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Macroeconomic impact of Pannonia Bio in Hungary between 2015 and 2019

Written for Pannonia Bio Zrt.

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Executive summary

1. The goal of our analysis has been to estimate the macroeconomic impacts of Pannonia Bio Zrt., a biorefinery. This is the first of two studies- focusing on an *ex-post* analysis for the five-year period covering 2015 and 2019. The next study will be an *ex-ante* analysis for the five-year period covering 2020-2024.

2. The overall impact is the sum of direct and indirect impacts. Pannonia Bio's direct impacts come from its own employment, value added, export, and tax payments. Indirect impacts, by definition, are the sum of the other impacts that Pannonia Bio has on the rest of the economy. The indirect effects are estimated from a calibrated CGE model for Hungary for the 2015-2019 period.

3. The CGE model used is an updated version of the model Major used in 2016 to estimate the macroeconomic impact of the same company for the period 2010-2020, of which 2016-2020 was based on projections. Depending on the scenario for the period 2016-2020 the estimated effect of the company on GDP was between 720 and 1,035 million euros; the employment effect was between around 1,300 and 2,150 persons on yearly average (most of which was indirect effects).

4. Our result for the 2015-2019 period shows an even larger GDP impact: almost 2 billion euros, 86% of which is indirect. The total employment effect is 1725 persons, 88% of whom are indirect. Tax revenues increased by 464 million euros, of which less than 9% comes from Pannonia Bio directly. The direct impact on trade balance is positive as Pannonia Bio’s exports are significantly higher than its imports. On the other hand, the indirect impact on trade balance is negative as the import of manufacturing products is higher than the indirect export increase of other chemicals. The *total* impact on the trade balance was positive.

	2015-2019 Ex-post Effects		
	direct	**indirect**	**total**
GDP*	267	1680	1947
Employment**	199	1526	1725
Budget *	39	424	464
Trade Balance*	1252	-264	988

*m€
**yearly average, persons

5. The impact of Pannonia Bio on GDP is about 0.8 euro for each litre of bio-ethanol produced. This is larger than our previous estimates, showing increasing impact coming from the production as it, and the Hungarian economy, mature.

6. The study contains one additional scenario where we acknowledge the yield increase of Hungarian maize production. In the model this would mean on average an additional yearly 0,45 percent increase for the efficiency

of the whole agricultural sector. Assuming that this yield increase is the result of Pannonia Bio stabilizing demand in the market and fostering investment, we incorporate this shock among the firm's effects.

7. This exercise increased the indirect impacts of Pannonia Bio in the economy. The GDP impact increased by 0.3 billion, the indirect employment impact by another 400 persons. The budget received an additional 75 million euros. The trade balance increased as well by 174 million euros, with exports and imports increasing at the same time.

	2015-2019 Ex-post Effects		
	direct	indirect	total
GDP*	267	2047	2314
Employment**	199	1950	2149
Budget *	39	500	539
Trade Balance*	1252	-90	1162

*m€
**yearly average, persons

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1. Introduction

Pannonia Bio (previously Pannonia Ethanol) is a firm producing bioethanol and animal feeds, most of which is sold abroad. The factory was constructed mainly in 2010-2011, but expansion investments have been continuous ever since. The factory started production in 2012, and today almost half of Hungarian industrial processing of corn occurs in the Pannonia Bio factory.

Our goal is to estimate the macroeconomic impacts of this enterprise. HÉTFA has carried out two previous analyses of Pannonia Bio. In an earlier *ex-ante* study by HÉTFA Research Institute (*Szabó-Morvai* [2012]), Szabó-Morvai used a different method to calculate the expected impact of the building up of two bioethanol factories (in Dunaföldvár and Mohács), of which only one factory was actually built. In 2016, Klára Major also carried out a mixed analysis (*Major* [2016]) – which contained an *ex-post* and an *ex-ante* part – for the 2010-2020 period. Back then, the 2010-2015 period was considered as the past – which provided an opportunity for *ex-post* analysis - and the 2016-2020 was considered as a projection. Results relating to this period are an *ex-ante* estimation, and as such dependent upon certain assumptions, which means several scenarios were estimated (see later in detail).

In our 2016 study, we mentioned that the full capacity was not reached by the end of 2015. Now the plant is operating at full capacity. The present analysis employs an updated version of Major's macroeconomic model to carry out an analysis of Pannonia Bio's production – thus it relies heavily on that study. This study focuses on an *ex-post* analysis for the five-year period covering 2015 and 2019; a next study to be completed in the immediate furture will be an *ex-ante* analysis for the five year period covering 2020 and 2024.

This study is organized as follows: first we shortly introduce the methodological approach (highlighting the parts that have been upgraded since the last study) and Pannonia Bio's activities. Then we summarize previous results; after that we turn to the simulation results. Technical issues are dealt with in the Annexes.

2. Methodological approach

In the following section we introduce the approach we used for this analysis. The main points are the same as they were in 2016: first we give a short introduction of our macroeconomic model. The impact of Pannonia Bio on the Hungarian economy is estimated using the updated HÉTFA CGE model. "CGE" stands for Computable General Equilibrium, which is a model family based on general assumptions and used mainly for policy simulations. In a CGE model the behaviour of the domestic participants of the economy (households, firms and governments) is described using standard solutions from microeconomics. As usual, households maximize their utility given their budget constraints, and firms use labour, capital and material inputs for their production. Governments buy products from firms, give income transfers to households and collect taxes. The transactions with the rest of the world are mainly pure exchanges of products, and we assume that domestic and foreign goods are not perfect substitutes to each other. The decisions of the participants (especially households and firms), namely decisions on consumption, production, export and import are mainly driven by price differentials. The decision makers in the economy take prices as given; they do not take into account their own influence on the determination of prices (assumption of price takers). Whenever an event leads to a change in the price of a particular good, households and firms try to substitute that good with a cheaper one. This substitution effect is quite strong; much of the adjustment process is driven by price changes.

The main model assumptions are the same as in 2016, but several details are updated since the last estimation:

- The updated model uses a new social accounting matrix based mainly upon the input-output tables for the year 2015, which were released in 2018;
- In the previous version, macroeconomic parameters were calibrated only for the first period (then 2010), and those parameters were used in all the other simulation years. In the current version some exogenous time-series, like the GDP path, labour supply, government expenditure etc. are all defined based on a Convergence Programme of Hungary. Using these variables, the parameters are recalculated for each period during the simulation;
- The updated model has only one kind of labour (not skilled and unskilled like before) and uses a simplified saving behaviour for the households.

As a consequence of these changes the results of the 2016 study are not directly comparable with the results detailed in following sections.

As before, we expect Pannonia Bio to have two, well distinguishable types of economic impacts: direct impacts and indirect impacts. Direct impacts come from Pannonia Bio's employees, investments and purchases. Indirect impacts, by definition, are the sum of all other impacts that Pannonia Bio has on the rest of the economy (for example employment and production in other, connected sectors). The current simulation starts in2015, the year of the new social accounting matrix, and ends with 2019, as that is the last year for which we have actual data. A forecast for the 2020-2024 period, an *ex-ante* study, will be executed in the near future. The calculations for each year were done in HUF, and those effects for each year were converted to euro using the yearly average exchange rate published by the Central Bank of Hungary.

The direct impacts encompass direct effects of the firm. Pannonia Bio purchases maize from farmers to produce ethanol. Also, other material inputs are needed for production, like energy, chemicals, logistics and business services. We assume that without the existence of Pannonia Bio, this demand would not exist either. The indirect effects include the incremental income (value added), employment, tax payments, etc. of all those who supply material inputs to Pannonia Bio, and of suppliers to these suppliers, etc. The indirect effects are the sum of all such impacts cascading through the input-output linkages of the economy. Further details of the CGE model and the assumptions made are summarized in Annex 1.

The indirect impacts of Pannonia Bio come from three different sources:

1. The factory itself was built in 2010–2011, so the largest investments have been already done. However, the company kept investing after starting operations, overall about 107 million euros, doubling its fixed and intangible assets since the beginning of production. We assume that approximately half of each year's investment sum went to the construction industry, while the other half went to buying equipment, machines and production facilities from the manufacturing sector. This demand shock is called *'investment channel'* in the simulation.

2. Production of ethanol started in 2012, and both the volume and value kept increasing for the period of 2015-2019. Production requires a large amount of material inputs, of which the most important is maize. The share of maize in the total costs of material inputs varies between 60-80%, which shows the importance of this input. In addition to maize, energy and chemicals are also needed for production. Logistic services and other business services are used to market ethanol and animal feed. This demand shock is called the *'production channel'* in the simulation.

3. Employees of Pannonia Bio live in Hungary; therefore, they spend the non-saved part of their income and therefore increase the demand for consumption goods. This income effect is taken into account as an approximation: we assume that the total sum of net wages increases the demand for consumption. This demand shock is called the *'income channel'* in the simulation.

