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Technological Progress in Croatian Non-Perennial Agriculture

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A B S T R A C T

Croatian agriculture stagnates over the last quarter of the century. Although it is heavily subsidized and the investment in mechanization was high, Croatian agriculture did not improve its production level, not even after the accession to the European Union. The project of green and blue Croatia, which aim is to connect agricultural production and tourism, did not show significant results import substitution. In this paper non-perennial crops agriculture is analyzed since it forms more than 40% of total agricultural production in Croatia. In order to distinguish the contribution of capital, labour and total factor productivity, a Cobb-Douglas production function is estimated on a panel data set for Croatian non-perennial agriculture in the period of 2008 – 2014. It was discovered that production elasticities do not correspond to the shares of expenditures on labour and capital which is a common production function assumption. Also, it is shown that total factor productivity declines over time, a disinvestment and labour decline caused stagnation of this sector of Croatian economy. A further analysis is made to determine the impact of subsidies and export orientation on TFP and it is found that Croatian agricultural production is affected by export orientation and subsidies, but their impact is almost irrelevant.

A R T I C L E I N F O

Keywords:
Cobb-Douglas production function, Croatian agriculture, Non-perennial, Production function, Total factor productivity

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1. INTRODUCTION

Croatian geographical position is beneficial for its agriculture; warm Mediterranean climate and several rivers pass through fertile fields of Istria, Northern Dalmatia and Neretva valley. These areas are very good for perennials like olives, vines, peaches, apricots, cherries and all citruses. Mountainous region of Lika with fertile valleys offers great conditions for cattle and some fruit, like plums, and potato. Pannonian part of Croatia with its hills and plains and moderate climate enables cultivation of almost all classes of NACE[1] rev. 2:

Table 1: NACE classification of agriculture, fishing and forestry

Code	Name
11	Growing of non-perennial crops
12	Growing of perennial crops
13	Plant propagation
14	Animal production
15	Mixed farming
16	Support activities to agriculture and post-harvest crop

[1] NACE = Nomenclature statistique des activités économiques dans la Communauté européenne

Table 1: NACE classification of agriculture, fishing and forestry	
Code	Name
	activities
17	Hunting, trapping and related service activities
21	Silviculture and other forestry activities
22	Logging
23	Gathering of wild growing non-wood products
24	Support services to forestry
31	Fishing
32	Aquaculture

Unfortunately, Croatia does not use its agricultural potential. As it can be seen on Figure 1, Croatian agricultural production declines in both volume and share in GDP; from HRK 14,4 Bill. in 2010 production fell down to HRK 12,2 Bill. in 2014, and from 4,4% share in GDP in 2010 it fell down to less than 3,6% in 2014.

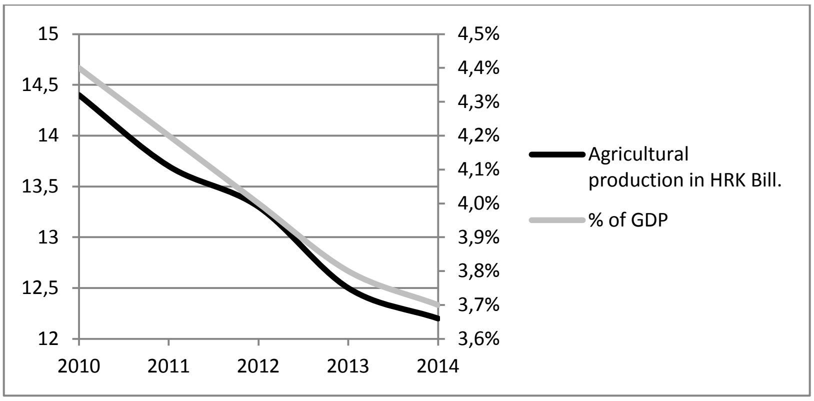

Figure 1: Agricultural production in HRK Bill. and share of agriculture in GDP of Croatia in 2014

Source: Own calculation based on FINA database

In order to find what is pulling Croatian agriculture down, agriculture was decomposed into NACE classes (Table 1). The most detrimental picture is a non-perennial agricultural production. Figure 2 shows that 53,7% of all the arable land in 2014 in Croatia was used for non-perennial cultures. However, in the same year non-perennial agriculture accounted for only 41,2% of the agricultural production, but took 56,9% of total amount of agricultural subsidies[2].

