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Wim HEIJMAN*, Zoltán SZABÓ and Esther VELDHUIZEN***

The Contribution of Biorefineries to Rural Development: The Case of Employment in Hungary

Most recent research concerning biofuels focuses on their potential for mitigating climate change, while their rural development dimension is given less prominence. Ongoing policy debates, including EU and US biofuel policies, pay little attention to this feature of the industry. This paper explores the impact of biorefineries on rural development, and employment in particular. It shows that biorefineries can have a considerable economic impact on the regions in which they are located. Embedded in the local social and economic fabric, the paper demonstrates their influence on regional and national labour markets. The case of a bioethanol plant in Hungary and its effect on the rural labour market in two counties of the country is studied by way of an input-output model. The research has found that the operation of a biorefinery stimulates the creation and maintenance of jobs in both farming and service industries. Results suggest that biorefineries are an important driver of rural development and that this aspect of the industry should be given greater weight in formulating biofuel policies.

Keywords: Biofuels, Biofuel Policies, Ethanol, Rural Development, Input-Output Analysis, Employment

JEL classifications: Q16, Q57

* Wageningen University, Department of Social Sciences, Netherlands.

** LátensDimenzió Consultancy, Budapest, Hungary. Corresponding author: zoltan.szabo@latensdimenzio.com

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Introduction

Biofuels have long been of interest to scientific research. They have been promoted for a variety of reasons, including their potential for mitigating climate change. The majority of scientific papers appear to focus on the climate profile of biofuels. However, this topic gained further prominence when the concept of indirect land use change (ILUC) impact was introduced, which suggests that a more complete picture of the impact of biofuels is necessary. Accordingly, climate change is perhaps the most often used angle in research papers looking at biofuels. A relatively smaller share of studies focuses on environmental impacts, and research angles include biofuels' impact on biodiversity, water and other environmental aspects. A substantial number of papers consider the so-called food versus fuel issue, that is, the food security dimension of biofuel production and use. Some authors focus on the agricultural aspects of biofuel production (Szabó, 2019). Combined, these topics are dealt with by the vast majority of research papers published in the scientific literature.

However, thus far, less attention has been paid to the rural development dimension of biofuel production. The impact of biofuel production on rural employment is a relatively little researched topic. By way of illustration, Wojan *et al.* (2014) stated that no research to that date had empirically evaluated the combined direct, indirect, and induced employment effects of ethanol plant operations in the US. The aim of our paper is to contribute to this particular aspect of the biofuel debate. Our aim is to investigate the local economic impact of a biofuel plant and in particular look at the impact on the number of jobs generated through an ethanol plant located in a disadvantaged rural region in Europe. Typically, biofuel plants are located in rural environments, often in the heart of areas that produce the feedstocks, and are embedded in the local economies. Biorefineries are plants producing a range of products from fuel, feed, food, green electricity, biochemicals to any other bio-based materials using feedstock as biomass.

Biorefineries are enterprises closely linked to agriculture. The feedstocks used in the plants are typically locally sourced. Therefore, biofuel plants have a strong link to the farmers in their vicinity. In the United States (US), bioethanol plants are often run as co-operatives, where farmers have a stake in the plant. In Europe, except for instances where the plant is located close to a port and relies on imported feedstock, the model is similar; a typical biofuel plant sources its feedstock from about a 50km radius, hence local farmers are its primary suppliers, and their business relationships are strong. The plant is significantly embedded in the local social and economic fabric. This notion is what makes biorefineries a special industry that has a close link to rural businesses, farming in particular.

Jobs are created directly (within the plants themselves) and indirectly (through impacting the regional economy). Urbanchuk (2018) finds that when the direct, indirect and induced jobs supported by ethanol production, construction activity, agriculture, exports, and R&D are included, the US ethanol industry supported nearly 360,000 jobs in 2017. Although not based on conventional biofuel feedstocks such as sugars and starches, Thornley *et al.* (2014) found that for straw and woody biomass feedstocks, a single facility could generate tens of thousands of man-years of employment.

After solar power production, biofuel production may be the second largest employer globally in the renewable energy industry. IRENA (2016) reports that the total employment, including direct and indirect jobs, in the biofuel sector globally amounted to 1.678 million in 2015. With 821,000 jobs, Brazil continues to have the largest biofuel workforce by far. The US comes in second place with 277,000 jobs, followed by the European Union (EU) with 105,000 jobs. In total, the jobs created by the biofuel industry amount to about one fifth of the total jobs created by the global renewable industry. Thus biorefineries may advance the socio-economic dynamics of the region, closing rural-urban income gaps and equalising intra-European disparities (Katainen, 2017).

Biofuel Policies

There are substantial differences in the rationale behind biofuel policies in the various jurisdictions globally. In this section the brief history of and the justification stated in the three key jurisdictions; namely the European Union (EU), the United States (US) and Brazil, are discussed.

The EU laid out its initial biofuel policy in the 2003 directive (EU Directive, 2003), which stated that biofuels are primarily promoted for their contribution to climate change mitigation, energy security and promoting renewable energy sources. The European Union adopted its flagship regulation on biofuels in 2009 under the Renewable Energy Directive (RED). The RED's overarching aim was to promote renewable energy, which is explained as something that contributes to climate change mitigation, promotes the security of energy supply (reducing dependence on imported oil), promotes technological development and innovation and provides opportunities for employment and regional development, especially in rural and isolated areas. The RED deals with the sustainability criteria of biofuels, focusing primarily on their impact on climate change (including ILUC), biodiversity and, to a lesser extent, on food security. Its impact on water and soil also gets mentioned.

The RED also states that "when favouring the development of the market for renewable energy sources, it is necessary to take into account the positive impact on regional and local development opportunities, export prospects, social cohesion and employment opportunities". It must be noted that the above sentence and another with a similar meaning are the only references in the entire document to the importance of considering the impact of the renewable energy industry on jobs. Also noteworthy is the fact that data is difficult to find on the direct and indirect employment provided by the biofuel sector in the EU.

Arguably, the opportunities for growth and employment that an investment in the regional and local production of energy from renewable sources brings about in the Member States and their regions are important. The European Court of Auditors (2018) finds that even though the RED refers to the rural development dimension of renewable energy deployment in its recitals, there are no specific provisions in the legislative part of the Directive related to promoting rural development.

In Europe, in essence, the key reason for supporting biofuels appears to be climate change mitigation. The ongoing policy debate in the EU about RED II (the revision of the RED) reinforces the above-mentioned priorities and does not give prominence to employment impacts. As an illustration of these priorities, the impact assessment behind the RED II proposal states that "only direct, permanent jobs were estimated; construction jobs and indirect employment impacts were not assessed" (Impact Assessment, 2016). In other words, the job aspect appears not to have been given a priority. This conclusion appears to be reinforced by the findings of the European Court of Auditors (2018), which finds that the rural development dimension of renewable energy, including bioenergy, was not adequately considered in the Commission and the Member States' policy framework.