The indirect effects of Pannonia Bio are the sum of the investment channel, the production channel and the income channel. As in the previous study, we made four different simulations: one for each channel, and a final simulation when all three channels were present at the same time. Using these four simulations we can disaggregate the impact into relevant parts. The takeaway is that the total impact of Pannonia Bio on the Hungarian economy is just the sum of the direct and indirect impacts.

The impact estimated by CGE models is always a difference between a baseline scenario and a counterfactual scenario. The baseline scenario is calculated assuming that there is no intervention (business-as-usual), while the counterfactual scenario is calculated assuming that some parameters of the model have been changed. Additionally, CGE models use the „representative firm" approach, which means that each sector is represented by a single firm which can be considered as an average of existing, real firms in a given industry. Given these two specifications, the influence of a single factory on the whole economy needs to be considered carefully.

We introduced three potential ways to do this in the 2016 study (*Major* [2016]): for the first one, Pannonia Bio could be considered as the representative firm of its sector. But as the cost-structure of the firm was really different from the cost structure of the average chemical firm, this option was rejected. The second potential way to estimate the impact of a single factory was to create a separate industry for it, but this was also rejected as the simulation of a counterfactual scenario (without the firm) was not possible. The third and final way was to simply assume that the firm's material input adds an additional demand to the economy, as the firm has few industrial relationships and its product is mainly sold abroad.

For this study, we revisited the idea of using Pannonia Bio as the representative firm of the chemical industry, so compared again the cost-structure of the average chemical firm to the cost-structure of Pannonia Bio. The production of bioethanol requires maize, an input material that constitutes 60-80% of Pannonia Bio's material costs. Other main cost elements are energy (natural gas and electricity) and different kinds of chemicals. The marketing of bioethanol requires the usage of logistics and business services. This bioethanol production, in the standard classification of activities (NACE rev. 2), belongs to the "20.14 Manufacture of other organic basic chemicals" category. The data on input-output linkages, however, is not available in such a deep disaggregation, so we compare it to the „20 – Manufacture of chemicals and chemical products" and „C – Manufacturing" industries' cost-structure. As can be seen in Table 1, bioethanol production technology is still very different from the average manufacturing firm in Hungary, even from the average chemicals firm.

Table 1. Cost structures of average manufacturing, chemical, R&D firm and Pannonia Bio (%)

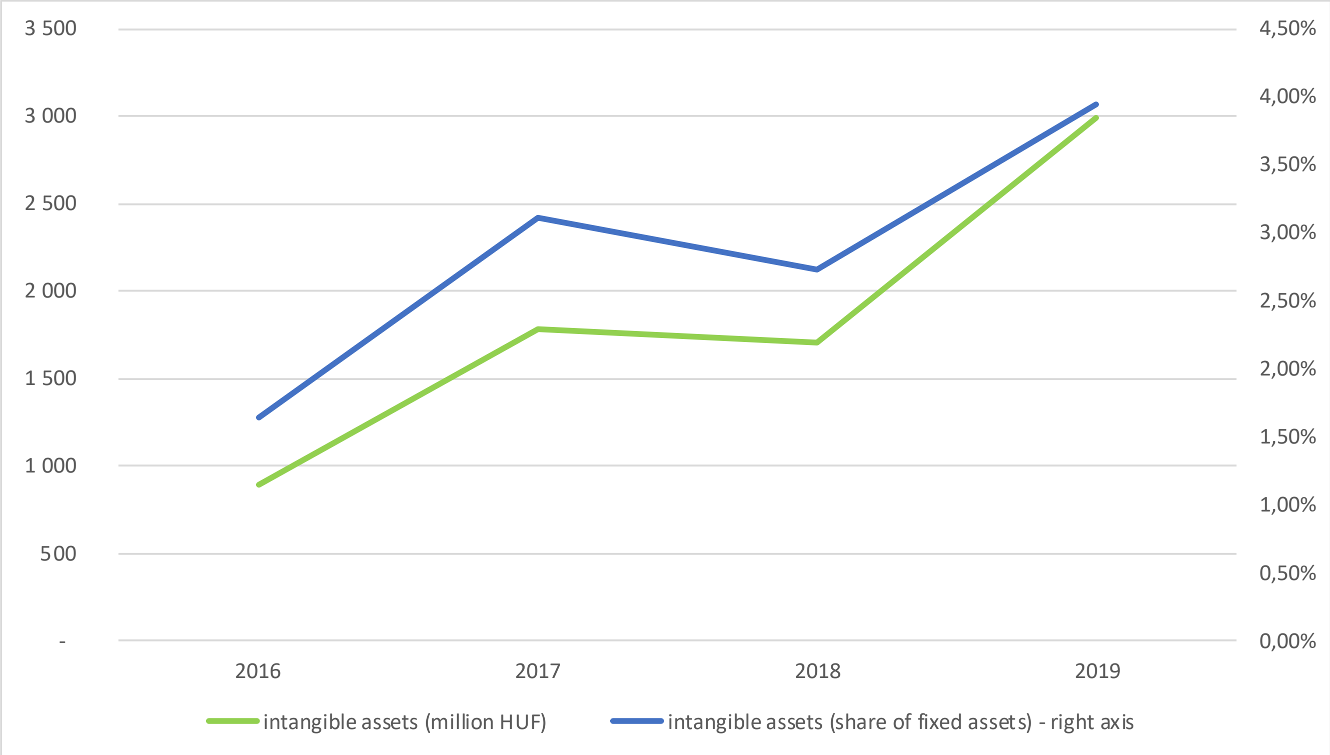
	Manufacturing (C)	Chemicals (20)	R&D (72)	Pannonia Bio
agriculture	5.36	4.85	1.35	67.73
manufacturing (without chemistry)	67.08	30.96	48.49	0.00
chemistry	7.58	38.29	4.93	2.92
energy	2.33	7.80	1.81	10.77
water	0.62	0.69	0.70	0.00
construction	0.19	0.25	4.25	0.00
trade	4.03	4.43	3.96	0.00
logistics	2.39	3.97	3.04	6.34
services	10.25	8.52	31.11	12.23
public services	0.19	0.21	0.37	0.00
total inputs	100.00	100.00	100.00	100.00

Source: Input-output table of 2015 from the National Statistical Office of Hungary and Pannonia Bio Zrt.

As is clear from the table above, there are major differences in almost all entries. The main difference between the average chemical company and Pannonia Bio is that the average chemical company uses a seventh as many agricultural products as Pannonia Bio. In 2016 this difference was even bigger because back then (based on a 2010 input-output table) chemical firms didn't use agricultural products at all - Pannonia Bio might have changed the industrial average. A manufacturing company usually gets more than three quarters of its inputs from its own sector. Even an average chemical firm buys a large share of its inputs from the manufacturing industry. However, only 3% of Pannonia Bio's inputs come from the chemicals industry.

Since our last study, Pannonia Bio launched significant research and development activities, the value of which they indicate as intangible assets in the balance sheet (see Figure 1). Several research approaches are considered, on the one hand in line with their chemical activity: they study how to produce ethanol from barley instead of corn. On the other hand, they are trying to utilize by-products as animal feed; and as another potential by-product of ethanol production is biogas, researchers at Pannonia Bio are investigating how to generate such biogas. These researches can result in new technologies and products in the future, and we will simulate these effects in the *ex-ante* study. In this *ex-post* scenario, we only could simulate the effort taken and since the company as whole is far from being a representative R&D industry firm (see again Table 1), the yearly changes of the net intangible assets were merely introduced as additional demand to the service sector (which contains research and development industry).

