The economic impact assessment of entrepreneurial ideas in the Smart Specialization Policy
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Illustrative policy simulations in Baranya County, Hungary

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1. Introduction

As a continuation of the Lisbon Strategy, the European Union launched a new development strategy between 2014 and 2020, called Europe 2020: A strategy for smart, sustainable and inclusive growth. The program mainly concentrates on the EU's new innovation policy: Smart Specialization Strategy (S3), which, breaking with the traditions of place-neutral policies, investigates regional and national development opportunities based primarily on local resources. An important element of this novel approach is that it identifies future regional development alternatives partially as the result of a bottom-up process, which means continuous consultation and evaluation involving local actors. By intervening in market processes, the policy encourages local actors to identify new market niches which can guarantee long-term regional development and regional structural transformation. However, due to the scarcity of available resources, it is necessary to allocate funds to the most promising areas, thus ideas must be filtered and not all of them can be supported (Foray, 2019). This selection mechanism is divided into two phases. In the first phase, broad promising specialization areas are selected in which a region might have competitive advantage in a top-down manner. This step is the so-called prioritization. In the second step, innovative entrepreneurial ideas are gathered, assessed and selected within those specialization areas which is called the selection of transformative activities (Foray et al., 2021).

In both steps the selection however must be determined based on how the alternative ideas and specialization areas serve the purpose of intelligent specialization (e.g. economic growth). Thus, this also requires the use of methodological tools, which makes it possible to calculate the extent each idea, specialization area contribute to general goals and to choose between a significant number of alternatives. Methods supporting prioritization can examine various aspects of innovations and entrepreneurial ideas, which can play a role in strengthening the competitiveness of the region. Since Smart Specialization fundamentally aims regional structural change, renewal and growth, it is necessary to take into account the expected economic effects of each alternative during the selection process (Foray, 2015). Without accounting for the expected economic effects of each alternative, we cannot get a real picture of the expected success of the specialization strategies.

However, new entrepreneurial ideas considered during the selection mechanism can be connected to different sectors on several threads, either locally or in other regions. On the one hand, a new activity can provide inputs to other sectors, generate input demand for the products of other sectors, produce for the final consumption of households, and increase employment, government tax revenues, etc. On the other hand, these effects do not stop at the directly affected actors, they will also change the behavior of other actors. They will adapt to the changed market conditions, by which the whole system will adapt to the introduction of novel activity. However, to take into account these direct, indirect and induced effects numerically, it is essential to account for the intersectoral relations. Furthermore, since the interventions affect a given location in space, the role of the spatial aspect must also be taken into account as well. Depending on whether a new activity appears in a developed or a lagging region, completely different local effects may arise, and, in addition, spillover effects may arise (e.g. through interregional trade, factor movements) that influence the development of other regions as well. Spatial general equilibrium models are typically used to estimate such direct and indirect spatial economic effects (Varga et al., 2020c, Lecce et al., 2018).

In Cohesion Policy, the use of economic impact models is widespread in the ex-ante and ex-post evaluation of the expected effects of interventions (Varga, 2017). The use of such rich economic estimations can significantly influence the preparation of policies for the following periods. Some of these models only prepare aggregate calculations, however, more and more methodological approaches have been created that attribute a significant role to spatiality, such as the MASST (Capello, 2007), the GMR (Varga et al., 2020a, Varga et al. al. 2020b) and the Rhomolo (Brandsma – Kancs, 2015) models. However, due to the methodological difficulties of the impact assessment of the smart specialization strategy, until recently few examples could be found that would have quantified the economic effects of S3 (e.g. Varga et al., 2020a; Barbero et al., 2020), and to the best of the authors' knowledge, only one of them supported the first step of the selection procedure, prioritization in the context of economic impact analysis: Varga et al. (2020b).

The aim of this study is to present a method, based on the SCGE block of the GMR-Hungary model, which is suitable for contributing to the second step of the selection process: selecting transformative activities. In doing so, the expected economic effects of selecting alternative transformative activities can be calculated by combined process of 1) surveying individual alternative entrepreneurial ideas and 2) integrating the data collected into the impact assessment model. The estimated economic impacts then can be taken into account as one of the decision factors in the selection process. This way economic impact assessment can contribute to the strengthening of the weak empirical basis of S3.

Since CGE models primarily consider individual activities as sectors, the surveyed entrepreneurial ideas/technologies can also be integrated into the model as new industries[1]. The study illustrates the methodological steps of the integration of a new sector alongside the existing ones into the SCGE block of the GMR-Hungary multi-sector multi-regional impact assessment model.

The structure of the study is as follows. The second section briefly describes how spatial computable general equilibrium models can contribute to the impact assessment of S3. The third section gives a short description of the most important characteristic of the GMR-Hungary impact model. The fourth section describes the way new activities can be integrated into the modeling structure. The fifth section introduce the case studies selected for the impact assessment approach introduced in the paper which results are discussed in the sixth section. The study is closed by a summary.

2. A potential method to assess the impact of the selection of transformative activities: a general equilibrium approach

The economy is an extremely complex system, in which economic effects are determined by the optimizing behavior of many actors and their interactions. Thus, it is difficult to follow the chain of such interactions and their net economic outcome without a suitable methodological framework. Since the technology of each sector (specific labor, capital, material demand, etc.) can be very different, and since each region can be characterized by different characteristics and industrial structure, changes in the economic structure of a region fundamentally affect local and national economic processes (e.g. GDP, employment). By quantifying these effects, impact assessment models can be a powerful tool supporting policy design since they can provide useful and detailed information regarding the spatial economic impacts of various economic policy interventions, even in the case of the selection process of S3.

[1] Practically entrepreneurial ideas can be introduced in already existing, traditional industries as well as a form of modernization. In this case, the functions responsible for the behavior of the host industry must be recalibrated based on survey data.

Computable general equilibrium models can be used to assess these processes. These models are based on microeconomic theory, they display a sufficiently detailed sectoral breakdown and they *"describe the motivations and the behavior of all producers and consumers in an economy and the linkages among them"* (Burfisher, 2011. p. 1). The actors in the models are rational and follow optimizing behavior that can be described with traditional microeconomic theories and tools: companies maximize profits / minimize costs, and households maximize their welfare. Similar to input-output models, they are able to take into account interindustry connections and the different preferences of consumers, however, the behavior of these actors is described by non-linear equations (production, utility function). As a result, actors of the national economy are depicted in a less rigid system, which flexibly react to price changes according to the behavior described by nonlinear equations (Burfisher, 2011). Natural quantities, prices and the related income variables are determined simultaneously through the interaction between these actors. As a result of the optimizing behavior of the actors, the economic system continuously strives to improve efficiency.

With the rise of the new economic geography (Krugman, 1991), there was an increasing demand for the development of *spatial computable general equilibrium models* (SCGE), which expand the traditional CGE models with the spatial dimension of the economy. The role of space must be an endogenous part of these models since the spatial structure affects economic activities through a complex system of interactions, which also shape the spatial structure through feedback mechanisms (e.g. interregional trade, spillover effects, transport costs, agglomeration externalities, mobility of production factors). The spatial unit of these models is the region, thus these spatial models are single or multi-regional CGE models, in which the individual territorial units are connected through interregional trade that is influenced by interregional transport costs and through interregional factor flows (migration) that are shaped by territorial differences and agglomeration externalities.

Such models require a comprehensive database that describes both the behavior of economic actors and their interactions which usually can be found in *input-output tables* (IOT). An IOT is a table that consistently describes the production relationships between the sectors of the national economy, as well as the structural relationship between production and final use (EC, 2008). As a result, this table can describe the relationships between the various actors of the economy in a given year, and for this reason general equilibrium models are usually based on IOTs or SAMs[2], and their calibration is carried out on the basis of these tables (Hosoe et al., 2010).