The US is the world's leading producer of biofuels, most notably ethanol. In the US, the primary impetus for biofuel policies has been the desire to become less dependent on foreign oil, i.e. furthering energy security and supporting the agricultural industry. The history of the biofuel policy of the US can be traced back to the Energy Policy Act of 1992. The Energy Policy Act of 2005 created the Renewable Fuel Standard (RFS), a centrepiece of the US regulation on biofuels, whereby a minimum volume of biofuels is required to be used in the transportation fuel supply in the US each year. In 2007, another important regulation stressed the notion of "Energy security through increased production of biofuels". The Environmental Protection Agency assessed the impact of the policy along the lines of reduced energy dependence, reduced fuel prices, reduced GHG emissions, increased farm incomes and impacts on trade, food price and air emissions. The above listing includes impacts on employment or job creation as a decisive metric, whereby the outcome of the biofuel policy is to be evaluated on. The current policy debate in the US around the RFS is centred mostly around energy independence, fuel prices and impacts on farming, while job creation opportunities are not prominent in the debate.

Brazil is the world's second largest producer of bioethanol. Brazil has perhaps the longest history, over four decades, of biofuel policy. Its policy is based around its sugarcane programme, unlike in the US and the EU where the dominant feedstock is grain, and corn in particular. Since 1976, blending ethanol into petrol has been mandatory. Brazil has the highest blending rate, currently at 27%, reflecting the strength of the sugarcane industry. The policy's aim is primarily the promotion of the economy. The Brazilian ethanol industry produces sugar as well as ethanol, and the two products are considered important. However, their impacts are difficult to disentangle. Hence the underlying justifications behind the policies relate to both the biofuel and sugar businesses. Given that its policy is primarily an industry policy, economic contribution and employment impacts are prominent in the discussions about biofuel policies.

In summary, the key policy documents in the US and the EU, in contrast to Brazil, do not rely substantially on justification backed up by the rural development benefits, let alone the job creation opportunities. In the two major grain-based biofuel jurisdictions, especially in the EU, the benefits biorefineries may bring to rural communities seem to have been neglected.

Methodology

In order to examine the economic impact of biorefineries in rural areas, the case has been specified for a business (Pannonia Ethanol) that operates an ethanol plant or a biorefinery in Dunaföldvár, Hungary (Annex 1). The biorefinery has a significant impact on the regional and national corn market, utilising about a million ton of corn each year, which is about 15% of total nation production.

The assessment has been carried out by means of an input output model (I-O model). Only the national I-O table is available in the national statistical datasets, therefore, by means of the RAS-procedure the regional I-O tables of Tolna and Fejér, the two counties in Hungary directly impacted by the operation of the plant, was calibrated. Furthermore, the multipliers per sector were determined such that the change in employment per sector can be measured.

The biorefinery produces bioethanol, animal feed, corn oil and other bio-based materials from feed grade corn as the feedstock used in processing. The ethanol is eventually blended in petrol and used as a biofuel. The plant was constructed in 2010-2011, but capacity expansion investments have been undertaken on a constant basis and are continuing today. Farms in the regions of Fejér and Tolna supply over one million tons of corn to the plant each year. From this amount, the refinery produces 325,000 tons of animal feed, 450 million litres of bioethanol and 10,000 tons of corn oil. Based on a grey publication (Koós, *et al.*, 2016), the business directly employs 172 people and has created over 2,000 jobs indirectly, and it can be said that the economic impact on the region is significant.

The biorefinery is set on the banks of the Danube one hundred kilometres from Budapest, in the heart of Hungary's corn growing region, with the nearest town Dunaföldvár, which has around ten thousand inhabitants (Annex 1). The major economic activity in this region is farming. The biorefinery has been expanding and has more than doubled in capacity since 2012. Besides producing bioethanol, the business is also engaged in the development of new bio-based technologies. It is clear that the business stimulates the local economy, but it is unknown to what extent (Major, 2016). Therefore, the main aim of this analysis is to estimate the impact of the business on the local and national employment level. For this endeavour, the multiplier effects of the sectors of the two regions were to be determined. Additionally, the expenditures of the business in the different sectors were to be investigated such that the effects per sector can be measured. Therefore, a standard tool, an input output (I-O) model has been built and calibrated to the regional economies of Fejér and Tolna. In this way, it can be simulated how the plant influences incomes, jobs and production output.

As stated above, it is expected that the development of biofuels in rural areas influence the local economy. A tool to measure the regional economic impact is the I-O model. The model provides an answer to questions such as: *How much additional employment will be generated due to the establishment of new biorefineries?* The focus of this model is to measure the impact on output, additional income and employment. The model was originally developed by Leontief in the sixties, since then, it has been used to calculate the regional economic impacts of many activities (Heijman, *et al.*, 2017).

The I-O model is one of the most commonly used models in economic impact analysis (EIA). Other methods which can be used to measure the impact of new plants in regions are: the computable general equilibrium (CGE) model and the non-linear input output (NLIO) model. The CGE model is more extensive than the I-O model. With this model it is possible to provide an answer to more types of questions. Furthermore, it can be specified according to the economic reality. The downside of this model is that much more knowledge of economic and mathematical concepts is required for its application, also substantially more data is required. Therefore, it is harder to apply this model in practical studies, especially at the regional level. The NLIO model can be considered as an intermediate form between the I-O and the CGE models. This model can also take other issues into account, such as productivity changes and substitution, without an extreme increase in the data requirement (Klijs, 2016) .

Among these three models, the I-O model remains the most popular method for economic impact studies. The advantage is that the model is relatively simple and the computations can be done with standard software such as Microsoft Excel. In addition, the model is well known, and the advantages and disadvantages are described in many publications. Moreover, in the absence of a regional I-O table it is simple to generate one based on the national I-O table. This is convenient when there is no time to conduct an extensive survey in a particular region. Further, the I-O model requires a relatively modest amount of data. Still, the outcome of the table is detailed and shows the impact on production, value added, income and employment, in total and by sector (Klijs, 2016).

The model also has its disadvantages, which should be taken into account before application. Most of the disadvantages are strongly dependent on the assumptions made in the research. First of all, in the case of our research, the model is based on technical coefficients that are fixed ratios between the total revenues and the expenditures of a sector. This relationship implies that a change in the final demand will never lead to productivity changes, which would not necessarily be the case in reality. Furthermore, the model does not consider substitution as a possibility.

In reality, substitution of production factors may occur. This is not accounted for in the I-O model. Secondly, the model does not provide answers to detailed questions. Thus, it is not possible to say anything about the impact of lower or higher subsidies on the production of ethanol for instance. Also, the model only predicts the impact on regional level and cannot be specified to municipalities. Thirdly, the I-O model only shows the differences between the old and the new equilibrium demand. In reality this can take quite some time before an economy will adapt to the changes in the final demand and quantities. Lastly, in some cases the I-O table is not available and hence needs to be created. The process requires assumptions about employment and the shares of regions in sectors and these assumptions may lead to a distorted image of reality. Moreover, research needs to determine how to collect the necessary data to determine the change of the final demand. The decision can be complicated since it is hard to determine how much money will be spent if the money is not actually there already (Heijman, *et al.*, 2017).

