part of the analysis, a series of worldwide benchmark examples has been compared. They offer different methodologies, using primary and secondary data, with different results regarding the relative impact of universities, per student or via GDP that are partly explained by the diverse methodologies. In the last chapter, we analysed the situation of Hungarian higher education to find the appropriate measurement tools and a set of indicators to catch the intensity of third mission activities in the country.

Finally, as we discussed in the paper, in small, Eastern European countries we recommend applying a multiplier and primary data based models to estimate short-run gross primary and induced impacts on local and regional level. A multi-country comparative study with these recommendations would be an efficient tool to explore the background differences in the impact of universities. However, the difficulties in disclosing long run and catalytic impacts are not yet resolved, and only partial results (multidimensional indicator systems) and non-university targeted solutions (general regional economic simulation models) are available.

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