The spatial extensions of these CGE models are based on regional-level data of sectoral interrelations, which requires *regional-level input-output tables* (Lecca et al., 2018). In addition to the regional IOT, accounting for trade linkages between regions is also important in multi-regional studies. However, this territorial data is usually not available in statistical databases, because the compilation of these tables would require the large amount of time and resources, thus the statistical offices do not publish such regional tables. With the rise of regional sciences, there was an increasing demand for the estimation of these regional tables. Thus, a new methodological approach, regionalization raised, which includes the methods for estimating regional input-output tables and their empirical testing (Szabó, 2015). However, these methods are not without precedent, as a similar problem also arises in the case when it is necessary to estimate and update national IOTs for the years between the publication of two IOTs (a

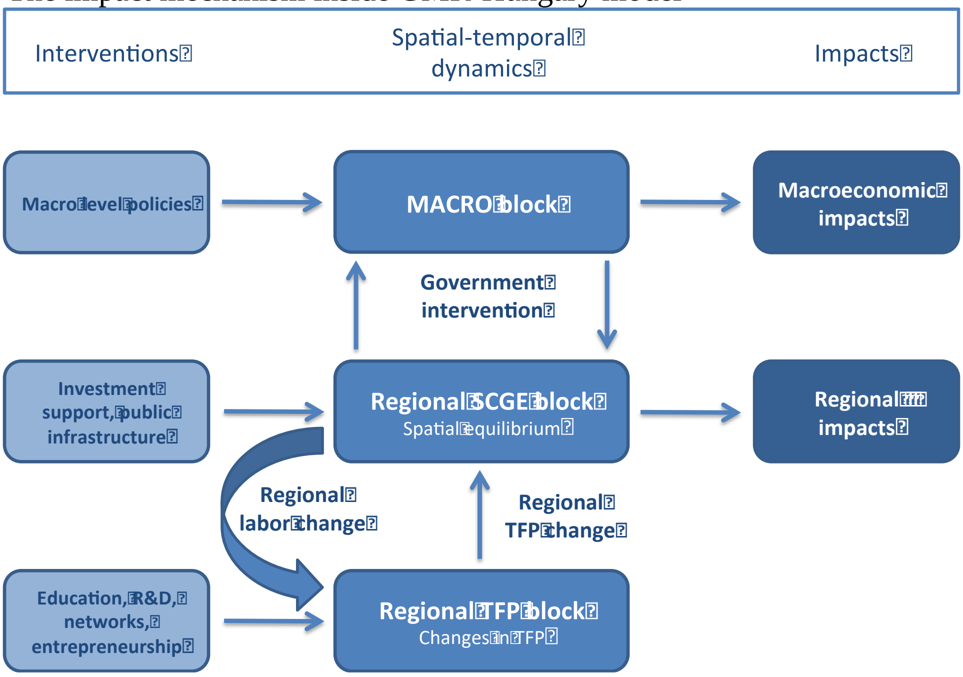
[2] Social accounting matrix

summary of these methods can be found, for example, in the work of Koppány and Révész, 2018).

3. The GMR-Hungary impact assessment model

GMR (Geographic, Macro and Regional) policy impact models are designed to provide support in development policy decisions by simulating the effects (ex-ante and ex-post) of different economic policy interventions. Economic impacts of policy instruments such as R&D support, entrepreneurship, human capital development, innovation-related network policies, and traditional economic interventions (e.g. investment support) are usually estimated by the approach. In the impact analysis practice most of the models estimate the national level effects of interventions, the novelty of GMR is that it takes into account geographic effects (agglomeration externalities, interregional trade, migration) and simulates the regional and national economic impacts as well.

Figure 1. The impact mechanism inside GMR-Hungary model



GMR models consist of three main model blocks, each of them is rooted in different theoretical approaches. First, the productivity (TFP) block, which accounts for the dynamics of regional productivity changes, is built upon the methods developed by the literature of the geography of innovation (Anselin et al., 1997; Varga, 2000). Second, the spatial computable general equilibrium (SCGE) block accounts for the spatial allocation of economic activities, the migration of factors of production, and the dynamic effects of agglomeration externalities. This block is rooted theoretically in the new economic geography (Krugman, 1991; Fujita, Krugman, & Venables, 1999). Third, the macro block, which is responsible for calculating macro-level effects and dynamics, is based on macroeconomic theories. A detailed description of the modeling framework can be found in Varga (2017) and Varga et al. (2020a). In this paper, we use the latest version of the GMR models for Hungary, which is a multisector-multiregion model (Varga et al. 2020b). For previous model specifications and their applications see Schalk and Varga (2004) and Varga (2007) (GMR-Hungary), Varga and Baypinar (2016) (GMR-Turkey), Varga (2017) (GMR-Europe).

The outline of the impact mechanism of the model and the way different blocks are interlinked are illustrated in Figure 1. Some of the policy interventions enter the TFP block and their effects are primarily directly present in that block. The productivity effects of these interventions are then transferred to the SCGE block, which simulates the expected effects of these changes on its spatial economic variables considering inter-industry and interregional linkages as well. Investment support and infrastructure development are taken into account directly within the SCGE block. Changes in economic variables influence macroeconomic processes which generate feedbacks to the SCGE block and productivity levels as well (through changes in regional employment) generating another feedback between the TFP and SCGE block. As a result of these feedback mechanisms, the model can track the dynamic effects of different policy interventions at the national, regional, and industrial levels as well.

4. Introducing a new activity in the GMR model

The introduction of new technologies entails a unique procedure for each CGE model and technology, as both models and technologies can show large differences. The integration of new technologies is not unprecedented in the literature (e.g. Varga et al., 2013; Phimister - Roberts, 2017; Berg - Eskildsen, 2019), and there are also works on the disaggregation of existing sectors (Truong and Hamasaki, 2018). However, due to the above mentioned unique characteristics, these works can only serve as a reference point for conducting own research. In most cases, the technology of new activities is filled up with micro-level data, which are then incorporated into the models by calibrating the parameters of the corresponding production functions.[3]

However, the estimated regional IOT does not contain information about how a potential new entrepreneurial idea is interlinked with various actors in the region (or in other regions). Thus, the model based on the IOT alone cannot account for the effects of this new idea. However, by assessing the transformative activities through micro-level data collection and inserting that data into the IOT structure a new row and column is created in the interregional IOT, which describes the structure and volume of sales and input use of the new activity. However, this extended IOT is no longer consistent in terms of the total expenditure and total revenue of each actors (column and row sums of the table), due to the sales and purchases of the new sector. This inconsistency is a problem because CGE models consider the state described by the IOT as the initial equilibrium situation. However, a CGE model cannot be calibrated based on the extended IOT, because it contains imbalances. We will remedy this problem in two steps. First, we calibrate the new SCGE model without sectors based on the original IOT and assume that these results describe the behavior of the economic actors well. Second, the equations specific to the new sector are estimated based on the expanded IOT. Also, the equations that model the relations between sectors (e.g. I-O relations, the mobility of production resources between sectors) are recalibrated based on the data of the new extended IOT. The remaining inconsistencies are finally eliminated by the SCGE model during the simulation, which calculates how the new activity affects the other actors of the economy and vice versa. The integration of the new sector is divided into two steps. In the first step (in the "period t"), it is necessary to acquire the investment goods that are necessary for the operation of the new sector from the period t+1. These purchases can be interpreted as a traditional investment shock in the

[3] In the majority of CGE models, it is assumed that the future size of the new activity can be deterministically determined in advance by the authors, so it is not necessary to model the change in the size of the sector, however, in reality the future size of the new sector is not known, its determination comes as a result of the mutual influence of emerging economic processes created, as a result some works have already attempted to take into account the uncertainty regarding the size of the new sector (e.g. Phimister – Roberts, 2017).

model. In the second step, the integration of the new activity is taken care of. At that stage, the equations describing the new activity are calibrated and filled with variables and induce changes in the economic processes during the iterative calculations of the model.

In this section we describe the way we incorporated a new activity in the SCGE block of the GMR Hungary model. The first part of the section is responsible for introducing the approach followed in the case of the initial investment shock that creates the capital stock necessary for the new activity. In the second part, the entrepreneurial idea itself is incorporated into the modelling structure as a new industry. In this section, we focus only the necessary changes made to the model[4] and we do not intend to give a full, comprehensive description of the model itself that is beyond the scope of this study. Detailed description can be found in Varga et al. (2020c).

