TECHNOLOGICAL PROGRESS IN CROATIAN PERENNIAL AGRICULTURE

Abstract:
Agricultural sector in Croatia declines or stagnates from 1980’s. Croatian agriculture did not improve its production level despite high subsidies and EU accession. In this paper perennial agriculture is analysed in detail since it is a high yielding segment of agriculture in EU. A panel data set for all Croatian perennial agriculture legal entities in the period of 2008 – 2014 was used to build production function. Cross section data were sub-sectors of perennial agriculture. Contributions of capital and labour were obtained as well as total factor productivity. It is shown that common approximation of production elasticities with share in costs is entirely inadequate in this case, showing decreasing returns to scale. TFP in perennial agriculture remained constant in this period despite subsidies. Finally, a TFP model was built. Using a set of 301 variables only two remained significant: export and subsidies, but with almost inexistent effect, showing that exports and subsidies make almost no effect on perennial agriculture productivity in Croatia. It may be the consequence of inefficient distribution of subsidies.

Keywords:
Total factor productivity, Croatian agriculture, Cobb-Douglas production function, agricultural subsidies, export orientation, perennial agriculture, non-perennial agriculture

JEL Classification: D24, Q12
Introduction

Croatian agriculture has all geographical advantages for all moderate and Mediterranean cultures; Pannonian planes with rich soil, moderate climate and big rivers that pass through it offer conditions for intensive irrigated farming; mountainous regions and its valleys offer unique conditions for extensive cattle and potato farming, while red-soil plains with rivers of Northern Dalmatia and Istria, as well as Neretva valley, are ideal for perennials like peaches, olives, apricots, cherries, vines and citrus.

Given the conditions above, cultivation of almost all classes of NACE\(^1\) rev. 2 is possible:

| 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 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                                  |

However, Croatia is far from its potential agricultural output. As it can be seen in Table 2, 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 (Herceg, Vrankiće, Galetić, 2016).

| Year | Agricultural production in HRK Bill. | % of GDP |
|------|-------------------------------------|---------|
| 2010 | 14,4                                | 4,4%    |
| 2011 | 13,7                                | 4,2%    |
| 2012 | 13,3                                | 4,0%    |
| 2013 | 12,5                                | 3,8%    |
| 2014 | 12,2                                | 3,7%    |

\(^1\) NACE = Nomenclature statistique des activités économiques dans la Communauté européenne
So as to find reasons for its underperformance, agriculture was decomposed into NACE classes (Table 1). The most detrimental picture is a non-perennial agricultural production. Figure 1 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 (Herceg, Vrankić, Galetić, 2016).

**Figure 1: Arable land usage in Croatia in 2014**

Source: Croatian statistical Yearbook 2015, DZS

Perennial agriculture accounted for 5.5% of the agricultural land area where 193 Mill. HRK of goods were produced (Figure 2).

**Figure 2: Perennial agricultural production in Croatia from 2008 - 2014**

Knowing that on 53.5% of land 2.74 Bill. HRK of non-perennial products were produced (Figure 3) one can see that non-perennial agriculture was 46% more productive which is
opposite to the experiences of the other countries of EU, which reach much higher productivity in perennial agriculture.

**Figure 3: Non-perennial agricultural production in Croatia from 2008 - 2014**

However, perennial production more easily reach foreign markets (32.6% of the revenues are made abroad) than it is the case in non-perennial production (15.5% of production is exported). Low perennial productivity with high export orientation is a motive for this paper. Also, Croatia imports mostly products of perennial agriculture.

Perennial agriculture has also shown different subsidy dependence over the years (Figure 4).

**Figure 4: Share of subsidies in total revenue for perennial and non-perennial agricultural production in Croatia from 2008 - 2014**

One can see that large subsidies in the previous period did not improve position of Croatian perennial agriculture. Reasons for that, as well as for the higher export orientation and
low productivity, have to be found in more detailed analyses. Hence the subject of this paper will be perennial agriculture in Croatia.

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 799 legal entities which produced 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.

Perennial agriculture is broken into subclasses (Table 3) which will form cross-section dimension of the panel. Time dimension are the previously mentioned data from 2008 – 2014.