Figure 1. Intangible assets (million HUF and %)

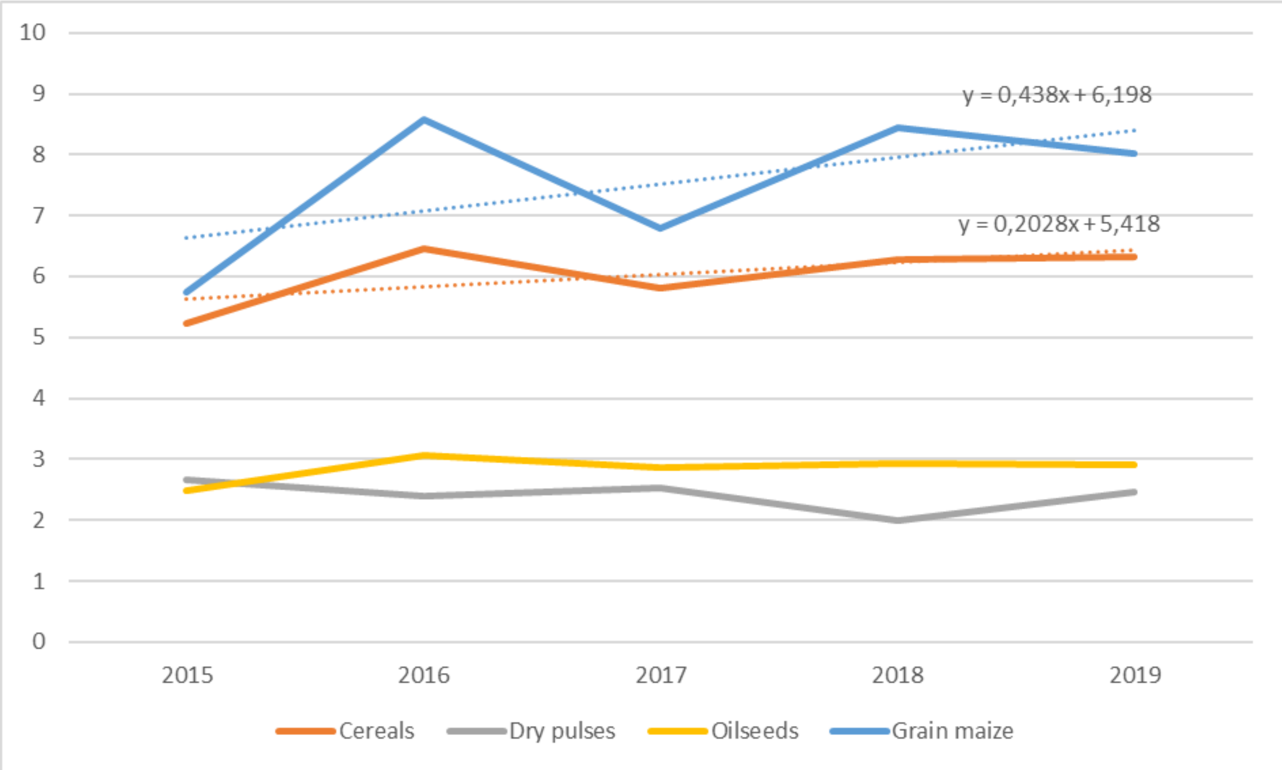


Source of data: Pannonia Bio Zrt.

There is another fact we have to address here in the methodological section. As can be seen in Figure 2, maize yields increased in the period examined (even if the positive trend was not significantly positive from zero). The timeseries are really volatile, but on average there is a yearly 6,5 percent change for the maize[1] and only a 3 percent increase for cereals as a whole. This additional trend could be introduced into the model by giving a shock to the total factor productivity of the agricultural sector, which is among others a measure of efficiency. This will be an alternative scenario in the result section. We are assuming that this efficiency increase is partly the consequence of Pannonia Bio stabilizing the Hungarian demand for maize and so fostering investments in the sector.

[1] Derived from the estimation of the equation ln(yield) = $\alpha + \beta$*year, the coefficient β is 0,646, the result is not significantly different from zero 90 percent significance level.

Figure 2. Crop yields (tonne/ha



Source of data: Eurostat - apro_cpsh1 database

To summarise: as Pannonia Bio can't be considered a representative firm of the chemical industry, we assume in the analysis that the costs of Pannonia Bio represents additional demand to certain industries. Our simulation will address how the overall employment, GDP and the sectoral distribution of these measures has changed as the extra demand appears through Pannonia Bio reaching its full capacity.

3. Previous results

In our 2016 study, we estimated Pannonia Bio's direct impacts on the Hungarian economy between 2010 and 2020, for which 2016-2020 was based on projections. Table 2 and Table 3 below shows the results. As shown in the previous chapter several aspects of the model changed since the previous study. This and the fact that an ex-ante study always has to make presumptions about the future make the results of this ex-post analysis not directly comparable to the previous results we present here. Our only goal in referencing them is to show how different scenarios affected the estimated impact.

In the baseline scenario, Pannonia Bio's total impact on GDP exceeded 1 billion euros in the estimation period. The impact on employment was 1300 - 1500 workers, 90% of them outside Pannonia Bio. Tax revenues increase by ~200 million euros, of which 75% are indirect. Pannonia Bio's ethanol and animal feed were sold abroad, which increased exports. However, other producers might have sold more at home – due to Pannonia Bio's impact on the economy – than before; therefore, Pannonia Bio's total impact on exports is actually lower than its direct impact. This is because as domestic goods become relatively more expensive, imports increased and exports decreased. Nonetheless the *total* impact on the trade balance was positive.

Table 2. Previous results – Base Scenario

	2010-2015 Base Scenario (ex_post)			2016-2020 Base Scenario (ex-ante)		
	direct	indirect	total	direct	indirect	total
GDP*	79	387	466	335	387	721
Employment**	78	1422	1500	147	1166	1313
Budget *	14	98	111	38	66	103
Export*	590	-156	434	1387	-361	1026
Import*	1	352	353	0	505	505
Trade Balance*	589	-508	81	1387	-865	521

*m€
**yearly average, persons
Source: Major [2016] p. 3 and 4.

One alternative scenario of the 2016 study assumed continuing investments (more in line with management's plans). Pannonia Bio's production volumes had been growing at a 12.2% annual rate between 2012 and 2015. The Base Scenario assumed that this rate of increase continued in 2016, but that this rate of increase wouldn't continue thereafter. Therefore, an Investment Scenario had been simulated by assuming that Pannonia Bio's investments would continue after 2016 at a rate similar to the past – see the results in the first columns of Table 3. Continued investments would have added a total of 314 million euros to the estimated overall GDP impact of Pannonia Bio, which is an almost 50% larger impact than if such investments stopped in 2016 (see also Table 3). Employment would have increased from 1,300 persons to more than 2,100 persons, and this increase would have come entirely from indirect effects. Tax receipts would have increased by about 10 million euros a year. The decline of induced exports would have been less, but nonetheless still rather significant. At the same time, imports would have increased more. The overall impact on the trade balance would remain positive; it might have been 110 million euros larger than in the Base Scenario.

Table 3. Previous results – Alternate Scenarios

	2016-2020 Investment Scenario (ex-ante)			2016-2020 Farmer Scenario (ex-ante)		
	direct	indirect	total	direct	indirect	total
GDP*	424	611	1035	424	2513	2937
Employment**	147	2024	2171	147	8476	8623
Budget *	44	118	162	44	238	283
Export*	1795	-444	1352	1795	-499	1297
Import*	0	720	720	0	639	639
Trade Balance*	1795	-1164	631	1795	-1138	657

*m€
**yearly average, persons
Source: Major [2016] p. 4 and 5.

Another alternative scenario of the previous study, called Farmer Scenario, treated the agricultural sector as a non-tradeable sector. This way the maize farmers would react to the increased demand created by the factory with increased investments and not by merely importing the maize needed to satisfy demand. These changes increased the factory's effects significantly. It added a total of 2,216 million euros to the estimated overall GDP impact of the factory, which is an almost four times larger impact than in the Base Scenario. Employment increased from 1,300 persons to more than 8,600 persons. Tax receipts also increased by about 30 million euros a year. This scenario was kept as a possible ceiling for the effects of Pannonia Bio.

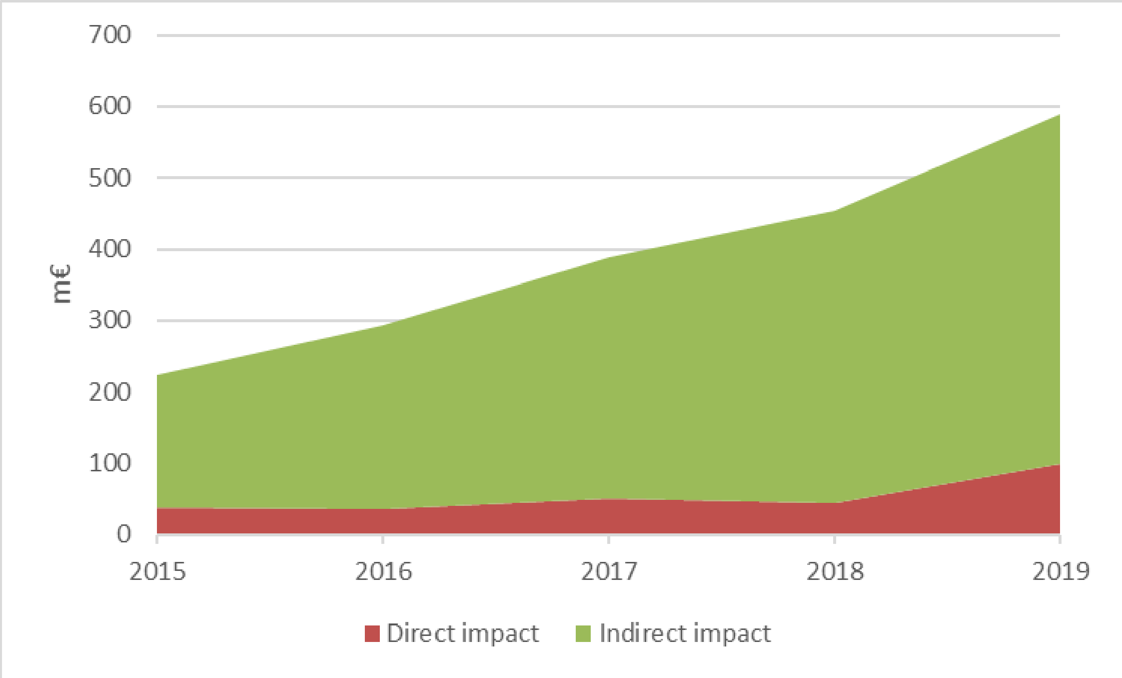
4. Evaluation of previous years' impact

Our recalculation of the macroeconomic impacts did not lead to surprising results. Thanks to the presence of Pannonia Bio, and its steady expansion, the overall employment, income and production increased even further than previously predicted. Both on the national and on the sectoral level, the indirect and direct impacts are positive and contributed visibly to the observed growth in the Hungarian economy between 2015 and 2019.