4.1. Introducing the investment shock

Initial investment is treated as an exogenous investment shock in the model. To account for the potential effects of this investment shock financed by foreign sources we made a number of changes to the model structure which are described in the followings.

First, it is necessary to decide on the *source of financing* of the investments. Since Smart Specialization investments are typically financed by the European Union, in the followings we assumed that the investments required for the new sector in the model are financed by foreign sources. In the model, this means that the financial support of the investments appears in the balance of payments as an inflow of money.
Second, the incoming funds must be allocated to the appropriate *region's investment* demand, where it will be spent and will finance a part of regional aggregated investment demand and increase regional capital accumulation. This is treated at the top level of the embedded investment demand function.
Third, within aggregated investment demand a part of the investment shock is allocated to *domestic and imported products*. At the second level of the embedded investment demand function these direct allocations can be done.
Fourth, at the bottom level, based on the survey data, domestic investment demand is further disaggregated into *industry-specific investment* demand.
Finally, if information is available on the expected location (region) of satisfying sector investment demand, domestic industry-specific investment shocks can also be interpreted in relation to the source regions, that is, it can be specified from which regions these demand quantities are met. Thus, the *interregional* Armington *demand* function should be modified accordingly.

4.2. Introducing the new activity

Once the initial investment created the necessary production capacities (capital stock), the new activity can be integrated into the model. This process involves the initialization of all the variables of the new activity and the calibration of the functions describing its behavior. In addition, all the functions that are responsible for the connections between the new activity and the rest of the economy must be recalibrated (e.g. interregional trade, interindustry demand, factor supplies, etc.). In what follows, we describe the calibration and the modification made to the behavioral functions. These changes are discussed in three groups. First, the calibration of

[4] This section mainly concentrates on a verbal description of the changes made to the model structure. A formal description of these changes and a list of parameters and variables can be found in Appendix A.1. and A.2.

the production of the new sector, then the demand for the new products, and finally, the industry-specific supply functions of the necessary primary inputs are described.

The calibration of the production function of the new activity

The new sector is modeled by an embedded production function similar to the other sectors (see: Szabó, 2020). This production function then needs to be filled up with the initial data and calibrated based on the extended interregional IOT which is partially based on the original estimated IOT and the survey data regarding the entrepreneurial idea. In addition to the production function interregional trade and industry-level factor supply equations are also updated and recalibrated in a similar way.[5]

Recalibrating the industry-specific supply functions of primary resources

Due to the assumed increase in capital created by the new sector, the stock of primary resources owned by households increases, and thus also the income of households, which must be taken into account in the income equation. Employment is endogenous in the model however the capital stock is treated exogenously which in each period changes as a result of capital accumulation and partially as a result of the shock (investment shock)

Since households decide to which industry (and to which regions) they allocate their primary resources, it is necessary to recalibrate the CET[6] functions that control this allocation. Otherwise, input demand of the new industry would not be possible to be satisfied by industry-specific supply, thus the model would not be able to find a solution.

The calibration of final and intermediate demand

Finally, there may be a demand for the new product from any of the final users, which can be taken into account in two ways: 1) we assume a fixed demand, because, for example, based on the preliminary survey data, it is expected that only a certain amount can be sold on the market. Then the final demand can be introduced into the model as an additional foreign or domestic demand to the investment shock. 2) the demand for the new product is an integral part (a variable) of the model (the same manner as the new industry itself) and its size depends on economic conditions (e.g. income). Then again, following a similar procedure as before, the functions controlling this final demand need to be filled with the survey data and calibrated. In this case for both scenarios we chose the 1) option since, based on the survey data, we assumed a fixed demand for the new products/services.

This step closes the series of modifications to the structure of the model. The values of the necessary variables were changed, the variables of the new sector were initialized, the parameters of the necessary equations were calibrated, and some of the already defined equations were recalibrated. However, with new data and calibration, the model is not balanced anymore, there will be a difference between demand and supply in some markets. During the solution of the model, the solver eliminates these differences through the optimizing behavior of the actors. This type of reaction and adjustment can be considered as the economic effects of the introduction of the new industry.

5. Case studies

As an empirical application of the modelling approach, we surveyed and assessed the potential entrepreneurial ideas in Pécs, which may meet the requirements of the smart specialization

[5] These equations and the method of their calibration are described in detail by Szabó (2020).

[6] Constant elasticity of transformation

selection process. Each of these ideas represents a new activity, the application of new technology, which is linked to the region's capabilities, existing specialization and knowledge base. Once the potential entrepreneurial ideas were screened and filtered, the ones that seemed the most promising were selected as case studies by taking into account the local characteristics, required knowledge, existing local capabilities and their expected spillover capacities. Eventually two of the ideas were selected to be assessed by surveys and interviews. Based on these surveys, the expenditures, necessary inputs, and expected revenues of the imagined activities were estimated. Once we obtained all the information necessary to reconstruct the activity's technology, the new activity was integrated into the impact assessment model to calculate the expected economic effects of supporting each idea. In the following two sections we briefly introduce the two selected entrepreneurial ideas and the most important investment and operating costs that were obtained from the surveys.

5.1. The manufacture of 3D printed cartilage and related medical services

One of the common areas of application of bio-printing technologies is the treatment of knee injuries, in which the method created by a local research group is unique, as it uses the patient's own cells, which can be implanted after being transformed into cartilage of the desired shape. During the procedure, the patient's fat cells can be used to grow cartilage cells, which are transformed into the personalized shape using 3D printing technology. A great advantage of the procedure is that the created cartilage can be adapted to the needs of the patient, and during the implantation of the cartilage, it is not necessary to open the given joint completely, so the recovery time from the operation can be reduced to a short time. In addition, the joint can already be put in use shortly after the intervention, which makes it particularly suitable perform the procedure to treat injuries of professional athletes. The expertise and knowledge necessary to carry out the various phases of the procedure is available at the University of Pécs. Based on the survey, we assembled the database that provides us the necessary information on the investment requirements and the production expenses of the new technology.

Table 1: Investment expenditure (million EUR)

Inputs	**Baranya**	**Budapest**	**Import**
Furniture, equipment, medical supplies	0,0246	0,1779	0
Medical equipment, machines, computers	0	1,8450	0,0019
Softwares	0	0,0003	0
Construction	0,5676	0	0
Air conditioning and cooling systems	0	0,0081	0
Total	**2,6254**		

The details of the initial investment can be seen in Table 1. These are the necessary inputs thar are required by the activity which consist of, on the one hand, the building in which the treatment and the cartilage production can take place, on the other hand all the necessary machinery that is needed by the doctors to assess the condition of the patients. The basic equipment and the construction services can be purchased in the local economy, other, more complex inputs must be imported from Budapest or foreign markets.

Table 2: Production inputs (million EUR)

Inputs	Baranya	Budapest	Import
Medical materials	0	0,01132	0
3D printing materials	0	0,00040	0
Basic medical supplies	0,0026	0,00404	0
Hazardous waste treatment	0,0012	0	0
Medical clothing and accessories	0,0016	0	0
Transportation	0,0039	0	0
Electricity, heating, etc.	0,0042	0	0
Water use	0,0005	0	0
Financial services	0	0,0023	0
Office accessories	0,0004	0	0
Security services	0,0078	0	0
Marketing	0	0,0129	0
IT services	0	0,0032	0
Labour cost	0,2529	0	0
Capital cost (maintenance, depreciation, etc.)	0,3215	0	0
Total	**0,6306**		

The information regarding the operation costs are comprised by Table 2, in which the operating cost of the activity means the annual cost of production inputs. The most important inputs are primary factors: capital and labor, since the activity relies heavily both on specialized medical equipment and high skilled labor (e.g. doctors and other medical specialist). Intermediate inputs cost a relatively small amount and the majority of that can be purchased in the local economy.