Although some scientists advocate the usage of the more advanced models, such as the CGE and the NLIO models, their use is not always necessary. In order to measure the regional impact of the biorefinery some assumptions need to be made, but the case is relatively small, making the I-O model applicable.

First, an appropriate scale for the I-O table and data must be chosen. The NUTS classification (Nomenclature of territorial units for statistics) is a hierarchical system for dividing

the economy territory of the EU. These classifications are made with the purpose to 1) collect, develop and harmonize the European regional statistics, 2) analyse socio-economic regions and 3) frame the European regional policies. For our research only the second point is of relevance. The statistical database of the European Commission distinguishes three 'levels' within a country, namely:
NUTS 1: Major socio-economic regions
NUTS 2: Basic regions for the application of regional policies
NUTS 3: Small regions for specific diagnoses

The NUTS 1 regions are the major economic regions, which are divided into NUTS 2 regions, which are finally further divided into NUTS 3 regions. It is important to use these classifications since the data (value added, employment rate and output per industry) are per NUTS region. Hungary has in total 20 NUTS 3 units, 7 NUTS 2 units and 3 NUTS 1 units (Eurostat, 2013).

The following division applies for Hungary:

- NUTS 0 region '*Hungary',* HU
- NUTS 1 region '*Dunántúl',* HU2
- NUTS 2 region *'Közép-Dunántúl'* HU21
- NUTS 3 region '*Fejér'*, HU211
- NUTS 2 region '*Dél-Dunántúl'* HU23
- NUTS 3 region '*Tolna'* HU233

Annex 1 shows all the NUTS regions of Hungary. As stated above, the regions Fejér HU211 and Tolna HU233 are NUTS 3 regions. These are the regions in which the impact of the biorefinery is the most apparent.

After examining which NUTS regions are of interest, one should determine the national economic activity per sector as well as the national and regional employment rates per sector. Unfortunately, there are no I-O tables available for these regions, but they can be constructed through the RAS procedure based on the national I-O table combined with the employment rates per sector. Each region should be treated separately. Thus, the procedure must be carried out twice. The national I-O table of 2016 can be obtained from the Hungarian Central Statistical Office. Before regionalizing the national I-O table, it is useful to split the industry into separate sectors. Since it is unclear at the start in which sector the business has the largest impact, all sectors will be taken into account.

The following nineteen sectors will used:

- Agriculture, hunting, forestry and fishing
- Mining and quarrying
- Manufacturing
- Electricity, gas and water supply
- Water supply, wastewater collection and treatment, waste management and pollution treatment
- Construction
- Wholesale and retail trade, repair of motor vehicles and household goods
- Transport and storage
- Hotels and restaurants
- Information and communication
- Finance and insurance
- Real estate, renting and business activities
- Professional, Scientific and engineering activities
- Administrative and support service activities
- Public administration and defence as well as compulsory social security
- Education
- Health and social work
- Arts, entertainment and recreation
- Other activities

By compressing the industry into nineteen sectors the I-O model is easier to conduct. With the I-O table, it is possible to visualize how much each sector contributes to itself or to the other sectors since the product of one sector can be used as an input for another sector. In tables in Annex 2 and 3 the rows record the outflow of production, showing how the production of an activity sector is distributed among the other sectors of the economy. The columns of the table record the necessary inputs for production, showing the structure of inputs used by each sector of the productive activity. The totals of the columns and the rows record the total output of each sector, which should be equal, thereby indicating the balance of the economy where the costs of each sector are equal to their respective revenues.

The national I-O table describes the linkages within an economy at a specified point in time. It records the various interdependencies between the various sectors in the economy and their consumption of intermediate goods and services. Furthermore, it also describes the final demand of the sectors, the exports, the imports and the value added. For this model three important economic assumptions are needed: (i) a production function with constant return to scale, because of the fixed technical coefficients; (ii) each sector produces unique products which are not produced by other sectors and (iii) sufficient production capacity (Brand, 2012).

The regional I-O table can be considered a scaled-down version of the national I-O table. This will be derived through a mathematical procedure. This requires information, such as sector sizes, on the national and regional levels in order to create the regional input output table. This information can be calculated with the use of different methods. The RAS procedure will be applied since this method is considered appropriate for the available data. A description of the RAS procedure is as follows.

The available data are the national employment rates and the employment rates in Fejér and Tolna. We can assume that the work efficiency on the national level is equal to the local work efficiency. The RAS procedure is considered an application of the bi-proportional matrix scaling algorithm, which was proposed by Stone (Lahr and De Mesnard, 2004) and elaborated on by Szabó (2015).

The initial matrix is the national table. The regional table is assumed to be identical to the national one ($\mathbf{Z}^o$=$\mathbf{Z}^n$). However, this will not satisfy the equality criteria between the total of the rows, columns and regional frames. Thus in order to scale down the national table, the rows need to be multiplied with a ratio such that the regional frame and total supply in Z are equal. In our case the ratio is the employment ratios of each region (Fejér and Tolna). Secondly, the same procedure should be done for the columns. The row scaling ratio (column vector) is

$$r_i^1 = \frac{Z_i^r}{\sum_j Z_{ij}^{r1}} \quad (1)$$

where, Z_i^r implies the actual regional data and $\sum_j Z_{ij}^{r1}$ implies the sum of the stabilised table by j. In this equation, if $r_i^1 < 1$ then the elements in row i of the estimated table are higher than they should be and vice versa. Thus, the rows of the estimated table will satisfy the regional constraints by multiplying the table by this vector. In this stage the column totals will differ from the regional column frame. Therefore, the same procedure has to be applied for the columns as well. The column scaling ratio (row vector) is

$$s_i^1 = \frac{Z_i^r}{\sum_i Z_{ij}^{r1}} \quad (2)$$

The previous elaborations also account for this situation; if $s_i^1 < 1$, then elements in the estimated table are higher than they should be. Thus, they need to be scaled down by s_i^1 to achieve consistency ($Z^2 = \widehat{r}^1 Z^0 \widehat{S}^1$).

At this stage, it is likely that the rows will no longer satisfy regional constraints, thus the procedure has to be started again. The sequential repetition of step 1 and step 2 will adjust the initial table to be constrained by regional frames. Usually the procedure is convergent and after a few iterations, the estimated values will be very close to the regional frames (Szabó, 2015).

Through the RAS method the regional input output tables are created (see Annexes 2 and 3). The second step is to determine the technical coefficients. The technical coefficients are needed in order to calculate the multipliers such that one can calculate the direct and indirect effects of a change in the final demand. If the demand changes, the household incomes will change as well, which will lead to a change in employment. In this case, it is interesting to examine to what extent the increase in demand for inputs such as corn will lead to more jobs.

The multipliers are mathematically derived from the regional I-O table. It is important to realise that the model does not take increasing returns to scale into account, but only assumes a linear relationship between input and output. Moreover, all firms in a given industry are assumed to employ the same production technology.

The initial monetary values in the transaction matrices can be converted into ratios via the so-called technical coefficients. The technical coefficients, matrix *A*, represent the relationship between the total revenue of the sectors and the intermediary inputs they demand. This conversion can be done by dividing each cell of the domestic intermediate matrix by its column total (output at basic prices). This computation should also be done for the imports (intra and extra EU) and the added value.