4.1. Impact on gross domestic product

The overall impact on Hungarian GDP between 2015 and 2019 sums up to nearly 2 billion euros, thanks to the constantly increasing direct and indirect effects, as shown in Figure 3 below and Table 5 in Annex 2. Most of the impacts were indirect, namely from the value added of suppliers through the input-output linkages of the Hungarian economy. The yearly direct impact shows no big variability thanks to the stable business. Just as in Major [2016], it may be surprising that indirect impacts increase even faster than the direct impacts. This result can be partly explained by the basic growth path of the Hungarian economy that is programmed into the CGE model. In accordance with that, it has been assumed that the overall national investment demand increases in this period, which leads to a small increase in the capital stock of the economy. This results in slow growth. The simulation aims to calculate how the path of the GDP changes if there is additional demand from Pannonia Bio, and even if this additional demand would be the same in monetary terms, it creates a larger impact in a slowly increasing economy by enlarging the multiplicative processes of the input-output linkages.

Figure 3. Impact on GDP (m€)



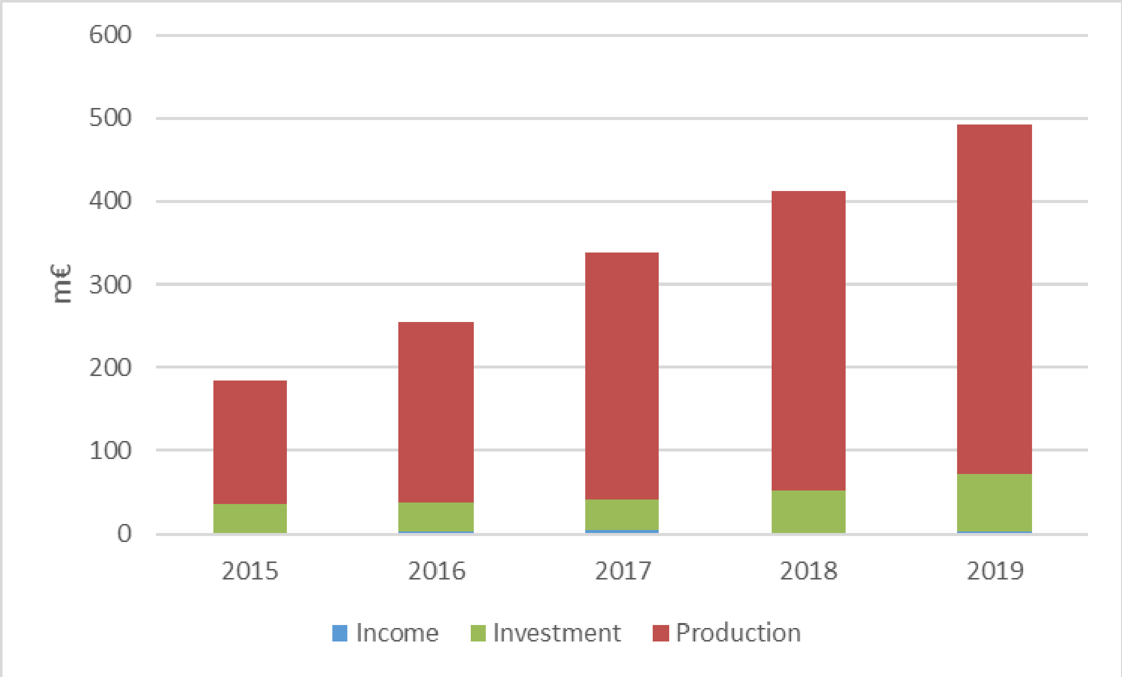
The impact of Pannonia Bio on GDP is about 0.8€ for each litre of bio-ethanol produced. This is larger than in the previous estimates, showing increasing impact coming from the production. Of this, about a quarter of the value added is done by Pannonia Bio itself, while the other 0.67 euro is the value added that is generated elsewhere in the economy.

Table 4. Per litre GDP impact

	2015	2016	2017	2018	2019	Average
Indirect (without construction)	0,51	0,54	0,69	0,76	0,84	0,67
Direct	0,13	0,09	0,12	0,09	0,20	0,13
Total	0,64	0,63	0,81	0,86	1,04	0,80

Next, we disaggregate the indirect impacts on GDP into its main channels, as explained in the methodological section. As seen in Figure 4, most of the effects come from the company's sales growth both in relative and absolute terms; however, the effects of investment can't be neglected. That additional impact is received mostly by farmers, suppliers of necessary chemical and other inputs bought by Pannonia Bio.

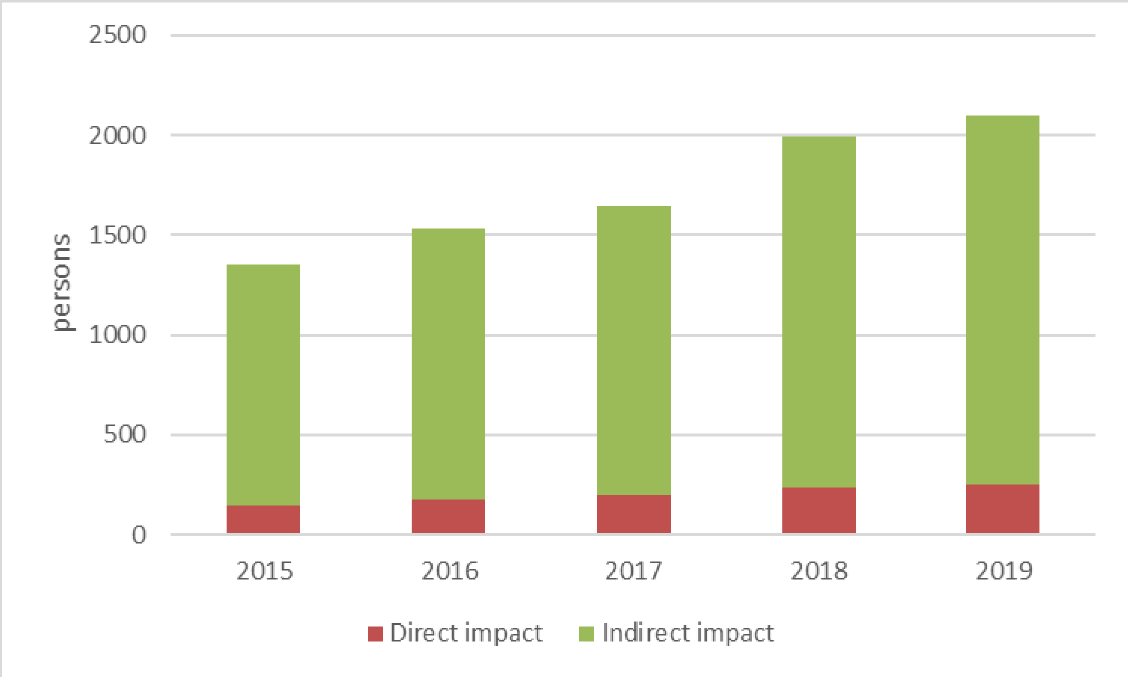
Figure 4. Disaggregation of indirect GDP impacts (m€)