Table 3: Expected tourism expenditures by patients (million EUR)

Consumption categories	Baranya
Manufacture of food products, beverages and tobacco products	0,110
Manufacture of coke and refined petroleum products	0,047
Wholesale and retail trade; repair of motor vehicles and motorcycles	0,260
Transporting and storage	0,252
Accommodation and food service activities	0,669
Human health activities	0,077
Arts, entertainment and recreation	0,180
Other services activities	0,073
Total	**1,669**

Finally, Table 3 comprises the information on the amount of potential tourism expenditure. According to the survey data around 1000 patients can be treated annually who spend around 13 days in Pécs for the treatment, recovery and monitoring. Thus, a significant part of positive local economic impacts might arise from tourism expenditures in the region since patients can put strain on their lags shortly after the intervention. Thus, in order to account for the tourism-related expenditure, we used the data from the Hungarian Central Statistical Office regarding the expenditure structure of foreign tourist in Hungary[7] and total amount of expenditures of foreign tourist per day per person[8].

5.2. Manufacture of special e-bikes

The selected activity is attributed to the managing director of a Pécs-based manufacturing company which has a long history in the production of machinery and components. According to the intentions, the invention itself is a high-quality unique electric bicycle whose design is very radical, which differentiates it completely from the bicycles currently available on the market. Every bicycle ordered is unique in every respect, the customer can customize its overall design, as well as the individually designed accessories she/he intends to purchase (e.g. child seat with airbag). The uniqueness of the product lies in the fact that, in addition to its high quality, it is immediately recognizable thanks to its distinctive design, and the owners also have access to a social application built specifically around the bike, on which they can share photos, routes, other information, unique solutions, experiences and accessories with other PeerBike users. In this way, in addition to the sale of the product, the marketing potential, user data and information inherent in the application can be an additional source of income. All of these together make up the PeerBike product and the services built around it. However, the product has not yet been introduced on the market, which has fundamentally financial reasons.
Since the entrepreneurial idea has already consumed a considerable investment, its details are treated confidentially. In order to carry out the investigations, the research group was given access to the extract of the above-mentioned business plan, which, although does not include the investment and current expenditures in their original detail, nevertheless provides a thorough description of the expected costs and revenues of the new activity in an aggregated form.

Table 4: Investment expenditure (million EUR)

Inputs	Baranya	Southern-Transdanubia	Budapest	Import
Real estate	0,17	0	0	0
Licensing and implementation plans	0,04	0	0	0
Construction	0	2,08	0	0
Machinery	0	0	3,20	0,80
Material handling (machines)	0	0	0	0,06
Machinery (IT, office, social)	0	0	0	0,08
Vehicles	0	0	0	0,09
Enterprise resource planning system	0	0	0	0,14
Taxes, duty	0	0	0,01	0
Total	**6,66**			

Table 4 contains the necessary information regarding the investment expenditures. The initial investment required by the activity consists of, on the one hand, the building in which manufacturing can take place, on the other hand all the necessary machinery that is needed for the production of bikes and accessories. The majority of production equipment can be imported from abroad and the construction services can be purchased in the local economy (or from neighboring regions), other inputs can be purchased in the local economy.

[7] https://www.ksh.hu/stadat_files/tur/en/tur0008.html
[8] https://www.ksh.hu/stadat_files/tur/en/tur0003.html

Table 5: Production inputs (million EUR)

Inputs	Baranya	Southern-Transdanubia	Budapest	Import
Battery	0	0	0	6,19
Electric motor	0	0	0	1,60
Seat	0	0	0	0,25
Tyre	0	0	0	0,12
Other components	0	7,85	0	0
Packaging	0	0	0,69	0
Electricity, heating, etc.	1,41	0	0	0
Water	0,09	0	0	0
Waste treatment	0,09	0	0	0
Insurance	0,09	0	0	0
Security services	0,09	0	0	0
Transportation	3,50	0	0	0
Labour cost	3,51	0	0	0
Depreciation, repayment of loans, profit, other operating costs.	16,57	0	0	0
Total	**42,06**			

Table 5 illustrates the production inputs used by the new activity and their annual cost. In terms of the operating costs, this activity is characterized by heavy reliance on intermediate inputs such as (battery, electric motor, metallic materials, etc.) and primary inputs (capital and labor). Relative to bioprinting, e-bike production is much more capital intensive meaning that in relative terms it relies more heavily on capital inputs than labor.

6. Results

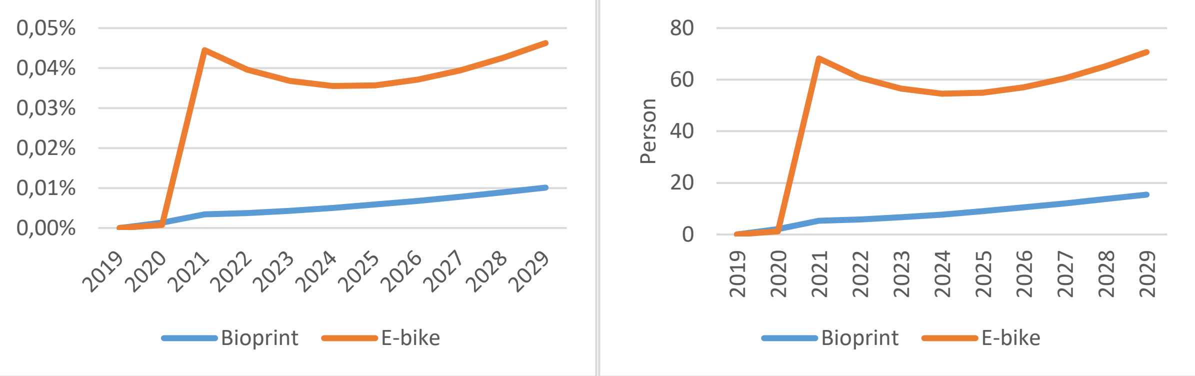
Based on the survey data we set up two alternative scenarios for each of the entrepreneurial ideas. In both cases, we assumed that the initial investment was realized in 2020 to create the capital stock required to start the operation of the new activity in 2021. In both cases we compare the changes in the most important economic variables to the baseline scenario without any interventions. In what follows first, we describe the most important tendencies and causes behind the change of regional employment and gross value added in the case of the two activities. Second, we perform a cost-benefit analysis of the two activities based on the economic impacts and the initial investment requirements to give policymakers a potential tool for selecting the most promising entrepreneurial idea.

6.1. Regional economic effects

We start our analysis with the *regional employment impacts*. As a result of the additional labor demand expressed by the new sectors, local wages rise, which, according to the wage curve equation, reduces the unemployment rate. The wage-curve expression captures a negative relationship between regional unemployment rate and regional real wages. As real wages increase local unemployment rate falls (potentially as a result of excess demand for labor).

In the case of e-bike, employment in Baranya is increased in 2021 by around 66 new jobs as a result of the new sector (compared to the baseline), which means an increase of 0.043% in relative terms. In the case of Bioprinting results are significantly smaller, 5 new jobs were created in 2022 which means 0.003% improvement but of course the absolute size of the activity is also smaller.