As stated above the matrix visualises the intermediary demand. The following equation describes the intermediary demand (*Int.*) plus the supply to the final demand (*F*), which is equal to the total supply (*X)*.

$$Int. + F = X. \quad (3)$$

The intermediary demand can be derived from the revenue received by the sectors of the economy. As already mentioned the technical coefficients, matrix *A*, represents the relationship between the total revenue of the sectors and the intermediary inputs they demand. Matrix *X* represents the total supply of the sectors as well as their total revenue. From these definitions it follows that the matrix *Int.* can be created by multiplying *A* with *X*:

$$Int. = AX. \quad (4)$$

These two equations can be combined such that the following equation will appear:

$$AX + F = X. \quad (5)$$

This equation can also be expressed as:

$$X = (I - A)^{-1}F. \quad (6)$$

where *I* for the Unity Matrix. Writing it in first differences gives:

$$\Delta X = (I - A)^{-1}\Delta F. \quad (7)$$

Equation (8) shows that a change in demand (ΔF) multiplied by the multipliers (matrix $(I\text{-}A)^{-1}$) will lead to the change in the total output (ΔX). In this way equation (8) immediately reveals how much the total output per sector will change based on a change in the final demand. (Heijman *et al.*, 2017).

The model predicts that if the output in one sector increases, the output of other sectors to a certain extent will also increase. In this way expenditures of a business affects the economic development of a country directly as well as indirectly. In our research we will look at the effect of the influx of money from a biofuel refinery on the employment rate. Thus, the following hypothesis will be tested: *'The expenses of the ethanol plant in several sectors leads to an increase in job opportunities in the regional as well as the whole economy'.* Using the I-O model the impact of the expenditures of the biorefinery on output per sector has been analysed. The increase in output will eventually lead to more jobs in the sectors. The model predicts that economic growth within one section stimulates growth in other sectors due to the multiplier effect.

The primary input for the production of ethanol is corn; hence, the agricultural sector will probably experience a sharp rise in demand. This increase will be mostly noticeable in the surrounding regions of the bioethanol plant, thus in Tolna and Fejér. The ethanol is transported to other regions and abroad; the transport sector is strongly involved. It will depend on the transport services for which regions will benefit the most from this increase in demand. The next sector that should experience considerable economic growth is the manufacturing sector, followed by the service industry. The plant initially employed 172 people plus external personnel for maintenance support, thus it stands to reason that this sector will experience a direct increase in employment opportunities. In short, it is expected that there will be a rise in jobs due to the expenditures of the biorefinery in the Hungarian economy.

Results

This section presents the results derived by the use of the input output analysis. The data needed for the I-O table was obtained from the website of the Hungarian Central Statistical Office. In cooperation with the biorefinery the regional I-O table has been created for the regions of Tolna and Fejér (see Annex 2 and 3).

The multiplier effect is caused by an increase in the final demand (an impulse) within the economy. This extra demand leads to more supply, which will lead in turn to a higher income and eventually to higher expenditures. The multiplier effect refers to the increase in the total output arising from any new impulses in a sector of the economy. The multipliers have been estimated with the use of the national and regional I-O tables. These multipliers concern the so-called Type 1 multipliers, which do not take into account the increased spending because of higher incomes (Perez-Verdin *et al*., 2008).

For this research it is interesting to examine which sectoral impulse generates the highest regional impact (see Figure 1 and 2). The following sectors contain the highest multipliers: Agriculture, Hunting and Fishing (1.30 Tolna; 1.21 Fejér), Manufacturing (1.47 Tolna; 1.53 Fejér) and lastly Electricity, Gas and Water supply (1.18 Tolna; 1.09 Fejér). The multiplier effects at the national level slightly differ from ones at the regional level. The effects are the highest in the following sectors: Agriculture (1.27), Manufacturing (1.49) and Finance and Insurance (1.25). At the regional level the multiplier effect of the Finance and Insurance sector is smaller. The plant spending one HUF extra in the agricultural sector of Tolna will lead to a total effect of 1.30 HUF. This is because an impulse in one sector stimulates other sectors indirectly. From these results we can conclude that the expenditures of the biorefinery have the highest regional impact in the following sectors: agriculture, manufacturing and electricity.

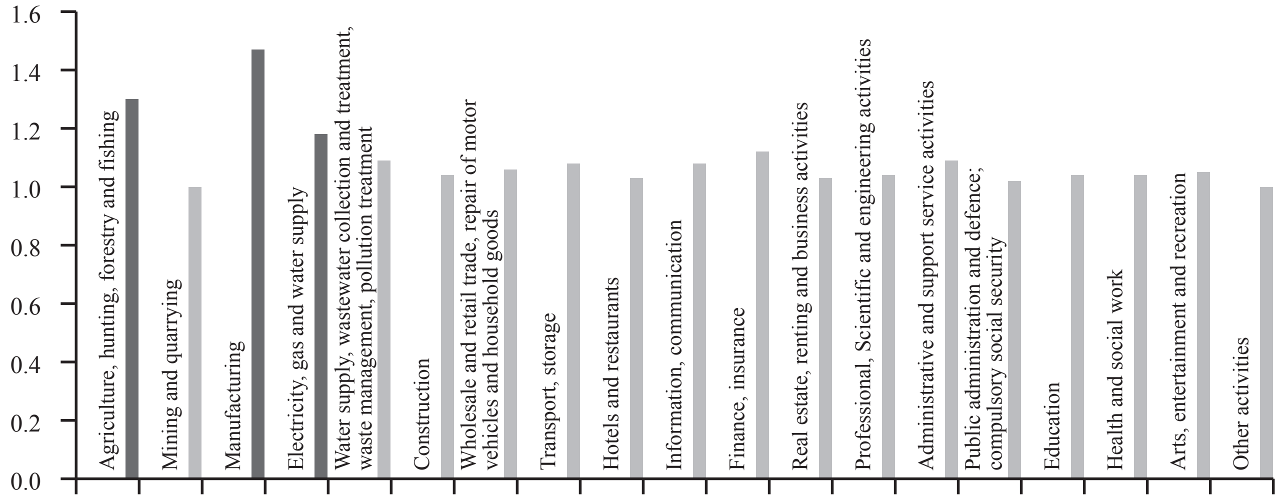

Figure 1: Multipliers for ‘Tolna’ region in 2017.

Source: Own composition based on HCSO (2018) data.