4.2. Impact on employment

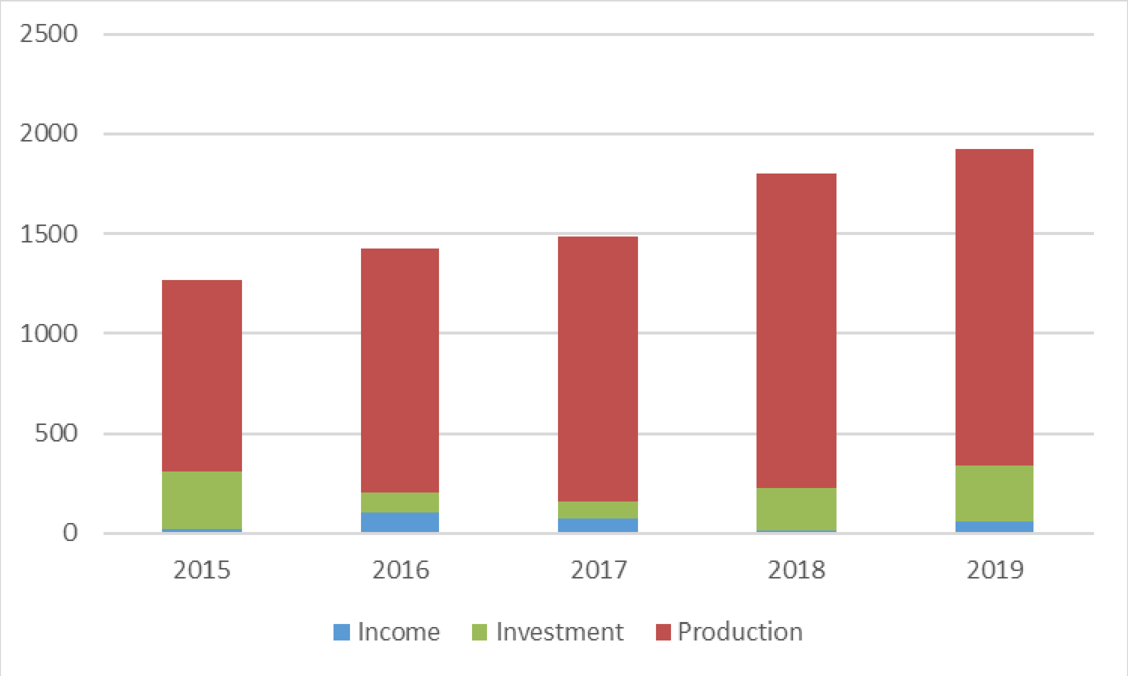
The employment effect shows a very different picture, as the indirect effects are way larger than the direct effects, as seen in Figure 5. This result comes from the fact that Pannonia Bio's technology is still less labour intensive than that of the average Hungarian firm. Even if we compare it to any industrial average, much less labour is employed by Pannonia Bio to achieve the same value added despite the sales-per-employee ratio showing a mild decrease. Therefore, Pannonia Bio's additional demand has a large impact on local employment as an indirect effect. This estimation is lower than some of the predictions cited in Chapter 3, and Annex 3 compares the employment impact of different models, methods (ex-post and ex-ante) and periods.

Figure 5. Employment Impact (persons)



We can see in Figure 6 that, just as for GDP, most of the indirect job impacts come from the production channel. The size of the investment effect largely depends on the initial size of the investment. The investment channel's impact on employment is more pronounced than on GDP, since Pannonia Bio is heavily connected to the non-tradeable construction sector, or relatively closed sectors like utility and agriculture that provide inputs that mostly cannot be procured from foreign markets. However, the income channel's importance largely depends on other factors, since its effect on employment doesn't seem to follow the size of income directly generated.

Figure 6. Disaggregation of indirect employment impacts (persons)



4.2.1. Relative impacts

In Table 5 we quantify the size of the shock and its impact in relative terms. Extra demand is constantly increasing over the period, while the relative impacts on both output and GDP are higher than before, showing a steadily increasing percentage impact on output and GDP.

Table 5. Size of the Impact (%)

	2015	2016	2017	2018	2019
Demand shock to GDP	0,152	0,178	0,178	0,182	0,227
Impact on Output	0,047	0,085	0,120	0,155	0,191
Impact on GDP	0,108	0,152	0,196	0,241	0,285
Impact on Employment	0,021	0,020	0,022	0,028	0,029

4.3. Further outcomes

In this section, we delve deeper into our results, further exploring the macroeconomic effects of Pannonia Bio.

4.3.1. Sectoral impacts

Positive effects for each affected sector value are presented in Table 4. The biggest beneficiary, not surprisingly, is the agricultural sector, since the biggest share of inputs come from this sector. The GVA increase for construction and manufacturing comes from the investment channel, and the manufacturing sector is further boosted, because Pannonia Bio is assigned to this sector.

As for output impacts, we see crowding out happening in services, decreasing sector output by a small margin, as seen in the Annex 2 tables. This negative value is heavily outweighed by the positive values of other sectors, especially manufacturing. Our calculations show some reorganization in the labour market, with some decrease of employment in the services sector, but a big increase in the agriculture and construction sector.

Table 6. Sectoral impact on value added (m€)

Sectors	2015	2016	2017	2018	2019	Total
Agriculture	85	146	170	203	227	831
Manufacturing	-47	-86	-101	-124	-153	-511
Energy	17	29	42	54	65	206
Construction	14	12	20	35	61	141
Services	24	52	69	87	120	352

As the model uses one kind of labour, which freely moves between sectors, the sectoral reconstruction of employment is probably overestimated in the model. On the one hand the highest employment gains are in the chemistry and the agricultural sector (75 percent of the new jobs are created in these two sectors), on the other hand manufacturing loses many jobs (87 percent of the lost jobs are from this sector). As there is no heterogenous labour and the model is highly aggregated we don't know which kind jobs disappear and what kind of new jobs were created in the process. But the highly aggregated nature of the model ensures that new jobs are created sector wide. For example, new jobs in the agriculture sector can mean animal breeders, farmers, forestry workers etc. as agriculture as a sector in the model contains three NACE categories:

- crop and animal production, hunting and related service activities,
- forestry and logging,
- fishing and aquaculture.

4.3.2. Crowding out effect

The table below contains the size of the crowding out effect in the period. Due to increased demand, there is more income in the economy, leading to higher household consumption. We can also see indirect effects in the international trade market, with import increase outweighing export increase, leading to an overall negative effect on the trade balance. The import increase can be explained by the price adjustment mechanism. The directly and indirectly increased demand generated by the company makes foreign goods relatively cheaper. The increase of export origins from the overall growth path of the economy. As expected, the total indirect impact is smaller than the extra demand of the company, so still leading to an increase in both GDP and employment.

Table 7. Crowding-out effect (m€)

	2015	2016	2017	2018	2019	Total
1. Extra demand of Pannonia Ethanol	223	293	389	454	589	1947
Impact on						
2. consumption	26	48	76	100	128	378
3. investment	0	0	0	0	0	0
4. government expenditure	0	0	0	0	0	0
5. export	77	213	398	562	742	1992
6. import	185	301	449	577	767	2280
7. trade balance (5.-6.)	-108	-88	-51	-15	-25	-288
Total indirect impact on GDP (1.+2.+3.+4.+7.)	141	252	414	539	692	2037

4.4. An alternate scenario – efficiency scenario

As we have shown at the end of the methodological section, there was an increase in maize yield during the period examined. The model in itself contains efficiency gains for the whole economy, so we only built in the additional increase that was specific for maize production. But as we can only shock the whole agricultural sector as a whole, we need to make the yearly 3.5 percent[2] additional increase in maize production relative to the whole sector. According to the Hungarian Statistical Office the maize production value was on average 13 percent of the whole agricultural production value for the period – which means that the additional 3.5 percentage point increase would mean a 0.45 percentage point increase for the whole sector. So in this scenario we give an additional yearly 0.45 percent shock to the total factor productivity of the agricultural sector (additional to the other demand shock from above), which is one way to simulate technological advancement. By assuming that this efficiency increase is partly the effect of Pannonia Bio we report here the changes in the GDP and employment impact.

The increase in agricultural efficiency increased the total indirect GDP impact by 400 million euros (Figure 7). As efficiency shocks of different years are adding together in a multiplicative way, the difference increases with time (is just 26 million in 2015 but 428 in 2019). The same is true for employment: on average the employment impact is 400 persons higher (Figure 8) and the difference is increasing as the efficiency gain increases, from 278 persons in 2015 to 1,126 in 2019.

[2] 6.5 percent for maize production – 3 percent for cereal production gives 3.5 percent.