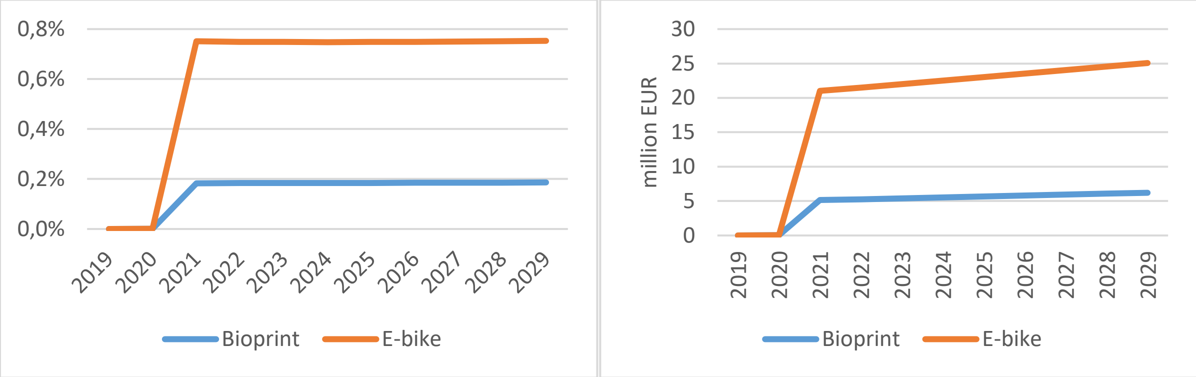
Figure 2: the regional employment impacts in relative (%) and absolute (person) terms



Considering the medium and long-run impacts, in the case of e-bike, the local employment effect is weakened later in the medium-term and strengthened in the longer run. There are two main mechanisms behind this phenomenon which affects real wage changes in the region.
First, the reason for the weakening is that the strong initial price increase caused by the initial excess demand for labor decreases in the longer. Initially local wages are increased due to the additional demand for labor which effect alone increases local real wages. This effect is however partially compensated by the initial increase in capital stock that makes capital a relatively abundant resource thus its price index decreases initially. As a result of the additional capital stock and employment increase, the region is capable of creating more income which increases local savings, thus investments, and thus ultimately the accumulation of the capital stock, which further reduces the price of capital in the region. As firms *substitute* labor and capital, the decrease in the price of capital reduces the increase of wages in the region. Again, according to the wage equation, this negative effect on real wages slightly increases local unemployment rate. Thus, the positive real wage effect in 2021 will decrease later, thus the initial employment effect will continue be weakened until 2024.
Second, as a result of the increased stock of resources (owned by households), household income and consumption (even per capita consumption) increased, which makes Baranya more attractive in terms of inter-regional labor migration. Thus out-*migration* in Baranya decreases (compared to the baseline) and the county able to retain more of its workforce. From 2024 this positive effect overcompensates the negative effects of the first mechanism. Thus, as a result of the slowly weakening employment effect and the increasingly strong positive migration effect, a U-shaped curve of employment impact in Baranya is formed between 2021 and 2029. This means that by the end of the period, the increase in local employment had risen to over 70 people (0.046%).

However, in the case of bioprinting, the first substitution effect is not visible since in that case the initial negative effect on capital price is much smaller, partially due to the smaller size of shock (both in absolute and relative terms) and to the relatively labor intensive nature of that activity, thus the substitution effect between capital and labor is much weaker. As a result, the weakening effect on employment is also smaller and it is overcompensated by the positive in-migration directly from 2022. As a result, by the end of the simulation period, the increase in local employment had risen to over 15 people (0.010%).

Figure 3: the regional GVA impacts in relative (%) and absolute (million EUR) terms



Now we turn our attention to the economic effects regarding *regional gross value added*. There are three factors behind the impact on regional gross value added. On the one hand, there is an increase in the labor force used, second, the capital used, and third, the increase in productivity. First, the impact mechanism behind the positive *employment* effect is discussed in the previous section. Thus, here we focus on the remaining two components.

Second, the *capital stock* is increased initially which is explained by two major factors. On the one hand, the local capital stock increased as a result of the *initial investments* required for the new activity. In the longer term, this effect is partially maintained by the expansion of investments financed by *increased savings* as a result of rising local incomes. These effects are similar in both alternative scenarios. In the case of E-bike capital stock increased by 1.36% in 2021 and the positive effect decreased to 1.22% by the end of the simulation period. In the case of Bioprinting effects are less significant since the investment itself is also smaller: 0.34% in 2021 and 0.29% by the end of the simulation period.

Third, according to the feedback mechanism between the SCGE and the TFP block of the model, positive employment effects are translated into *productivity* improvements in the TFP block. Thus, the initial expansion of employment in both scenarios are expected to improve regional productivity with a two-period time lag. However, the employment effects are not significant thus productivity only improves slightly. In the case of e-bike in 2023 productivity increased by only 0.0005% (which later increased to 0.0020%), while for bioprinting in 2023, productivity improved by only 0.00006% (which increased to 0.0003% by the end of the simulation period).

As a result of these effects, in the case of e-bike, Baranya's value added initially increased significantly by almost 21.04 million EUR (0.751%) in 2021, and then, as a result of the further expansion of employment, migration and the capital stock, it increased by 25.07 million EUR by 2029, which in relative terms it represents only a slight increase compared to the initial effect. For the case of bioprinting, regional value added initially increased significantly by almost 5.13 million EUR (0.183%) in 2021, and then, as a result of the further expansion of employment, migration and the capital stock, it increased by 6.20 million EUR by 2029, which in relative terms it represents only a slight increase compared to the initial effect (0.186%).

6.2. Prioritizing the most promising activity based on costs and benefits

Since the **size** of the initial investment and the level of operation (e.g. gross output) of the new activities are significantly different, economic effects are also significantly different. In the case E-bike the initial investment is around 6.7 million EUR and the annual output is around 42.1 million EUR. In the case of bioprinting these number are much smaller: the investment is only 2.6 million EUR, and the output is around 4.9 million EUR. This means that the economic impacts of the two scenarios are not directly comparable, thus in order to judge which activity might be more promising in terms of a cost-benefit analysis, we turn our attention to the GVA and employment multipliers of the initial investment. These multipliers give us the expected economic effects of spending only 1 million EUR on either of these activities on average.

Table 6: The investment multipliers and the backward linkages of the activities

	Multiplier		BWL
	GVA	Employment	
Bioprinting	1.945	3.357	1.241
E-bike	3.088	8.192	1.157

Table 6 illustrates the results regarding the investment multipliers[9]. Based on the table spending 1 million EUR on Bioprinting results in 1.9 million EUR GDP increase on average (annually during the simulation period), while spending the same amount on E-bike results in 3 million EUR increase. In case of employment, we can see similar patterns per million EUR (3.3 vs. 8 new jobs). Based on these results we conclude that in terms of economic effects, the e-bike activity seems to be a better candidate to be prioritized.

However, it is not evident why one activity seems to be more promising than the other one in terms of regional economic impacts. In what follows we try to explore the most important mechanism that explains why we have such large differences in the economic multipliers. There are interregional, technological and interindustry factors and individual characteristics that can help us understand the economic impacts.

First, economic effects are a function of *intraregional interindustry linkages*. If an activity is heavily reliant on primary factors direct impacts on GVA are expected to be larger. If an activity intensively uses locally produced intermediate inputs spillover effects are expected to be stronger, thus indirect demand for primary factors can be larger. Thus, in order to measure the expected effects of local intraregional interindustry based on the extended intraregional transactions we calculated the size of backward linkages of both the activities in case of output (see Table 5). According to these results manufacture of e-bikes has much stronger interindustry linkages to local producers, thus 1 unit increase in its output leads to a 1.241 unit increase in regional output, while the same value for bioprinting is only 1.012. Although for bioprinting it is not only the backward linkage of the activity that matters, since the multiplier effect is fueled partially by the bioprinting activity and partially by the tourism expenditures which might target industries with stronger intraregional economic ties, thus in this case we consider the potential effect of spending 1 million EUR in the region (partially on bioprinting and partially on other consumption products and services) which is around 1.157.

Second, *intensive use of factors* also contributes to economic effects. If an activity relies mainly on primary factors (large GVA share) than a significant portion of its cost is paid to primary factor owners, increasing local income, consumption and saving which can generate significant positive spillover effects to the local economy through additional consumption and investment demand. Although a part of that spending might target other regions or even foreign markets. The GVA share of e-bike is 0.567 while it is extremely high for bioprinting: 0.979.

Third, *productivity improvements* are also contributing to economic growth. Since employment growth is an important input of productivity improvement in the TFP block, significant improvement in employment might generate additional economic impacts through the productivity block as well.