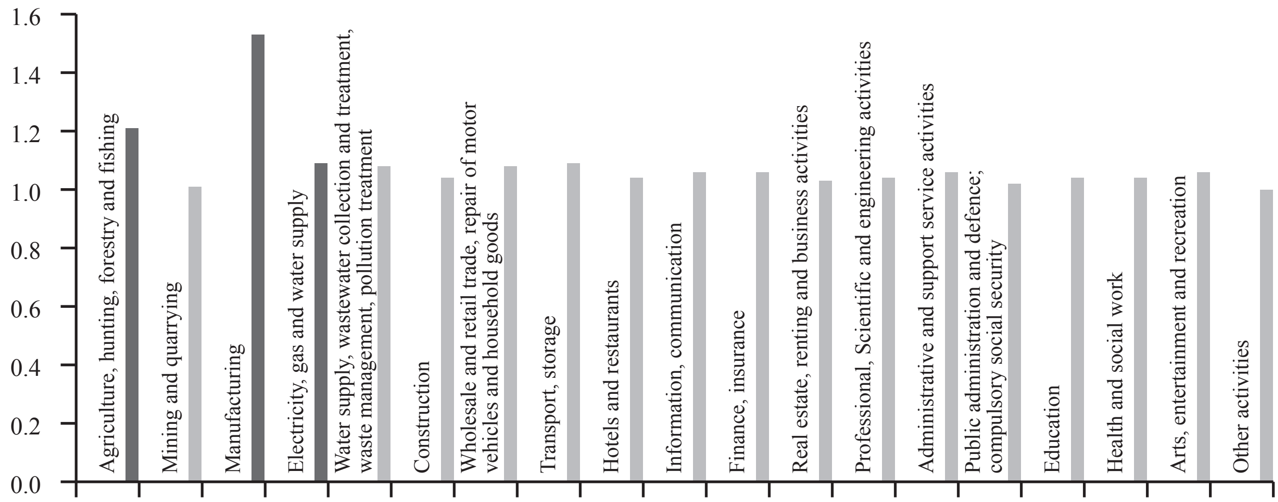

Figure 2: Multipliers for ‘Fejér’ region in 2017.

Source: Own composition based on HCSO (2018) data

The increase in demand (the impulse) can be estimated using the expenditures figures of the business among all of the sectors. In 2016, the biorefinery spent 58,116 million HUF in total on production factors and labour (Table 1). These expenditures, together with the expenditures of the households of the employees, form the total economic impulse. Remarkably, the results show that the biorefinery spends most of its money outside the regions of Tolna and Fejér. Hence, one can assume that the total impact of the biorefinery can be greater at the national level than at the regional level. Moreover, it is interesting to examine in which sectors most of the money is spent.

The majority of the expenditures of the biorefinery and the households were spent in 2016 in the Agriculture, Hunting and Fishing sector (more than 70%), with the remainder being spent in Electricity, Gas and Water supply (around 10%) and Transportation and Storage (6-7%). Smaller parts are spent in Construction (around 2%), Professional and Scientific Engineering (around 2%) and Public Administration and Defence (around 3%) (see Table 1).

The importance of the expenditures in the sectors will be further detailed when analysing the change in employment. As already shown, the multiplier effect is the highest in the sectors of Agriculture, Fishing and Hunting and Electricity, Gas and Water supply. Therefore, it is reasonable to assume that an increase in jobs will be significant in these two sectors at the national as well as local level.

The biorefinery´s expenditures lead to a change in the total output of Hungary. Using the calculated multipliers, an estimation can be made on the size of the change. With the use of the national output per sector and the national employment rates, it is possible to estimate the labour productivity per Full Time Equivalent. Moreover, we assume no variation across regions in Hungary in labour productivity. Since it is reasonable to assume that labour productivity differs between countries, we only focus on the changes in output within Hungary.

The biorefinery spent 58,116 million HUF in total in 2016, mostly in the agricultural sector (Table 1). If we take the change in output, ΔF, and we multiply this with the multipliers, we will get the total change in output per sector. In order

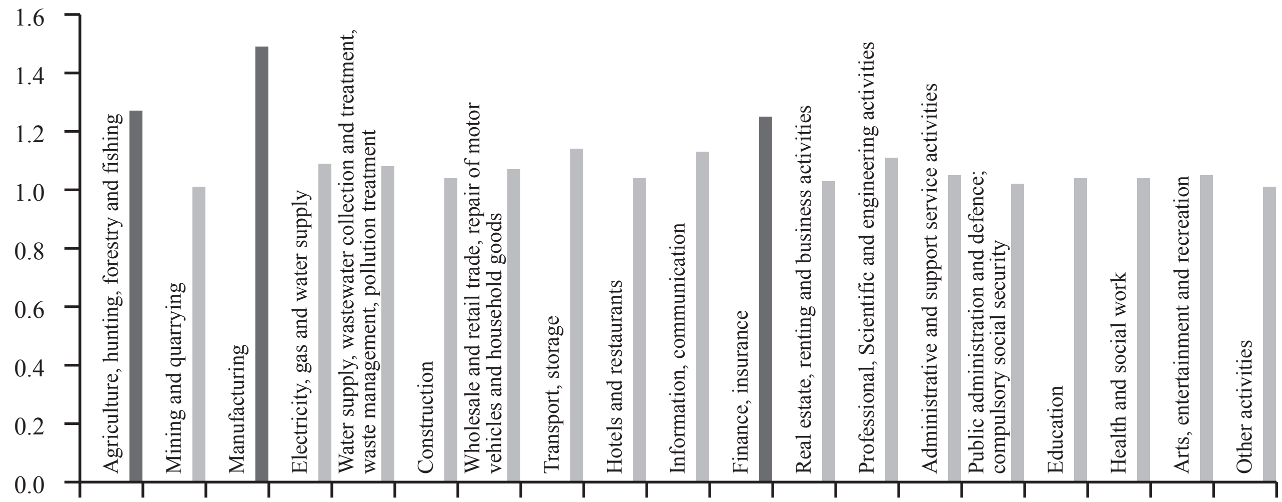

Figure 3: Multipliers for Hungary in 2016.

Source: Own composition based on HCSO (2018) data.

Table 1: Expenditures of the biorefinery per sector in 2016 (Millions of HUF).

	National	Tolna	Fejér
Agriculture, hunting, forestry and fishing	41,631.83	6,249.71	2,926.83
Mining and quarrying	19.20	5.99	9.30
Manufacturing	1,738.64	111.90	863.61
Electricity, gas and water supply	5,895.87	243.78	14.13
Water supply, wastewater collection and treatment, Waste management and pollution treatment	14.55	4.54	7.04
Construction	1,209.83	302.51	302.65
Wholesale and retail trade, repair of motor vehicles and household goods	5.66	1.77	2.74
Transport and storage	3,728.45	283.66	268.02
Hotels and restaurants	130.02	21.81	39.02
Information and communication	41.75	13.03	20.21
Finance, and insurance	449.55	12.98	20.13
Real estate, renting and business activities	97.39	30.40	47.14
Professional, scientific and engineering activities	1,069.12	0.33	0.51
Administrative and support service activities	353.56	106.14	20.14
Public administration and defence as well as compulsory social security	1,651.03	495.32	0.63
Education	13.69	4.27	6.63
Health and social work	21.82	6.81	10.56
Arts, entertainment and recreation	18.51	5.78	8.96
Other activities	25.78	8.05	12.48
Total Expenditures	**58,116.26**	**7,908.77**	**4,580.73**

Source: Own composition based on HCSO (2018) data.