[2] Authors' own calculation according to the data by FINA

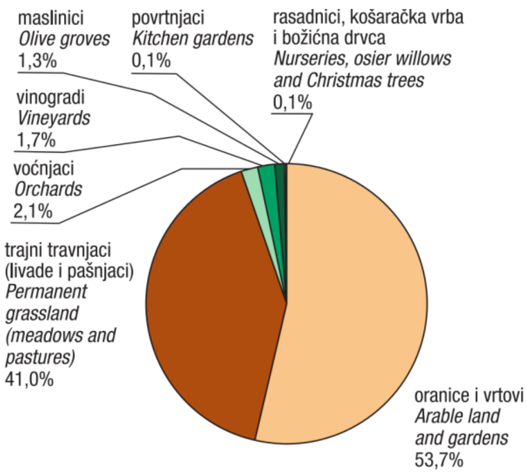

Figure 2: Arable land usage in Croatia in 2014
Source: Croatian statistical Yearbook 2015, DZS

Since lots of money and arable land is invested in the non-perennial agriculture in Croatia and revenues are not satisfactory, this paper will try to make its detailed analysis in order to find which classes of non-perennial production section are the least developed and what are the reasons for it.

2. DATA AND METHODOLOGY

Dataset for the analysis is obtained by FINA (Croatian Financial Agency) which collects company JOPPD reports with a number of standardized data. Since Croatian companies are obliged to consign these reports annually under threat of penalty, the dataset used here covers the entire statistical population.
The report outline changed several times. Therefore an adjustment between certain years was needed. After the adjustment, a 301 variable dataset is obtained in the time period from 2008 – 2014 for 1007 legal entities which produced non-perennial agricultural products. The unbalanced panel data set was used to estimate a Cobb-Douglas production function, which is the most commonly used in similar analyses.
Armagan & Ozden (2007) analyzed Turkish agriculture, namely crops, using a Cobb-Douglas function to estimate its production function. They used a number inputs in that study among which are the average age of farmers, their average education and land size and distinguished small, medium and large producers. The analysis was based on cross section data.
Echevarria (1998) constructed a production function for Canadian agriculture. In this paper a very common assumption was taken: scale elasticity ε = 1 (constant returns to scale) and that production elasticities of each input correspond to its share in total costs.
Parlinska & Dareev (2011) estimated agricultural production function for Poland and Republic of Buryatia. A simple two-input Cobb-Douglas function was used to estimate production functions for both countries/regions using a time series from 2000 – 2009.
Enaami, Mohamed and Ghani (2013) have shown even more advantages of using Cobb-Douglas function as a basis for production function estimation. They also show how to deal with multiple issues that might occur under a multiple input approach. Due to these suggestions, a following simple model is used to estimate Croatian non-perennial production function:

$$\hat{Y}_{xt} = A_{xt} K_{xt}^{\kappa} L_{xt}^{\lambda} \qquad (1)$$

Where x stand for the legal entity (company), t for year, Y for production volume, A for total factor productivity, K for capital, L for labour, κ for contribution of capital (production elasticity of capital) and λ for contribution of labour (production elasticity of labour). Also, it is assumed that total factor productivity changes in time with an exponential time path:

$A_{xt} = e^{at+b}$ (2)

Combining (1) and (2) the following function is estimated:

$\hat{Y}_{xt} = e^{at+b} K_{xt}^{\kappa} L_{xt}^{\lambda}$ (3)

After linearization the estimated model was:

$\ln Y_{xt} = at + b + \kappa \ln K_{xt} + \lambda \ln L_{xt} + u_{xt}$ (4)

A generalized least squares method was used with random effects, due to abundant dataset and expected differences between the companies. Multicollinearity, heteroscedasticity and autocorrelation test were made as well as the parameter and joint tests for validity of the model.

Using the obtained data total factor productivity is calculated as a residual :

$A_{xt} = \frac{\hat{Y}_{xt}}{K_{xt}^{\kappa} L_{xt}^{\lambda}}$ (5)

This was the end of the first stage. In the second stage a total factor productivity model was constructed using numerous regressors:

$A_{xt} = \sum_{i=1}^{n} Z_{xt,i} + u_{xt}$ (6)

Among many, the following regressors were taken into account: share of company on the market, number of companies on the market, export volume, subsidies taken[3], growth of the economy, investment volume and many others.

3. PRODUCTION FUNCTION ESTIMATE

Based on the previously described panel dataset and methodology, the estimated production function for Croatian non-perennial agriculture from 2008 – 2014 (7):

$\hat{Y} = e^{7,462-0,0288t} K^{0,266} L^{0,379}$ (7)

F-test, t-test and necessary autocorrelation and multicolinearity test show that this model is well defined with standard errors being independent one from the other. Also, it is shown that total factor productivity has a declining time path (Figure 3).