[9] Where investment multipliers are calculated from the simulation results in the following way:

$$Investment\ multiplier\ = \frac{Average\ absolute\ annual\ GDP\ growth}{Initial\ investment\ expenditure}$$

Fourth, the *resource intensity* of technologies might also contribute to economic effects. Bioprinting is more labor-intensive which means that there is more demand for labor, which might trigger larger employment growth and TFP effects. E-bike production, on the other hand, is more capital-intensive, thus this there is a weaker direct employment effect expected from this activity, however, through strong interindustry linkages additional spillover effects seem to overcompensate these effects.
Fifth, as a combination of all these effects, positive local effects and increased aggregated demand for primary factors might trigger labor and capital *migration* that can contribute to further economic effects in the longer-run.
Finally, effects are also influenced by activity-specific *individual characteristics* which are determined by the survey data collected. In this respect, bioprinting investments on average results in a smaller production volume compared to e-bike production which can contribute to the moderate positive economic effects as well.

Thus, based on our results it seems that on the one hand, bioprinting is more labor-intensive, thus it demands more labor, offers larger feedback effects from the productivity block and has a larger share of gross value added in its cost, which can contribute to increased local spending and multiplier effects compared to e-bike production. On the other hand, however, due to weak intraregional interindustry linkages and individual characteristics it cannot promote significant spillover effects to other local industries which constrains the potential economic effects. Thus, although e-bike production requires significant financial support in absolute terms its economic effects overcompensate these efforts since strong intraregional interindustry linkages generates additional spillover effects to the local economy boosting further economic improvements.
However, we must highlight however that our investigation is solely based on economic effects which comprise only one aspect of the total complex regional effects. In this complex effect collaboration with local firms, institutions and the result of these connection (e.g. innovation, new inventions, etc.) might mean further relevant positive effects that are not considered in this study due to data availability.

7. Summary

The paper argues that the expected economic impact of individual entrepreneurial ideas is typically not taken into account in the selection process of smart specialization. As a result, the decision-makers of the prioritization process cannot account for a very important aspect of interventions. The aim of the study is to offer a possible methodological solution to this shortcoming, thereby contributing to the success of smart specialization implementation.

Since the new entrepreneurial ideas are connected to the economic system in many ways (e.g. they demand additional amounts of primary resources, as well as intermediate inputs in a given region and other areas, they also supply products to local users and users in other areas), the spillover effects of the direct economic impacts are difficult to quantify. However, general equilibrium models, whose spatial extensions can be used to model the expected spatial economic results of the interacting of economic actors and their reactions to each other's decisions, since these models can represent the characteristics of regional economies, taking into account the local intersectoral linkages, available inputs, as well as agglomeration externalities.

As an empirical application of the modelling approach several entrepreneurial ideas in Pécs are already being surveyed, two of which have been selected for impact assessment (Bioprinting, E-bike production). Via surveys and interviews, we obtained the necessary information on investment requirements and production costs which were necessary to integrate new activities in the GMR-Hungary multiregional multisectoral impact assessment model. The new activities make other actors in the economy to adapt, as conditions change in the markets of resources, products and services. The result of this adaptation process can be considered as the expected economic impact of the given entrepreneurial idea, which can serve as an important input for policy decision-making in the selection and prioritization process of Smart Specialization. Based on the surveys, we set up two alternative scenarios for the two activities and we assessed the local economic effects of these activities.

Our results indicate that in a cost-benefit view spending 1 million EUR on bioprinting results in 1.9 million EUR increase in local GDP while spending the same amount on e-bike production results in 3 million EUR increase in GDP. We found that the large differences in economic effects can be explained partially by individual characteristics and by interregional, technological and interindustry factors. In this specific case it seems that the major factor which determined the relatively large economic effects of e-bike production is the strong intraregional interindustry linkages that created significant positive local spillovers to other actors in the economy.

However, it is important to note that this application only accounts for the economic effects of the new activities which only one aspect of the selection mechanism of S3. In this manner, our approach does not account for the whole range of potential positive effects (e.g. new collaborations, new inventions, etc.) which might be also important in the selection of transformative activities.

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Appendix A.1.

A1. List of variables and parameters

Quantities

$L_{r,i}$	-	regional industry level labor demand
$K_{r,i}$	-	regional industry level capital demand
$XIM_{r,i}$	-	regional industry level import
$QR_{r,q,i}$	-	interregional industry level demand (origin region: r, destination region: q)
$Q_{r,i}$	-	regional total demand by industries
$LI_{r,i}$	-	regional industry level labor supply
$KI_{r,i}$	-	regional industry level capital supply
KR_r	-	regional aggregate capital supply
KN	-	national aggregate capital supply
CIM_r	-	imported consumption demand
$IR_{r,i}$	-	regional industry level investment demand
I_r	-	regional domestic investment demand
IIM_r	-	imported investment demand
$ITOT_r$	-	regional total investment demand
GIM_r	-	imported government demand
$EXNAT_i$	-	national export demand for industry products

Prices

$PL_{r,i}$	-	regional industry level wage
$PK_{r,i}$	-	regional industry level price of capital
PIM	-	price index of imported products
$PD_{r,i}$	-	regional price index of domestic supply
$PQ_{r,i}$	-	price index of regional total demand
$PIR_{r,i}$	-	price index of regional industry-level investment (including taxes)
PI_r	-	price index of regional domestic investment
$PITOT_r$	-	price index of regional total investment
$PEXNAT_i$	-	price index of national industry-level export demand (national currency)
PLR_r	-	regional wage
PKR_r	-	price index of regional capital
PKN	-	price index of national capital (numeraire)

Other nominal variables

ER	-	exchange rate
$INVREG_r$	-	Total regional savings

Exogenous variables - closure

PWM	-	world price of import
PWE_i	-	world price of export
$CIVM_r$	-	price index of imported changes in inventories
LS_r	-	regional labor supply (changed between periods by labor migration)
KS_r	-	regional capital stock (changed between periods by capital accumulation)

SW	-	balance of payments

Model-parameters

$d^{Q}_{r,i}$	-	shift parameter of the CES function controlling interregional trade
$b^{QR}_{q,r,i}$	-	share parameter of interregional trade volumes
$\sigma^{Q}_{r,i}$	-	elasticity of substitution
$\rho^{Q}_{r,i}$	-	elasticity parameter
d^{LR}_{r}	-	shift parameter of the CET function controlling interindustry allocation of labor
$b^{LI}_{r,i}$	-	share parameter of sectoral labor supply
σ^{LR}_{r}	-	elasticity of transformation
$\rho^{LR}_{r,i}$	-	elasticity parameter
d^{KR}_{r}	-	shift parameter of the CET function controlling interindustry allocation of capital
$b^{KI}_{r,i}$	-	share parameter of sectoral capital supply
σ^{KR}_{r}	-	elasticity of transformation
$\rho^{KR}_{r,i}$	-	elasticity parameter
d^{KN}	-	shift parameter of the CET function controlling interregional allocation of capital
b^{KR}_{r}	-	share parameter of regional capital supply
σ^{KN}	-	elasticity of transformation
ρ^{KN}	-	elasticity parameter
d^{I}_{r}	-	shift parameter of the CES function aggregating sectoral investment volumes
$b^{IR}_{r,i}$	-	share parameter of sectoral investment volumes
σ^{I}_{r}	-	elasticity of substitution
ρ^{I}_{r}	-	elasticity parameter
d^{ITOT}_{r}	-	shift parameter of the CES function aggregating domestic and imported investment goods
b^{I}_{r}	-	share parameter of domestic investment goods
b^{IIM}_{r}	-	share parameter of imported investment goods
σ^{ITOT}_{r}	-	elasticity of substitution
ρ^{ITOT}_{r}	-	elasticity parameter
$\tau_{q,r,i}$	-	ice-berg type transport cost (uniform across industries)

Appendix A.2.
A2. The methodological details of the calibration procedure

A2.1. Introducing the investment shock

To account for the part of the investment shock, which is related to domestic investment demand, three parameters are introduced to the model:

$$Inv\_dom_r = \sum_i Inv\_ind_{r,i} = \sum_{q,i} Inv\_interreg_{q,r,i} \tag{1}$$

Where Inv_dom_r is the total regional domestic investment demand (measured in the local currency), $Inv\_ind_{r,i}$ is the shock to the industry-specific investment demand, and $Inv\_interreg_{q,r,i}$ shock also shows the producing regions that should satisfy the regional investment demand. In addition, it is necessary to introduce the parameter that is responsible for the expenditure on investment goods of foreign origin (Inv_imp_r).