Table 3: NACE classification of agriculture, fishing and forestry

| Code | Name                                      |
|------|-------------------------------------------|
| 12   | Growing of perennial crops                |
| 121  | Growing of grapes                         |
| 122  | Growing of tropical and subtropical fruits |
| 123  | Growing of citrus fruits                  |
| 124  | Growing of pome fruits and stone fruits    |
| 125  | Growing of other tree and bush fruits and nuts |
| 126  | Growing of oleaginous fruits              |
| 127  | Growing of beverage crops                 |
| 128  | Growing of spices, aromatic, drug and pharmaceutical crops |
| 129  | Growing of other perennial crops          |

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 $\varepsilon = 1$ (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.

Herceg, Vrankić and Galetić (2016) estimated non-perennial production function, due to its high area share in the overall area used for agriculture. It was concluded that subsidies make no impact on the improvement of its total factor productivity, unlike the Czech case described by Kroupová & Malý (2010).

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:

\[ \hat{Y}_{xt} = A_{xt}K_{xt}^{\kappa}L_{xt}^{\lambda} \]  

(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, \( \kappa \) for contribution of capital (production elasticity of capital) and \( \lambda \) 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, growth of the economy, investment volume and many others.

**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):

$$\tilde{Y}_t = e^{0.37631u_{t-1}+1.7857}K_t^{0.181}L_t^{0.376}$$

(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. Total factor productivity time path has a horizontal time path, unlike the non-perennial agriculture where TFP was downward sloping (Herceg, Vrankić, Galetić, 2016):

$$\tilde{A}_t = e^{0.37631u_{t-1}+1.7857}$$

(8)

$$E(u_{t-1}) = 0$$

(9)

$$\tilde{A}_t = e^{1.7857} = 5.96 \text{ const.}$$

(10)

Using the obtained production function coefficients a total factor productivity for classes of perennial agriculture can be calculated. TFP matrix has all the columns, but some of the subclasses did not exist in certain periods, hence there are many missing data in the matrix (Table 4).

**Table 4: Production function residuals for Croatian perennial agriculture from 2008 – 2014.**

| Year | Grapes | Tropical & Subtrop. f. | Citrus f. | Pome & Stone f. | Other f., bush f. and nuts | Oleaginous | Beverages f. | Spices, aromatic, drug and pharmaceutical crops | Other perennials |
|------|--------|------------------------|----------|----------------|---------------------------|------------|-------------|---------------------------------|-----------------|
| 2008 | 3820   | 3997                   | 2845     | 203            | 528                       | 849        | 1820        | 1820                            |
| 2009 | 3508   | 2366                   | 2134     | 696            | 971                       | 2240       | 2240        | 2240                            |
| 2010 | 3324   | 3106                   | 1783     | 1417           | 1220                      | 2132       | 2132        | 2132                            |
| 2011 | 2831   | 13234                  | 3056     | 2280           | 1122                      | 918        | 2710        | 2710                            |
| 2012 | 3192   | 12685                  | 3070     | 2106           | 1002                      | 1125       | 1107        | 1107                            |
| 2013 | 2757   | 9412                   | 2966     | 2179           | 862                       | 694        | 1887        | 1887                            |
| 2014 | 2791   | 40                     | 9268     | 2700           | 2198                      | 1181       | 1934        | 1934                            |

Dynamics of TFP for each sub-class (Grapes, Citrus fruits, Pome and Stone fruits, Other fruits, bush fruits and nuts, Oleaginous fruits, Spices, aromatic, drug and pharmaceutical crops and other perennials) is given with the Figure 5. Tropical and subtropical fruits as

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2 Kroupová & Malý (2010) show the importance of subsidies on Czech agriculture, again using a multiple input Cobb-Douglas production function.
well as beverage fruits are omitted since they have only one data in the set (there was no production registered in the other years).

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

In order to be able to observe dynamics in detail, a base index TFP matrix is made (Table 5).