Figure 7. Impact on GDP efficiency scenario (m€)

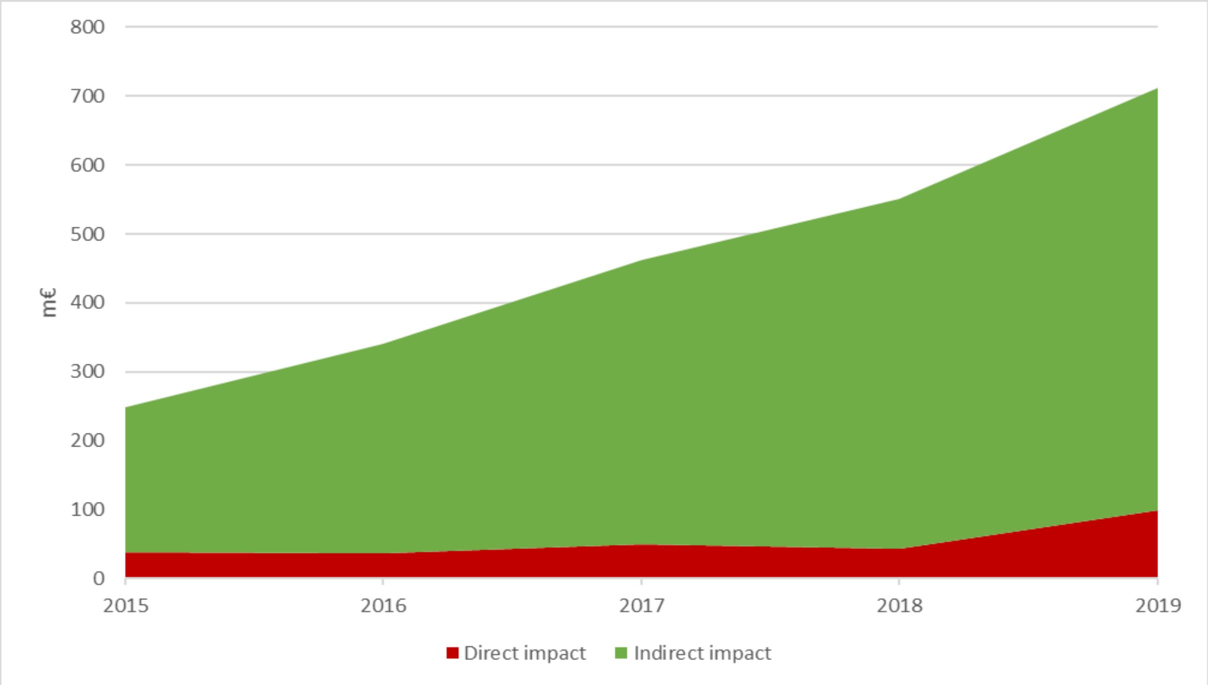
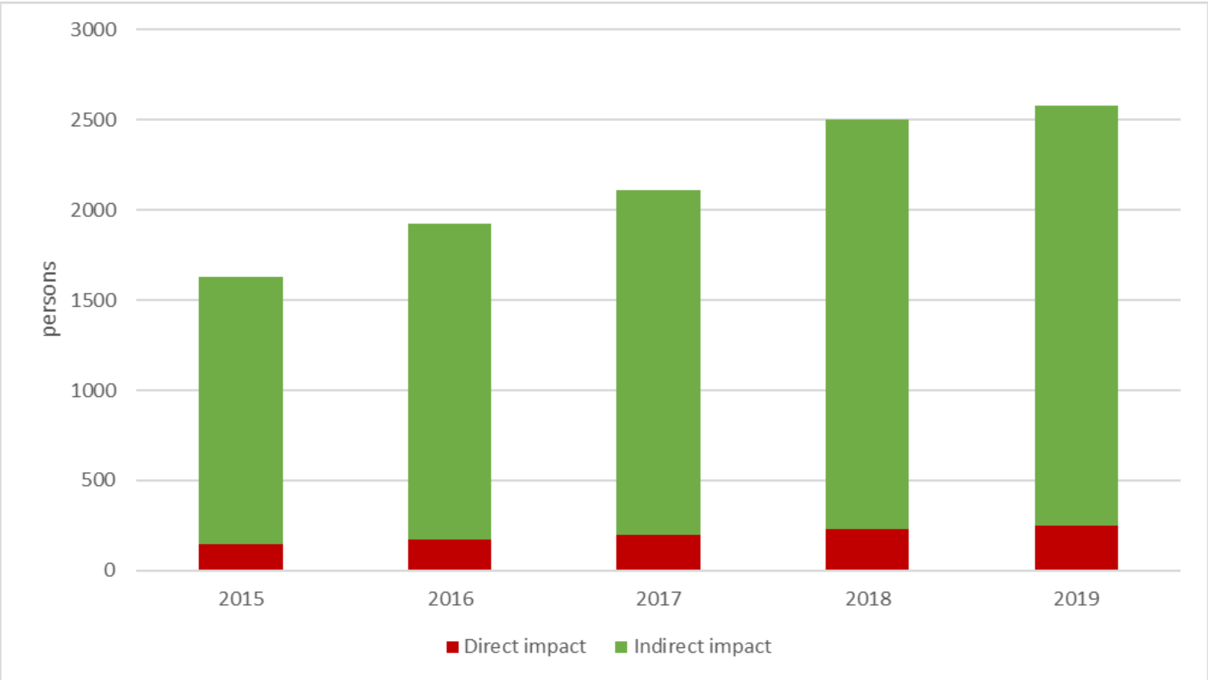


Figure 8. Employment Impact efficiency scenario (persons)



Annex 1. Hétfa-CGE model of the Hungarian Economy

We apply a dynamic CGE model to estimate the impact of Pannonia Bio on the Hungarian economy. The core of the model is a standard, static CGE model which has been modified for the purpose of this analysis in the following aspects:

1. Firms utilize two primary factors in production, namely labour and capital. However, unlike in a standard CGE model, in our application capital is not mobile across sectors. Capital is given by past investment and depreciation in each sector; only the labour input is free to adjust to the shocks.

2. The market for labour is modelled following efficiency wage theories, which makes it possible to simulate the impact on (involuntary) unemployment, as well.

3. Recursive dynamics have been added to follow how investment decisions influence the path of capital.

Finally, 10 sectors (and therefore 10 products) have been distinguished by the application: these are (1) agriculture, (2) manufacturing, (3) energy, (4) construction, (5) services, (6) tourism, (7) ICT (8) R&D, (9) public services and (10) private services, while construction, tourism and public services are non-tradeable.

The core CGE model

The core of the CGE model is a set of static equations describing the behaviour of the agents, namely their decisions about consuming or producing goods and services. As a result of their decisions, the flows are completely determined and they influence the time path of the stock variables as it is shown in the section on dynamics.

Household behaviour

The representative household divides its income between savings and consumption. The primary income of the household equals the income generated in production, since the household is the only owner of factors of production. It pays tax on the income of primary factors of production, and furthermore, it receives a transfer from the government. In the static CGE framework savings are exogenous; however, in our application the savings rate is driven by the past real interest rate. Disposable household income is therefore given as the difference of primary income and savings, transfers and taxes. We assume that labour supply is given by the value of the initial year. Therefore, household decisions focus on the basket structure of consumption. The utility level of aggregate consumption is a CES aggregate of all goods.

Production block

The relationships between factors of production and the goods produced follow the structure of standard CGE models. Therefore, the products of different sectors are used for intermediate inputs and for final use, as well. The structure of the relationships is shown in Figure 5.

First, primary factors of production (capital, labour) are aggregated to a composite factor of production using the Cobb-Douglas production function.

The domestic supply of goods is produced using the composite factor and intermediate inputs for production. We assume Leontief-technology at this level. Therefore, both the composite factor and the intermediate inputs are used in fixed shares in the production of goods.

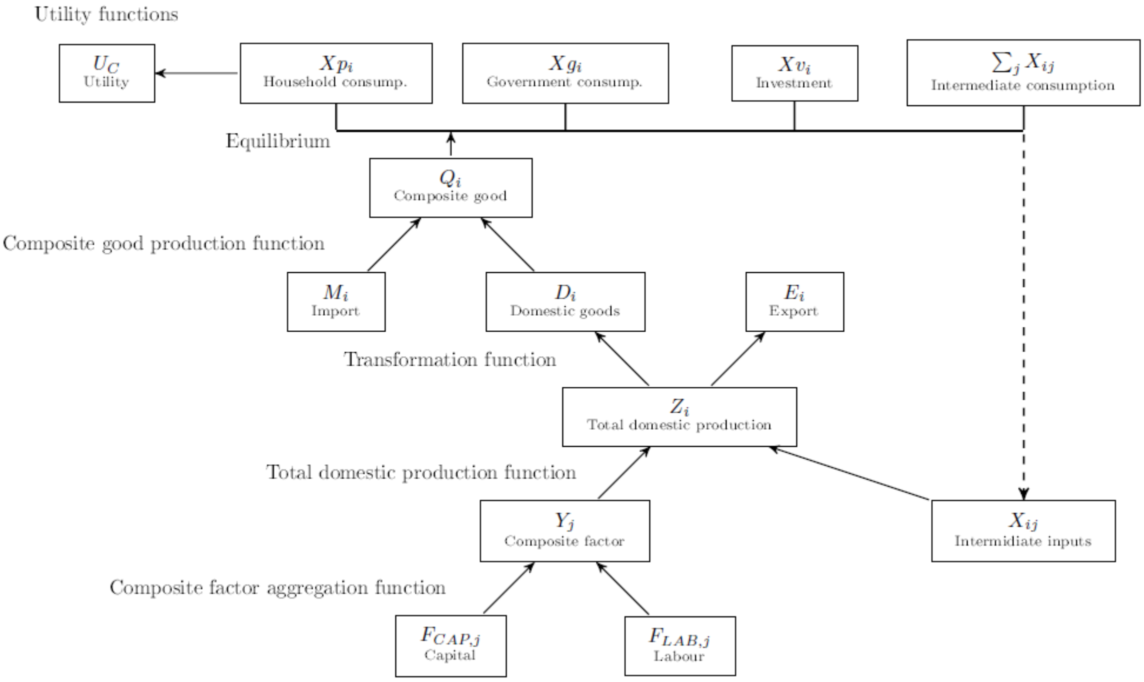
Domestic output is sold both at home and abroad. The usual transformation function is used to split domestic production between domestic sales and exports. The transformation function utilizes the price differences between domestic sales and foreign sales, and it assumes final elasticity of substitution, thus avoiding perfect specialization.