Using these shock parameters, the modifications necessary for the introduction of the investment shock are described below. For each equation, the newly introduced elements due to the shock are highlighted in bold.

First, it is necessary to decide on the source of financing for investments. Since smart specialization investments are typically financed by the European Union, in the following we used the assumption that the investments required for the new sector in the model are financed by foreign sources. At the level of the model, this means that the amounts that ensure the realization of the investments appear on the left side of the foreign currency balance sheet (measured in foreign currency):

$$SW + \sum_j PWE \cdot EXNAT_j + \frac{\boldsymbol{\sum_r (Inv\_dom_r + Inv\_imp_r)}}{\boldsymbol{ER}} = \sum_r PWM \cdot \left(\sum_j \left(XIM_{r,j}\right) + CIM_r + IIM_r + GIM_r + CIVM_r \right) \tag{2}$$

Where $\sum_j PWE \cdot EXNAT_j$ is the total value of national exports, ER is the exchange rate, and the right-hand side of the equation shows the total value of imports[10].

In the next step, the incoming funds must be allocated to the appropriate region, where it will finance a part of all regional investment demand on the left side of the following equation:

$$PITOT_r \cdot ITOT_r = INVREG_r + si_r \cdot \left(\sum_{r,i} (1 + tcomCIV_{r,i}) \cdot PD_{r,i} \cdot CIV_{r,i} - \sum_r PIM \cdot CIVM_r \right) + \boldsymbol{Inv\_dom_r + Inv\_imp_r} \tag{3}$$

After that, the domestic and import investment demand (I_r, IIM_r) functions need to be modified. Since these demand quantities, as well as all regional investment demand, have different price indexes, they must also be taken into account in the allocation. In the following, a part of the total real demand $\left(\frac{\boldsymbol{Inv_{dom_r} + Inv_{imp_r}}}{\boldsymbol{PITOT_r}}\right)$ is artificially allocated to the corresponding categories based on the preliminary data and not on the basis of the CES demand functions. In order for the cost functions and measurement units to remain consistent, it is necessary to correct the additional demands assigned to domestic and import sources with the appropriate price indices $\left(\frac{\boldsymbol{Inv\_dom_r}}{\boldsymbol{PI_r}}, \frac{\boldsymbol{Inv\_imp_r}}{\boldsymbol{PIM_r}}\right)$.

$$I_r = \left(\frac{PITOT_r}{PI_r}\right)^{\sigma_r^{ITOT}} \cdot (b_r^I)^{\sigma_r^{ITOT}} \cdot (d_r^{ITOT})^{\sigma_r^{ITOT}-1} \cdot \left(ITOT_r - \frac{\boldsymbol{Inv_{dom_r}} + \boldsymbol{Inv_{imp_r}}}{\boldsymbol{PITOT_r}}\right) + \frac{\boldsymbol{Inv\_dom_r}}{\boldsymbol{PI_r}} \tag{4}$$

$$IIM_r = \left(\frac{PITOT_r}{PIM_r}\right)^{\sigma_r^{ITOT}} \cdot (b_r^{IIM})^{\sigma_r^{ITOT}} \cdot (d_r^{ITOT})^{\sigma_r^{ITOT}-1} \cdot \left(ITOT_r - \frac{\boldsymbol{Inv_{dom_r}} + \boldsymbol{Inv_{imp_r}}}{\boldsymbol{PITOT_r}}\right) + \frac{\boldsymbol{Inv\_imp_r}}{\boldsymbol{PIM_r}} \tag{5}$$

A similar procedure is followed in the case of industry specific investment demand ($IR_{r,i}$):

$$IR_{r,i} = \left(\frac{PI_r}{PIR_{r,i}}\right)^{\sigma_r^I} \cdot \left(b_{r,i}^{IR}\right)^{\sigma_r^I} \cdot (d_r^I)^{\sigma_r^I-1} \cdot \left(I_r - \frac{\boldsymbol{Inv\_dom_r}}{\boldsymbol{PI_r}}\right) + \frac{\boldsymbol{Inv\_ind_{r,i}}}{\boldsymbol{PIR_{r,i}}} \tag{6}$$

Finally, if information is available on the expected location (region) of satisfying sector investment demands, domestic investment shocks can also be interpreted in relation to the regions, that is, it can be specified from which regions these demand quantities are met. However, for this, it is necessary to introduce a shock into the interregional demand function using the above methodology. It is then necessary to take into account that the price index of interregional trade also includes the cost of transport ($(1+\tau_{q,r,i}) \cdot PD_{q,i}$):

$$\frac{QR_{q,r,i}}{1+\tau_{q,r,i}} = \left(\frac{PQ_{r,i}}{(1+\tau_{q,r,i}) \cdot PD_{q,i}}\right)^{\sigma_{r,i}^Q} \cdot \left(b_{q,r,i}^{QR}\right)^{\sigma_{r,i}^Q} \cdot \left(d_{r,i}^Q\right)^{\sigma_{r,i}^Q-1} \cdot \left(Q_{r,i} - \frac{\boldsymbol{Inv_{ind_{r,i}}}}{\boldsymbol{PQ_{r,i}}}\right) + \frac{\boldsymbol{Inv\_interreg_{q,r,i}}}{(\boldsymbol{1}+\boldsymbol{\tau_{q,r,i}}) \cdot \boldsymbol{PD_{q,i}}} \tag{7}$$

A2.2. Introducing the new industry

Since the new sector is modeled by the same embedded production function as all the other industries the calibration process is almost identical to those industries with a couple of exceptions. Here we account for these specific calibration steps.

First, it is worth highlighting the interregional consideration of intermediate demand, in which case already existing trade quantities change as a result of the new activity. This requires a recalibration of the parameters of the *interregional CES demand function*. First, we introduce the quantities of intermediate use broken down along sectoral and interregional dimensions:

$$XINT_{r,i}^{Tech} = \sum_q XIR_{q,r,i}^{Tech} \tag{8}$$

Where $XINT_{r,i}^{Tech}$ the sector-specific value of the inputs to be used by the new sector, while $XIR_{q,r,i}^{Tech}$ contains the interregional dimension of these transactions. The original IOT can be expanded by these parameters and the interregional demand function can be recalibrated for the corresponding sectoral products. Where the CES share parameters can be calculated as follows:

$$b_{q,r,i}^{Q} = \frac{(1+\tau_{q,r,i})\cdot PD_{q,i}}{PQ_{r,i}} \cdot \left[\frac{\left(\frac{QR_{q,r,i}+XIR_{q,r,i}^{Tech}/PD_{q,i}}{1+\tau_{q,r,i}}\right)}{\left(Q_{r,i}+XINT_{r,i}^{Peer}/PQ_{r,i}\right)}\right]^{\frac{1}{\sigma_{r,i}^{Q}}} \tag{9}$$

The shift parameters are then given by the following expression:

$$d_{r,i}^{Q} = \frac{Q_{r,i}+XINT_{r,i}^{Tech}/PQ_{r,i}}{\left[\sum_q b_{q,r,i}^{Q}\cdot\left(\frac{QR_{q,r,i}+XIR_{q,r,i}^{Tech}/PD_{q,i}}{(1+\tau_{q,r,i})}\right)^{\rho_{r,i}^{Q}}\right]^{\frac{1}{\rho_{r,i}^{Q}}}} \tag{10}$$

Second, due to the assumed increase capital stock created by the new sector, the stock of primary resources owned by households increases, and thus also the income of households, which must be taken into account in the income equation. The *stock of capital* is treated exogenously in each period, and it changes as a result of capital accumulation which effect is partially extended by the effects of investment shocks, which is controlled by the following equation:

$$KS_r = KS0_r + \frac{\sum_i \boldsymbol{K\_shock_{r,i}}}{\boldsymbol{PKR_r}} \tag{12}$$

Where $K\_shock_{r,i}$ are the stock of capital used (created) by the new activity in the region[11].