**Table 5: Base indices (2008 = 100) of production function residuals for Croatian perennial agriculture from 2008 – 2014.**

|                  | Grapes | Tropical & Subtrop. f. | Citrus f. | Pome & stone f. | Other f., bush f. and nuts | Oleaginous | Beverages | Spices, aromatic, drug and pharmaceutical crops | Other perennials |
|------------------|--------|------------------------|-----------|-----------------|----------------------------|------------|-----------|-----------------------------------------------|------------------|
| 2008             | 100    | 100                    | 100       | 100             | 100                        | 100        | 100       | 100                                           | 100              |
| 2009             | 92     | 59                     | 75        | 344             | 114                        | 123        |           | 144                                           | 117              |
| 2010             | 87     | 78                     | 63        | 700             | 144                        | 117        |           | 108                                           | 149              |
| 2011             | 74     | 100                    | 76        | 80              | 554                        | 108        | 132       | 61                                            |                  |
| 2012             | 84     | 96                     | 77        | 74              | 495                        | 132        | 104       |                                               |                  |
| 2013             | 72     | 71                     | 74        | 77              | 426                        | 82         | 104       |                                               |                  |
| 2014             | 73     | 100                    | 70        | 68              | 583                        | 228        | 105       |                                               |                  |

Although the overall TFP did not variate in the period, subclasses show significant data variations in some sub-classes; TFP in grapes production fell down by 27% in the period from 2008 – 2014. In the same period bush fruits and nuts fell even more in productivity – by 32%. Citrus fruits had a fall in productivity by 30% in the period from 2011 – 2014. Other perennials stagnated (increase by 5% in 6 years), but oleaginous fruits (namely olives) had an impressive increase in productivity reaching almost six – fold increase in 6
years. Spices and pharmaceutical crops also had a significant increase in the period, 128% (Table 5 / Figure 6).

Figure 6: TFP of Croatian perennial agriculture per classes (2008 – 2014), 2008 = 100

Alternative production function construction

Echevarria (1998) made a different, non-econometrical approach where a share of inputs costs in total costs is used as a proxy for input contribution. In this analysis, and many other after that, it was assumed that companies are on their expansion paths, where cost minimizing rule holds:

\[ MRTS_{KL} = \frac{w}{r} \quad (11) \]

Therefrom returns to scale are constant. The comparison between these two approaches is given in the Table 4.

Table 6: Comparison between share in costs and econometric production function coefficients for Croatian perennial agriculture from 2008 – 2014.

|       | Production elasticities | Share in total costs |
|-------|------------------------|----------------------|
| K     | 0.180                  | 0.868                |
| L     | 0.544                  | 0.132                |
| Total | 0.724                  | 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. Furthermore, 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. Similar results are obtained for non-perennial agriculture.

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.

**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:

$$TFP_t = 0.0000605SUB + 0.000305EXP + 0.3768332 TFP_{t-1} + 332.7949$$  \hspace{1cm} (12)

There is slight positive effect of the export and subsidy rise, but it is almost inexistent. In non-perennial agriculture subsidies have three times bigger influence on TFP but exports have three times smaller influence on TFP (ibidem). Kroupová & Malý (2010) have shown that in Czech Republic subsidies have a positive effect on TFP in agriculture. The reasons for it should be found in the inefficient subsidy distribution and poor education in agriculture. Also, Croatia does not irrigate its orchards and other perennial areas.

**Conclusion**

Croatian perennial agriculture section occupies only 5.5% of the arable land. While in the other European countries this sector yields greater returns than the other segments of agriculture, in Croatia it is by 1/3 less productive than the non-perennial production, traditionally the least productive sector of agriculture in EU. To analyse reasons for its bad performance a Cobb-Douglas production function for perennial agriculture in Croatia was estimated using a panel data and TFP was calculated for all the observed years (2008 – 2014) and all 9 sub-sectors (grapes, citrus, stone & pome fruits, etc.).

It was found that its overall TFP stagnates in time. A detailed dynamics of TFP per sub-sector shows that oleaginous fruits productivity increased almost six fold and pharmaceutical herbs and spices more than doubled in this period. Other perennials stagnated, but the other sub-sectors have shown a significant fall in productivity (cca. 30%) in 7-year 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 which should hence be avoided.

Finally, subsidies show almost no effect on the perennial agriculture TFP improvement, just like in in non-perennial sector. Lower productivity in perennial agriculture in Croatia can also result from the fact that although perennials use almost 10% of the non-perennial land, it gets only 7% of the non-perennial subsidies. That may be the reason why subsidies are even weaker in the TFP formation in perennial than in non-perennial agriculture.

Further analyses should take into account also live-stock production, hunting and fishing so as to find other ways to reach faster agricultural growth.

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