The goods finally consumed are either produced domestically or imported. Goods for final use are aggregated by Armington's aggregation functions from domestic goods and import goods. This method is similar to the transformation function approach: by introducing final price elasticities, domestic and foreign goods are considered as not perfect substitutes to each other.

The composition of domestic demand is the following: private consumption, government expenditure, investment demand and intermediate inputs.

Technically, the production decision is modelled in a nested structure. Firms take the prices of inputs and the prices of their products as given at every decision level. At the first level, firms use primary factors of production (labour and capital) to obtain the composite factor. The technology of production is described by a Cobb-Douglas production function. The demand of the different sectors for primary inputs can be derived from the profit maximization of the firms. At the second level, firms produce their goods from the composite factor of production and intermediate inputs. At this level aggregation is modelled by Leontief-technology, assuming that the composite factor and the intermediate inputs are used at fixed ratios in production. The demand function of factors and the supply function of products are derived from the profit maximization decisions.

Figure 9. Production and use of good in tradeable industries



Source: Major [2016] p. 26. updated

It is assumed that the amount of capital is given by past decisions on investment and depreciation (however, the whole process is completely exogenous). Therefore, there is no market for capital in the model. The income share of the capital is modelled as gross operating profit and is given to the households, it forms part of their primary income.

Foreign trade is modelled assuming that Hungary is a small, open economy. Therefore, by assumption the world price of export and import goods are exogenous and given in foreign currency. The foreign savings is also expressed in foreign currency.

Goods produced domestically and imported goods are not perfect substitutes; therefore, it is important to define composite goods that express the relationship between domestic and imported goods. Therefore, for tradable goods, the so-called Armington aggregation functions are used, where a parameter shows the substitutability of foreign and domestic goods. From these functions demand for domestic and imported goods can be derived.

Domestic goods are either consumed in the country or are exported. These two types of use are expressed by a transformation aggregation function where the elasticity of substitution is described by a parameter. The domestic supply and the supply for exports can be derived from this function.

Government

Government income is determined endogenously, while the real expenditures are exogenous. Government income comes from two parts: indirect taxes stemming from the use of products and direct taxes levied on the primary factors of production. Expenditures of the government are governmental consumption and transfers paid to households. The primary balance of the budget is the difference of the incomes and expenditures, which is expressed as a percentage of GDP.

Labour market

In standard CGE models labour markets and other markets clear due to the adjustment of the real wage, and thus unemployment occurs only voluntarily. However, in the last decades several ways of modelling labour market rigidities were implemented in the CGE framework; for an excellent summary of these methods see Boeters and Savard (2012). In the present model, labour market rigidities are introduced following efficient wage theory.

In the efficient wage model, the equilibrium wage is determined as the intersection of the labour demand curve and the wage curve. Since this wage level is not necessarily the one where labour supply and demand are equal, there is an oversupply of labour in the market; thus, there is unemployment. The wage curve is the result of an incentive situation stemming from the information asymmetry between employers and employees. The firm wants to determine a wage at which workers are incentivized to work hard; therefore, the utilities of workers from working must be at least the utility from shirking. The parameterization of the labour market follows Boeters and Savard (2012).

Market equilibrium

As the present model has a general equilibrium framework, equilibrium must hold in all markets; therefore, total consumption of every tradable good must be equal to the sum of the supplies of the import and domestic production. As for non-tradable goods, domestic supply must equal to domestic demand. The trade balance and the balance of the capital account add up to determine savings of the rest of the world. The investment-savings balance holds as domestic investment can only be financed from domestic savings and foreign savings.

Equilibrium must hold in the market of production factors, as well. However, in the labour market it means that the difference between labour demand (as is defined by the sum of sectoral labour demand) and the labour supply (from household utility maximization) defines unemployment. However, this unemployment rate must be consistent with the wage specified by the wage curve.

Closure rule

The macroeconomic aggregates of a static CGE model are not fully determined. As is usual in this modelling environment, a so-called “closure rule” is applied. The closure rule entails identifying which macroeconomic variable is considered as being exogenous in order to fully specify the macro level of the model. In our application, the investment-driven closure rule is applied. We assume that the model simulations aim at measuring the impact of a short-run event without having any significant impact on future plans, including investment. Therefore, (sectoral) investment demands are taken as exogenous.

The numeraire is the real exchange rate. By using this usual small country assumption, we suppose that the shock has no overall impact on the real exchange rate. Moreover, by assuming exogenous world prices for the export and import goods, the prices of foreign goods in domestic currency is completely exogenous. This assumption means that the supply of foreign goods is fully flexible and given in any amount at any domestic prices.

Dynamics

The characteristics of the system described above determine the static equilibrium of the model. However, for describing the time path of the economy, dynamics should be added. Dynamics of a model can either be forward-looking or backward-looking. In the present model recursive dynamic relationships are used; therefore, past and present values determine the initial values of the next period.

These recursive relationships are the following: (1) capital stock increases with investments and decreases due to depreciation. (2) Net foreign debt of the country is the debt of the previous period increased by payable interests and decreased by redemption, which is expressed by the balance of trade of the country. Real interest rates are determined by the foreign real interest rate. Risk premium related to the debt of the country is a nonlinear function of the indebtedness of the country, and is modelled by a so called linex function that punishes high indebtedness strongly. The household savings rate is exogenous; however, it may change in time due to the changes in the real interest rate. In this model it is assumed that the lagged value of the real interest rate affects the household savings rate.

Annex 2. Additional tables and figures

Table 8. Sectoral additional demand, simulation parameters (m€)

Sectoral additional demand, simulation parameters						
	2015	2016	2017	2018	2019	Total
Investment demand (m€)						
Construction	11,36	5,34	4,81	10,60	21,75	53,87
Manufacturing	11,36	5,34	4,81	10,60	21,75	53,87
Intermediate materials for production (m€)						
Agriculture	92,13	132,25	133,92	151,94	156,45	666,69
Chemistry	13,84	0,00	13,62	-9,38	10,82	28,90
Energy	18,83	19,04	21,10	25,39	21,81	106,16
Logistics	8,35	12,40	12,74	13,06	15,86	62,41
Services	8,20	21,25	13,00	10,32	22,01	74,78
Additional demand from salaries (m€)	4,61	4,03	6,16	7,38	8,94	31,12
Total demand shock (m€)	168,69	199,65	210,17	219,90	279,39	1077,80

Table 9. GDP impact (m€)

	2015	2016	2017	2018	2019	Total
Direct impact	38	36	50	44	99	267
Indirect impact	185	257	339	410	489	1680
Total impact	223	293	389	454	589	1947

Table 10. Employment impact (persons)

	2015	2016	2017	2018	2019
Direct impact	147	170	199	232	247
Indirect impact	1207	1360	1450	1760	1852
Total impact	1354	1530	1649	1992	2099

Table 11. Sectoral output impact (m€)

	2015	2016	2017	2018	2019	Total
Agriculture	15,2	22,5	24,0	28,2	29,9	119,8
Manufacturing	-29,1	-50,6	-64,9	-83,3	-106,8	-334,7
Energy	5,6	8,1	11,0	14,1	16,1	55,0
Construction	4,4	2,4	2,4	4,7	9,0	22,9
Services	-0,1	-0,3	-5,5	-9,0	-10,8	-25,8

Table 12. Impact on budget (m€)

	2015	2016	2017	2018	2019	Total
Direct impact	6	5	7	7	14	39
Indirect impact	26	44	82	115	158	424
Total impact	32	49	89	122	172	464

Figure 10. Impact on budget (m€)