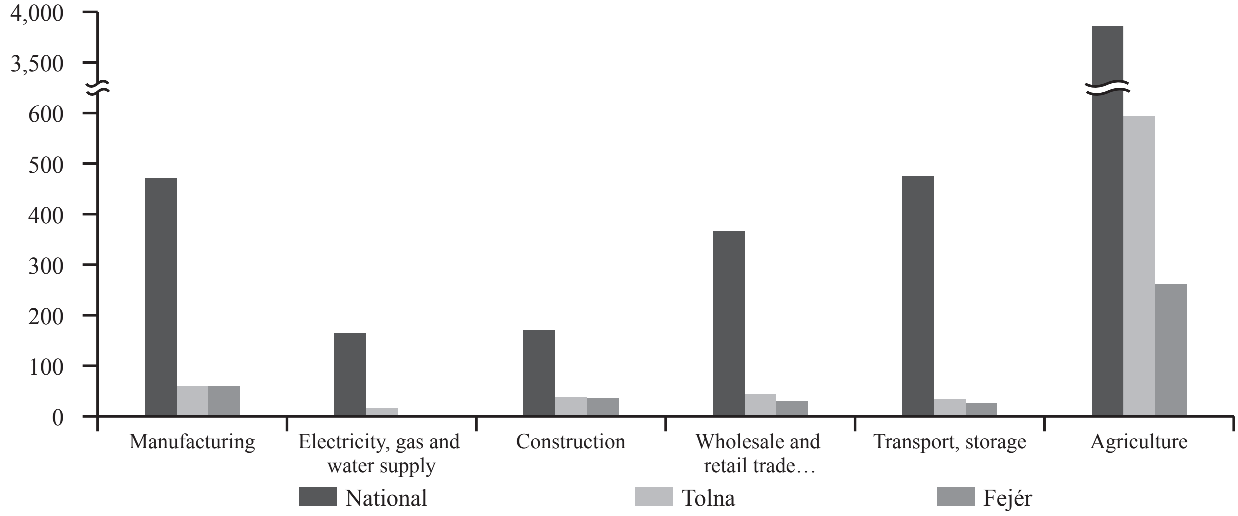

Figure 4: Expected increase in the number of jobs per sector.
Source: Own composition based on HCSO (2018) data.

to estimate the change in employment per sector the last step is to divide this change in output by the labour productivity per sector. The main findings are displayed in Figure 2.

Given the increase in expenditures in the agricultural sector, we see that this sector will experience the sharpest rise in the number of jobs. At the national level the biorefinery generates 3,859 jobs in the agricultural sector. In Tolna and Fejér, this number corresponds to 594 and 261 jobs, respectively. The Transport and Storage sector also shows a sharp increase in employment. However, in comparison to the agricultural sector the change in employment is higher at the national level than at the regional level. Therefore, we can conclude that the biorefinery mainly uses transport facilities outside the regions of Tolna and Fejér. The construction, the manufacturing, the electricity, gas and water supply and the trade and repair sectors show a significant increase in jobs as well.

The biorefinery has kept expanding and will continue to do so in the next couple of years, but this trend may slow down in the mid future. Thus, it is possible that the expenditures for construction will decrease in the future, which will have a mitigating effect on the rise of employment in the construction sector. The increase in jobs is partly due to constant expenditures and partly due to one-time expenditures in the establishment of the plant.

Overall, the biorefinery creates around 5,500 jobs. This is a large number if we take into account that directly the plant itself employs only 172 people. This means that the number of indirect jobs connected to the biorefinery includes more than 5,000 jobs in total. At the regional level this is approximately 785 jobs in Tolna and 416 jobs in Fejér counties. These numbers show that the biorefinery creates jobs at the regional as well as national level. These numbers are estimated using the 2016 expenditures, and therefore may change over the years.

Discussion and Conclusions

The results of our research show that at the national level the number of jobs related to the activities of the biorefinery is around 5,500 jobs. For the regions Tolna and Fejér this number corresponds to 785 and 416 jobs, respectively. These figures are significant compared to the size of the regions assessed. Furthermore, the reason behind the relatively high figures may be the specific nature of biorefineries; embedded in the local economy, low level of inputs from outside of the region, most expenditures have impacts within the region, which, as a consequence, may lead to largely keeping the jobs created in the region and in the country.

Direct and indirect jobs are also created. While Hunsberger *et al.* (2017) fails to consider indirect jobs in the service sector and therefore their analysis is lacking, the latter category appears larger. Our finding shows that the number of jobs created indirectly in the agriculture and services industries are more than an order of magnitude higher than jobs created and maintained within the plant gates (5.000 v 172). Little previous research has focused on indirect jobs; however, our modelling underlines their importance. Furthermore, biorefineries are embedded in the local economy; therefore, most expenditures lead to jobs being created in the region, more specifically in the rural areas, because the major inputs for the biorefinery are generated by agriculture.

The significance of the national jobs with respect to county level ones may be due to the fact that biorefineries operate across the borders, i.e. the products they make are sold across countries. For instance, ethanol is a commodity freely traded on the European market and beyond. This notion implies that the adjacent service industry may be of cross-boarder character, and, as a result, jobs created and maintained are not strictly rooted in the local or regional economies.

The value of the multipliers is in line with results from similar analyses. For example Heijman *et al.* (2017) computed regional multipliers for the 12 Dutch Provinces, of which results are comparable to the findings in this article. Though we are of the opinion that our results are rather robust, in order to find out how much changing the assumptions may modify results, it may be considered to carry out a sensitivity analysis in a follow up study. This may concern variations in sectoral and regional labour productivity and other assumptions. For a reasonable range of values concerning these variables, a considerable impact on the final results is not to be expected.

Ultimately, the results show that there is a considerable contribution by the biorefinery to the Hungarian economy. What has not been discussed is its effect on the surrounding countries. Unfortunately, it is difficult to make an educated guess regarding the extent to which trading partners benefit in terms of jobs. The use of the I-O model is insufficient for answering such a question, since it makes use of the national labour productivity. One cannot assume that the labour productivity is the same for all European countries. Nonetheless, it is reasonable to assume that the surrounding countries will experience an increase in the demand for their products. Looking at the results, it can be expected that the imports will increase in comparison to the previous situation. Thus, it is likely that the surrounding countries will also experience some rise in employment. We can conclude that there must be a positive effect on those countries; only the size of this effect is unclear.

Since its primary input is corn, the bioethanol plant we examined increases the demand in the agricultural sector significantly. The service industries, including the construction, logistics and administrative sectors, have also experienced an increase in demand. The increase in demand in these sectors leads to an indirect demand effect in the remaining sectors. Due to the multiplier effect and the increase in demand the economy as a whole grows, which leads to more jobs at the national level.

Our conclusion is that the spending of the biorefinery in the agricultural sector significantly effects the economic development at the national as well as regional and perhaps international level. In particular, rural areas benefit from this type of spending, since biorefineries are typically located in rural settings. The resulting increase in jobs may help rural regions overcome poverty and can positively influence the national and European economy as a whole. Our results appear to be in line with figures presented by IRENA (2017) and Urbanchuk (2018). Based on this result it may be a good idea to explore the potential in Europe and elsewhere to expand the production of biofuels to foster rural development.