Third, since households decide to which industry they *allocate* their *primary resources*, it is necessary to recalibrate the CET[12]-type functions that control this allocation. Otherwise, input demand of the new industry would not be possible to be satisfied by industry-specific supply, thus the GAMS software would not be able to find a solution. First of all, we recalibrated the

[11] Note that employment is endogenous in the model, thus there is no need to shock the stock of labor exogenously. Additional labor demand will reduce unemployment rate according to a wage-curve function.

[12] Constant elasticity of transformation

share and shift parameters of the equation of the CET-type function[13] controlling the sectoral labor supply with the following extensions:

$$b_{r,i}^{LI} = \frac{PL_{r,i}}{PLR_r} \cdot \left[\frac{\left(LI_{r,i} + \frac{\boldsymbol{L\_shock_{r,i}}}{\boldsymbol{PL_{r,i}}} \right)}{\left(LS_r + \sum_{\boldsymbol{i}} \frac{\boldsymbol{L\_shock_{r,i}}}{\boldsymbol{PLR_r}} \right)} \right]^{\frac{1}{\sigma_r^{LS}}} \tag{13}$$

$$d_r^{LS} = \frac{LS_r + \sum_{\boldsymbol{i}} \frac{\boldsymbol{L\_shock_{r,i}}}{\boldsymbol{PLR_r}}}{\left[\sum_i b_{r,i}^{LI} \cdot \left(LI_{r,i} + \frac{\boldsymbol{L\_shock_{r,i}}}{\boldsymbol{PL_{r,i}}} \right)^{\rho_r^{LS}} \right]^{\frac{1}{\rho_r^{LS}}}} \tag{14}$$

Where $L\_shock_{r,i}$ is the initial labor demand of the new activity. The share ($b_{r,i}^{LI}$) and shift (d_r^{LS}) parameters are calibrated using the amount of primary inputs demanded by the new activity. A similar approach is followed in the case of capital in two steps. First, the share (b_r^{KR}) and shift (d^{KN}) parameters of CET functions[14] controlling the interregional allocation of capital were recalibrated:

$$b_r^{KR} = \frac{PKR_r}{PKN} \cdot \left[\frac{\left(KR_r + \sum_{\boldsymbol{i}} \frac{\boldsymbol{K\_shock_{r,i}}}{\boldsymbol{PKR_r}} \right)}{\left(KN + \sum_{\boldsymbol{r}} \sum_{\boldsymbol{i}} \frac{\boldsymbol{K\_shock_{r,i}}}{\boldsymbol{PKN}} \right)} \right]^{\frac{1}{\sigma^{KN}}} \tag{15}$$

$$d^{KN} = \frac{KN + \sum_{\boldsymbol{r}} \sum_{\boldsymbol{i}} \frac{\boldsymbol{K\_shock_{r,i}}}{\boldsymbol{PKN}}}{\left[\sum_r b_r^{KR} \cdot \left(KR_r + \sum_{\boldsymbol{i}} \frac{\boldsymbol{K\_shock_{r,i}}}{\boldsymbol{PKR_r}} \right)^{\rho^{KN}} \right]^{\frac{1}{\rho^{KN}}}} \tag{16}$$

Second, the share (d_r^{KR}) and shift ($b_{r,i}^{KI}$) parameters of the CET functions[15] controlling the interindustry allocation of capital is also recalibrated:

$$b_{r,i}^{KI} = \frac{PK_{r,i}}{PKR_r} \cdot \left[\frac{\left(KI_{r,i} + \boldsymbol{K\_shock_{r,i}/PK_{r,i}} \right)}{\left(KR_r + \sum_{\boldsymbol{i}} \boldsymbol{K\_shock_{r,i}/PKR_r} \right)} \right]^{\frac{1}{\sigma_r^{KR}}} \tag{17}$$

$$d_r^{KR} = \frac{KR_r + \sum_{\boldsymbol{i}} \frac{\boldsymbol{K\_shock_{r,i}}}{\boldsymbol{PKR_r}}}{\left[\sum_i b_{r,i}^{KI} \cdot \left(KI_{r,i} + \frac{\boldsymbol{K\_shock_{r,i}}}{\boldsymbol{PK_{r,i}}} \right)^{\rho_r^{KR}} \right]^{\frac{1}{\rho_r^{KR}}}} \tag{18}$$

Where again all the shock parameters ($L\_shock_{r,i}$, $K\_shock_{r,i}$) has nonzero values only in case of the new activity.

Finally, in the case of bioprinting, tourism spending adds another layer of effects to the processes, thus tourism spending also needs to be incorporated into the modelling structure. In case of the additional regional spending of patients (as tourists) we also change the regional consumption budget of the households with an additional foreign inflow of money ($\sum_i Con\_shock_{r,i}$):

$$BH_r = (1 - sy_r) \cdot YH_r + \sum_{\boldsymbol{i}} \boldsymbol{Con\_shock_{r,i}} \tag{19}$$

[13] $LS_r = d_r^{LR} \cdot \sum_i \left(b_{r,i}^{LI} \cdot {LI_{r,i}}^{\rho_r^{LI}} \right)^{\frac{1}{\rho_r^{LI}}}$

[14] $KN = d^{KN} \cdot \left(\sum_r b_r^{KR} \cdot {KR_r}^{\rho^{KR}} \right)^{\frac{1}{\rho^{KR}}}$

[15] $KR_r = d_r^{KR} \cdot \sum_i \left(b_{r,i}^{KI} \cdot {KI_{r,i}}^{\rho_r^{KI}} \right)^{\frac{1}{\rho_r^{KI}}}$

Where $Con\_shock_{r,i}$ shows the additional monetary consumption spending on regional industries which is based on the expenditures detailed in Table 3. This amount will be part of the regional consumption budget:

$$PCTOT_r \cdot CTOT_r = BH_r \tag{20}$$

As in the case of the investment shock first we need to assign these spending to domestic regional consumption:

$$C_r = \left(\frac{PCTOT_r}{PC_r}\right)^{\sigma_r^{CTOT}} \cdot (b_r^C)^{\sigma_r^{CTOT}} \cdot (d_r^{CTOT})^{\sigma_r^{CTOT}-1} \cdot \left(CTOT_r - \frac{\sum_i \boldsymbol{Con\_shock_{r,i}}}{PCTOT_r}\right) + \frac{\sum_i \boldsymbol{Con\_shock_{r,i}}}{PC_r} \tag{21}$$

$$CIM_r = \left(\frac{PCTOT_r}{PIM_r}\right)^{\sigma_r^{CTOT}} \cdot (b_r^{CIM})^{\sigma_r^{CTOT}} \cdot (d_r^{CTOT})^{\sigma_r^{CTOT}-1} \cdot \left(CTOT_r - \frac{\sum_i \boldsymbol{Con\_shock_{r,i}}}{PCTOT_r}\right) \tag{22}$$

$$PCTOT_r \cdot CTOT_r = PC_r \cdot C_r + PIM_r \cdot CIM_r \tag{23}$$

Second, the additional domestic consumption spending has to be accounted for in the selected industries (based on the available statistical data):

$$CR_{r,i} = \left(\frac{PC_r}{PCR_{r,i}}\right)^{\sigma_r^C} \cdot \left(b_{r,i}^{CR}\right)^{\sigma_r^C} \cdot (d_r^C)^{\sigma_r^C-1} \cdot \left(C_r - \frac{\sum_i \boldsymbol{Con\_shock_{r,i}}}{PC_r}\right) + \frac{\boldsymbol{Con\_shock_{r,i}}}{PCR_{r,i}} \tag{24}$$

$$PC_r \cdot C_r = \sum_i PCR_{r,i} \cdot CR_{r,i} \tag{25}$$

In the case of consumption, shock we do not recalibrate the interregional trade parameters, thus a part of the demand shock will be satisfied by interregional import but a greater portion will remain within the region. The reason is that some of the goods that are purchased by the patients are not produced in Baranya thus it needs to be imported (e.g. pharmaceutical products, etc.).