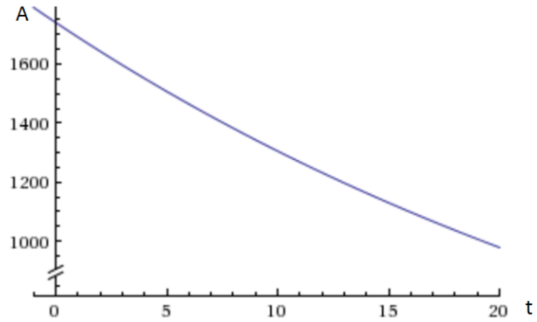

Figure 3: Total factor productivity time path of Croatian non-perennial agriculture

Using the obtained production function coefficients a total factor productivity for classes of non-perennial agriculture can be calculated. In Croatia only sugar cane cannot be produced hence the TFP matrix has 5 columns (Table 3).

Table 2: Production function residuals for Croatian non-perennial agriculture from 2008 – 2014.

	Cereals	Rice	Vegetables	Tobacco	Other

[3] Kroupová & Malý (2010) show the importance of subsidies on Czech agriculture, again using a multiple input Cobb-Douglas production function.

2008	27.365	22.733	5.113	2.594	1.703
2009	22.064	5.586	5.614	4.217	3.786
2010	21.894	6.567	3.900	4.561	4.757
2011	27.693	4.609	4.292	3.442	2.446
2012	28.744	4.423	3.913	3.306	2.478
2013	27.784	7.137	6.987	2.837	3.030
2014	29.529		6.250	3.295	3.064

Source: Own calculation based on FINA database

Dynamics of TFP for each class (Cereals, rice, vegetables, tobacco, other) is given in the Figure 4.

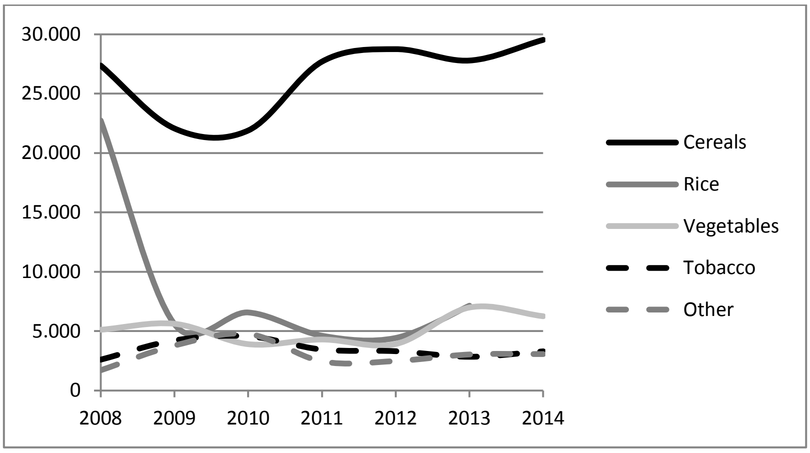

Figure 4: Total factor productivity of Croatian non-perennial agriculture per classes (2008 – 2014)
Source: Own calculation based on FINA database

In order to be able to observe dynamics in detail, a base index TFP matrix is made (Table 3).

Table 3: Base indices (2008 = 100) of production function residuals for Croatian non-perennial agriculture from 2008 – 2014.

	Cereals	Rice	Vegetables	Tobacco	Other
2008	100,0	100,0	100,0	100,0	100,0
2009	80,6	24,6	109,8	162,5	222,3
2010	80,0	28,9	76,3	175,8	279,3
2011	101,2	20,3	83,9	132,7	143,6
2012	105,0	19,5	76,5	127,4	145,5
2013	101,5	31,4	136,7	109,4	177,9
2014	107,9		122,2	127,0	179,9

Source: Own calculation based on FINA database

Table 3 and 4 shows that cereals production stagnates in terms of technology improvement. Since rice production volume is insignificant, it can be ignored. Vegetables had a TFP decline, but in 2014 are 22,2% above the level in 2010. However, the most significant rise in TFP is seen in tobacco cultivation and other cultures, like soy bean, sugar beet, herbs and many other (Figure 5). These findings suggest that in non perennial agriculture a dynamic rise can be expected in tobacco and other smaller non-perennial production.