As a thought experiment, the European context and potential may be scaled by a simple calculation. 5.81 billion liters of bioethanol was produced in Europe in 2015 (ePURE, 2017). The production of the biorefinery in question (450 million litres) amounted to 7.7% of total European bioethanol production. To put the findings into perspective, provided the impact on jobs does not differ significantly across the European bioethanol industry, we may extrapolate that about 70 thousand jobs are created and maintained in various rural regions in Europe by the European ethanol industry (5,500 divided by 7.7%). Needless to say that the actual impacts of each biorefineries are different, depending among other things on their technology, spending patterns and the contexts of the regional economies, so more research is warranted to extrapolate to European context.

The revision of the Common Agricultural Policy (CAP) offers an opportunity to consider rural development impacts of EU policies. One of the objectives of CAP reform has been to foster rural development. Our finding suggests that biorefineries may be seen as a useful element in achieving such objective. In addition to the CAP, it is proposed that the Renewable Energy Directive as well as other energy, climate, agriculture or transport related policies are to consider the rural development dimension of biofuels, or the bioeconomy in general.

Acknowledgement

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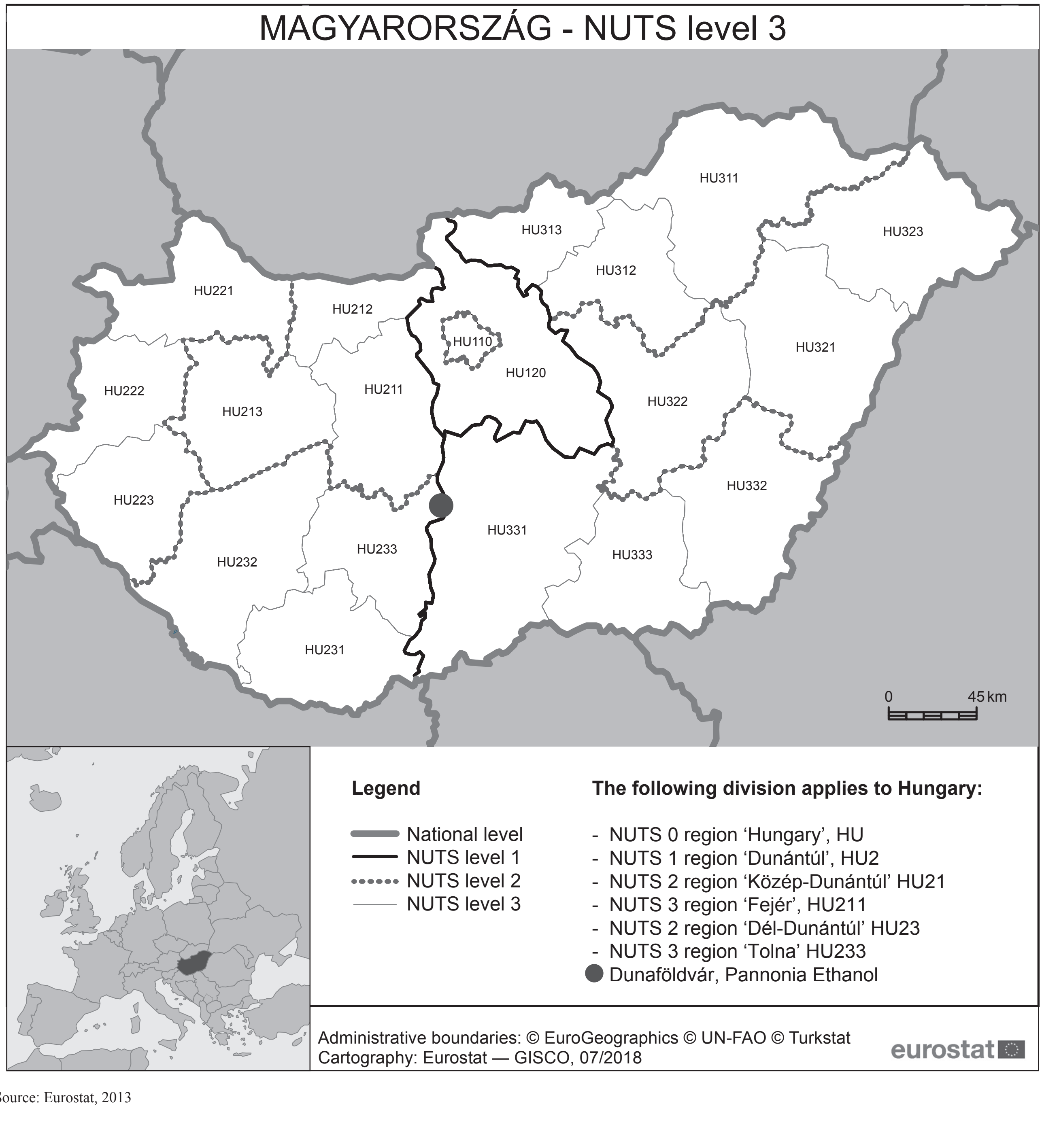
Annex

Annex 1: NUTS Regions in Hungary.



Source: Eurostat, 2013

Annex 2: I-O Table for Fejér.