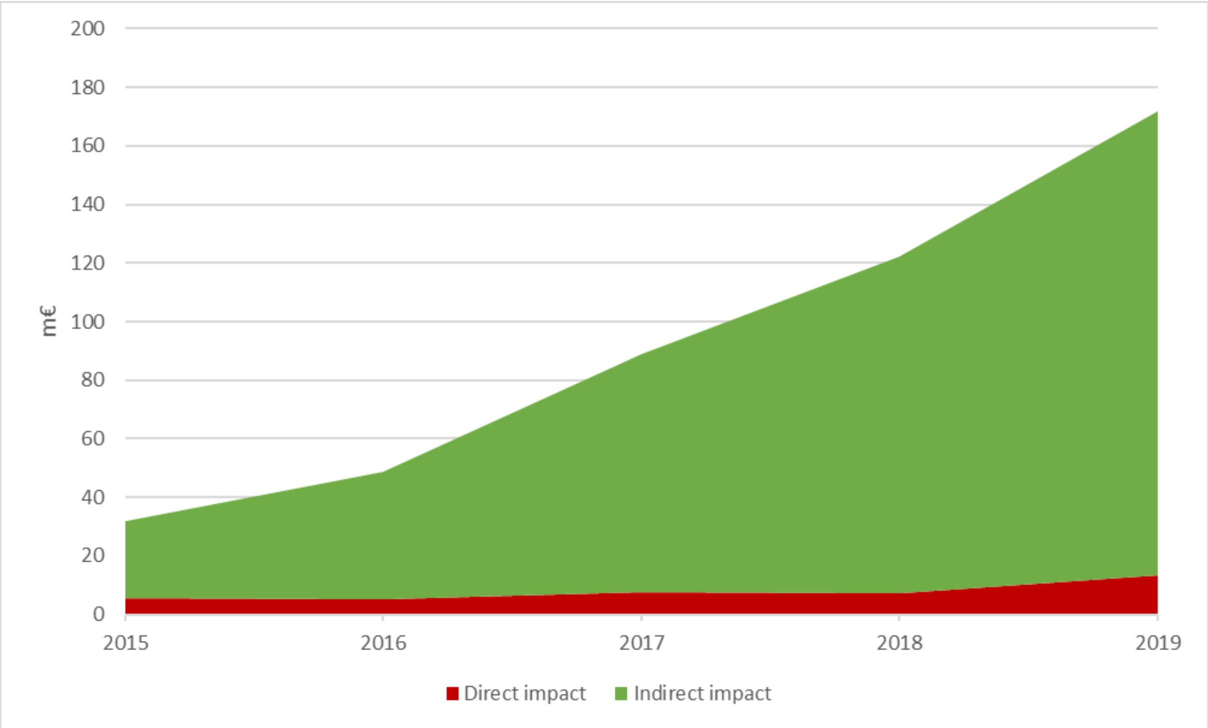


Table 13. GDP impact efficiency scenario (m€)

	2015	2016	2017	2018	2019	Total
Direct impact	38	36	50	44	99	267
Indirect impact	211	304	412	508	613	2047
Total impact	249	340	462	552	712	2314

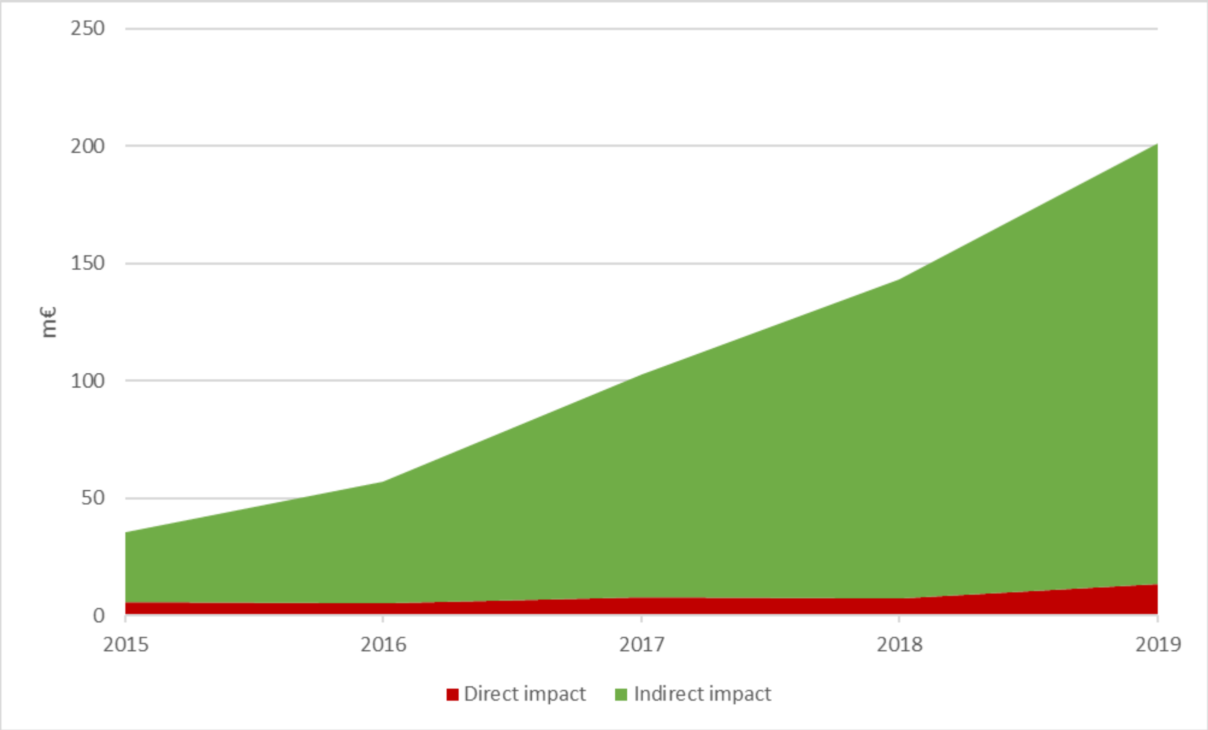
Table 14. Employment impact efficiency scenario (persons)

	2015	2016	2017	2018	2019
Direct impact	147	170	199	232	247
Indirect impact	1484	1754	1908	2272	2333
Total impact	1631	1924	2107	2504	2580

Table 15. Impact on budget efficiency scenario (m€)

	2015	2016	2017	2018	2019	Total
Direct impact	6	5	7	7	14	39
Indirect impact	30	52	95	136	188	500
Total impact	36	57	103	143	201	539

Figure 11. Impact on budget efficiency scenario (m€)



Annex 3: Comparison of previous and recent employment effect

As mentioned before, direct comparison of previous and current results leads to unfounded conclusions. Even small changes in the assumptions can lead to great differences in the outcomes. In our case this means that, even as the investment behaviour of Pannonia Bio between 2015 and 2019 is more similar to the assumptions made in the *ex-ante* investment scenario of 2016, the estimated indirect employment effect is smaller using the updated model (2,024 to 1,526 on average). Most of this difference can be explained by three sources:

1. As mentioned previously, the current model uses a social accounting matrix based on the input-output tables for the year 2015, instead of the year 2010, which was used in the previous calculation. One can assume that the sectoral pattern of 2015 is more similar to the current one than the pattern of 2010, in which year the Hungarian economy was still recovering from the crisis. Therefore, the outcomes should be more plausible with the updated version.
2. The current model uses exogenous time-series to calibrate the model parameters for each simulation year.
3. Obviously, the previously forecasted paths and the reality can differ. That's why the government also regularly updates its own forecasts, allowing us to update the exogenous paths as often as possible, in order to make sure that our calibrations are well-grounded.

To show how these changes could affects the results, in Table 16 we show how a lower GDP and labour force forecast (from the baseline run of the model in 2017[3]) in itself would affect the estimated employment impact of Pannonia Bio. As the table below shows, the older predicted nominal GDP values were significantly lower than the more recent forecasts (or the actual values). It comes from the fact that slower recovery was expected from the crisis even in 2014. Just by changing the exogenous path we see significantly larger indirect employment effects; this happens because the same amount of direct impact (investment and production) is relatively larger in a smaller economy, leading to larger effects.

[3] *We used the following method. In a previous analysis we had a different exogenous path calibrated for the model using a 2010 SAM. Using the Convergence Programme of Hungary, published in April 2017 by the government, they gave exact forecasts for the GDP and labour statistics for the next 4 years.*

Table 16. Impact of different GDP paths on estimated employment effect of Pannonia Bio

		2015	2016	2017	2018	2019
2010 calibration	GDP path for Hungary (bln HUF)	29 509,94	30 021,13	31 264,83	32 628,43	33 916,05
	Estimated employment effect of Pannonia Bio (persons)	1845	1879	2242	2371	2564
2015 calibration	GDP path for Hungary used in current version (bln HUF)	34 379	35 163	36 617	38 412	39 948
	Estimated employment effect of Pannonia Bio (persons)	1207	1360	1450	1760	1852
Difference of estimated employment effect (persons)		638	519	792	611	712

Note:

As a conclusion we can say that a robustly growing model economy reacts to a smaller extent to the same demand shock, as a model economy based on the 2010-2015 period would have.

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