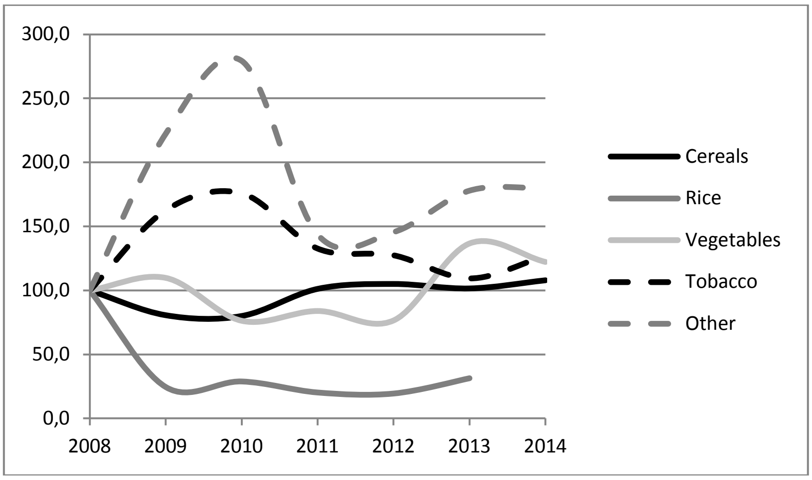

Figure 5: Total factor productivity of Croatian non-perennial agriculture per classes (2008 – 2014)

Source: Own calculation based on FINA database

4. ALTERNATIVE PRODUCTION FUNCTION CONSTRUCTION

The alternative approach, used in many production function analyses like Echevarria (1998) did for Canada, suggested a different, non-econometrical approach where a share of inputs costs in total costs is used as a proxy for input contribution. Using this assumption the analyst assumes that companies are on their expansion paths, where cost minimizing rule holds:

$$MRTS_{KL} = \frac{w}{r} \qquad (8)$$

Also, it is assumed that returns to scale are constant. The comparison between these two approaches is given in the Table 4.

Table 4: Comparison between share in costs and econometric production function coefficients for Croatian non-perennial agriculture from 2008 – 2014.

	Production elasticities	Share in total costs
K	0,266	0,858
L	0,379	0,142
Total	0,645	1,000

Source: Own calculation based on FINA database

Comparison shows significant differences between the coefficients obtained by econometric and cost-minimizing approach; first, econometric approach shows that returns to scale are not

constant, but decreasing. Secondly, labour contribution is much bigger than the share of labour costs in total costs. Finally, contribution of capital is much smaller in the estimated function. These findings suggest that too many workers are used per unit of capital, which is due to poor education of Croatian farmers. Hence less capital is used since there is not enough human capital to run it which causes decreasing returns to scale.
Significant difference between econometric and non-econometric function coefficient suggests that the econometric approach should be used for further analyses of TFP in this paper.

5. TOTAL FACTOR PRODUCTIVITY MODEL

The estimation of a model defined in (6) used more than 100 variables, as described in Section 2. It was found that only export orientation and subsidies affect TFP. In order to remove autocorrelation an autoregressive model (9) was estimated:

$$T\hat{F}P_t = 0{,}0001571SUB + 0{,}0001115EXP + 0{,}37429902\,TFP_{t-1} + 2016{,}898 \quad (9)$$

There is slight positive effect of the export and subsidy rise, but it is almost inexistent. As compared to the findings of Kroupová & Malý (2010), while in Czech Republic subsidies have a beneficial effect on TFP in agriculture, in Croatia it is not a case. The reasons for it should be found in the fact that subsidies are given for the area of land and not for the volume, then because subsidies are directed to the least productive sector of agriculture in terms of revenue, and finally because educational system does not supply necessary human capital to match high technology without which it is impossible to make progress.

6. CONCLUSION

Croatian non-perennial agriculture section occupies most of the arable land and takes almost 60% of all agricultural subsidies, but yields only 41,2% of the agricultural production. A Cobb-Douglas production function for non-perennial agriculture in Croatia was estimated using a panel data. It was found that its TFP has a downward sloping time path. After calculation of TFP as a function residual it was shown that cereals stagnate in terms of technological progress, while vegetables and tobacco production increased 22-27% from 2008 – 2014. Finally, other non-perennial agricultural production has shown the most dynamic TFP growth of almost 80% in the mentioned time period.
Comparison between the theoretical expansion path and the real data has shown that the inadequate education led to excessive usage of labour, inadequate usage of capital and decreasing returns to scale. It also showed that in Croatian case an econometric approach gives significantly different results than the share-of-cost approach.
Finally, subsidies show no effect on the TFP improvement. Since this analysis used a NACE class data, some of the specific data variation might have been lost, hence a differentiated approach has to be taken in order to see which specific classes and subclasses react better to subsidies. Also, further analyses should take into account also live-stock production, hunting, fishing and perennial production which combined account for almost 60% of agricultural production.

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