Fejer (Million HUF)	Agriculture, hunting, forestry and fishing	Mining and quarrying	Manufacturing	Electricity, gas, steam and air conditioning supply	Water supply, sewerage, waste management and remediation activities	Construction	Wholesale and retail trade; repair of motor vehicles and motorcycles	Transportation and storage	Accommodation and food service activities	Information and communication	Financial and insurance activities	Real estate activities	Professional, scientific and technical activities	Administrative and support service activities	Public administration and defence; compulsory social security	Education	Human health and social work activities	Arts, entertainment and recreation	Other activities	F	Total Sum horizontal X
Agriculture, hunting, forestry and fishing	10,521	2	26,576	338	52	81	2,957	53	354	6	3	112	42	81	28	15	118	9	4	20,941	62,293
Mining and quarrying	46	49	6,360	696	49	313	129	39	9	2	1	77	12	26	29	31	37	8	3	1,043	8,957
Manufacturing	13,230	461	594,715	12,239	2,573	14,402	29,007	8,349	5,280	1,208	329	7,935	1,551	4,437	1,499	1,450	9,961	590	468	1,101,577	1,811,258
Electricity, gas and water supply	1,100	69	18,467	4,220	818	307	5,182	838	527	181	59	1,776	233	468	1,238	961	974	340	89	19,635	57,483
Water supply, wastewater collection and treatment, waste management, pollution treatment	194	11	4,908	301	1,548	147	1,244	95	126	19	16	536	40	190	356	200	396	104	38	10,729	21,198
Construction	64	12	2,011	679	299	1,530	551	546	52	54	8	2,518	64	139	955	333	200	83	30	32,204	42,336
Wholesale and retail trade, repair of motor vehicles and household goods	3,155	78	44,627	1,188	642	2,978	13,597	1,598	922	332	134	2,939	499	1,869	518	414	1,737	218	146	150,363	227,955
Transport, storage	806	110	16,016	2,527	364	915	9,252	4,079	203	188	127	838	222	1,308	1,533	265	349	130	87	15,539	54,857
Hotels and restaurants	15	5	794	31	13	66	418	90	616	28	12	75	82	1,553	345	142	558	44	99	13,700	18,684
Information, communication	84	9	4,482	470	170	202	2,852	382	109	905	191	534	333	768	576	516	313	326	126	4,181	17,528
Finance, insurance	225	12	1,716	188	70	211	1,522	234	82	45	593	3,487	123	272	316	42	74	25	34	903	10,174
Real estate, renting and business activities	302	24	7,243	839	762	808	10,333	887	650	453	233	2,622	747	1,590	2,119	985	1,141	609	349	93,761	126,455
Professional, Scientific and engineering activities	228	65	7,185	1,053	208	535	6,154	324	126	263	139	1,708	790	996	362	124	202	137	51	2,725	23,376
Administrative and support service activities	271	76	24,112	1,749	575	929	8,974	1,686	484	579	539	3,291	644	3,383	829	515	898	542	158	19,001	69,235
Public administration and defence; compulsory social security	93	16	1,443	300	310	111	1,593	560	89	169	120	388	129	254	929	80	54	90	83	55,891	62,703
Education	23	1	754	54	34	38	540	56	21	38	40	90	63	122	5	1,481	23	6	32	38,518	41,940
Health and social work	4	1	610	48	26	21	398	73	53	7	8	36	14	75	12	23	2,035	19	30	49,594	53,085
Arts, entertainment and recreation	11	1	409	30	16	29	260	37	21	50	7	66	24	247	5	4	16	499	20	7,805	9,556
Other activities	72	1	592	78	77	56	792	101	82	46	27	243	58	153	86	69	189	38	20	3,149	5,929
added value	23,844	1,279	246,376	22,392	10,414	17,391	107,879	22,472	7,625	9,089	6,938	96,386	12,788	31,664	50,142	34,110	33,641	5,427	3,908	743,765	
Imports cif intra EU	6,822	1,434	550,859	5,439	1,956	976	17,129	7,406	971	2,205	529	599	3,761	13,122	572	141	123	210	73	614,327	
Imports cif extra EU	1,169	5,241	250,726	2,612	221	282	7,152	4,944	277	1,658	122	186	1,153	6,509	245	37	41	100	80	282,757	
Total Sum vertical (X)	62,279	8,957	1,810,981	57,471	21,195	42,327	227,914	54,849	18,681	17,526	10,173	126,443	23,373	69,227	62,698	41,937	53,079	9,554	5,929		

Source: Own composition based on HCSO (2017) data.

Annex 3: I-O Table for Tolna.

Tolna (Million HUF)	Agriculture, hunting, forestry and fishing	Mining and quarrying	Manufacturing	Electricity, gas, steam and air conditioning supply	Water supply, sewerage, waste management and remediation activities	Construction	Wholesale and retail trade; repair of motor vehicles and motorcycles	Transportation and storage	Accommodation and food service activities	Information and communication	Financial and insurance activities	Real estate activities	Professional, scientific and technical activities	Administrative and support service activities	Public administration and defence; compulsory social security	Education	Human health and social work activities	Arts, entertainment and recreation	Other activities	F	Total Sum horizontal X
Agriculture, hunting, forestry and fishing	8,738	0	9,332	965	39	73	741	25	220	6	3	70	27	74	20	11	132	6	2	18,442	38,927
Mining and quarrying	7	1	411	366	7	52	6	3	1	0	0	9	1	4	4	4	8	1	0	28	913
Manufacturing	7,070	42	134,372	22,495	1,249	8,306	4,675	2,582	2,114	769	247	3,196	642	2,613	698	721	7,179	259	130	245,253	444,612
Electricity, gas and water supply	1,301	14	9,229	17,158	879	392	1,847	574	467	255	98	1,583	213	610	1,275	1,058	1,553	330	55	84,707	123,597
Water supply, wastewater collection and treatment, waste management, pollution treatment	133	1	1,417	707	960	109	256	37	65	16	15	276	21	143	212	127	364	58	14	6,994	11,924
Construction	39	1	516	1,417	165	1,001	101	192	24	39	7	1,151	30	93	504	188	164	42	9	20,491	26,173
Wholesale and retail trade, repair of motor vehicles and household goods	1,448	6	8,657	1,875	267	1,475	1,881	424	317	182	87	1,017	177	945	207	177	1,075	82	35	21,470	41,803
Transport, storage	413	10	3,466	4,448	169	505	1,428	1,208	78	114	91	323	88	738	684	126	241	55	23	4,635	18,843
Hotels and restaurants	9	0	190	60	7	40	72	30	262	19	9	32	36	971	171	75	427	21	29	5,922	8,382
Information, communication	72	1	1,629	1,389	133	188	739	190	70	926	231	346	222	728	432	413	363	230	56	4,460	12,817
Finance, insurance	247	2	800	715	70	251	506	150	68	60	919	2,898	105	330	303	43	110	23	19	1,516	9,134
Real estate, renting and business activities	185	3	1,872	1,764	423	533	1,905	314	298	330	200	1,208	353	1,071	1,129	561	941	306	111	45,069	58,574
Professional, Scientific and engineering activities	153	8	2,040	2,432	127	388	1,246	126	64	211	131	865	411	737	212	78	183	75	18	1,456	10,960
Administrative and support service activities	229	11	8,600	5,074	441	845	2,283	823	306	582	640	2,092	421	3,145	610	405	1,022	375	69	18,099	46,070
Public administration and defence; compulsory social security	56	2	366	618	169	72	288	194	40	121	101	176	60	168	485	45	44	44	26	30,080	33,154
Education	14	0	191	112	18	25	98	19	9	27	34	41	29	80	3	827	18	3	10	22,158	23,716
Health and social work	3	0	154	98	14	13	72	25	24	5	7	16	7	50	6	13	1,642	9	9	40,292	42,458
Arts, entertainment and recreation	7	0	105	63	9	19	47	13	10	36	6	30	11	165	3	2	13	248	6	4,170	4,962
Other activities	36	0	127	136	35	30	121	30	31	28	19	93	23	86	38	33	129	16	5	851	1,866
added value	14,043	130	61,350	45,359	5,573	11,053	19,160	7,660	3,364	6,376	5,744	42,793	5,832	20,552	25,736	18,710	26,720	2,626	1,193	323,977	
Imports cif intra EU	4,018	146	137,170	11,017	1,047	620	3,042	2,525	429	1,546	438	266	1,715	8,517	293	77	97	102	22	173,088	
Imports cif extra EU	688	533	62,434	5,291	118	179	1,270	1,685	122	1,163	101	83	526	4,225	126	20	32	49	24	78,670	
Total Sum vertical (X)	38,906	912	444,426	123,560	11,920	26,168	41,784	18,830	8,380	12,810	9,128	58,563	10,951	46,045	33,151	23,715	42,456	4,962	1,865		

Source: Own composition based on HCSO (2017) data