

Introduction

The 1998–1999 war left Kosovo's agricultural sector in a fragile state since it caused a collapse of the rural infrastructure as well as law and order [1]. One consequence of the war was reflected in a loss of productivity.

After the war, there have been attempts by the national government to revive failing agricultural production levels. Greenhouse vegetables exemplify the post-war resilience of Kosovo agriculture. However, there is dependence on imports that can influence production efficiency [2].

The production of greenhouse vegetables is a relevant example of a subsector that is experiencing low input efficiency. The low yields and the inefficient use of inputs may lead to a decrease in the domestic production of greenhouse tomatoes and peppers.

Aim

Little attention has been given to greenhouse tomatoes and peppers in Kosovo. Maximizing input efficiency is a subject that has important implications for the government. For these reasons, the aim of the study was to contribute in the following aspects.

- I. To maintain current yields while decreasing resource waste
- II. Uncover evidence about input efficiency use at a regional and farm level

Materials and Methods

Data were collected from 1 June, 2017 to 7 August, 2017 with a sample covering 136 greenhouse tomato and pepper farms from 22 villages, 11 municipalities, and 7 regions of Kosovo. Production information was obtained through face-to-face interviews with farmers and by using two research surveys.

After the data gathering, there were two primary methods used in the study to provide insight in the determination of input efficiency use.

- I. Data envelopment analysis (DEA) to quantify:
 - o Technical efficiency (TE)
 - o Pure technical efficiency (PTE)
 - o Scale efficiency (SE)
- II. Linear regression to analyze:
 - o Efficiency scores derived from DEA
 - o External variables affecting efficiency scores

PTE efficiency scores were considered more relevant in the study since TE scores assumed all greenhouse tomato farms operate at an optimal scale. This assumption may not hold in Kosovo's newly emerging greenhouse sector.

Results

I. Regional level: input efficiency use analysis

In a regional analysis, Prizren was found to be the most efficient in the production of greenhouse tomatoes (Figure 1). The results suggest that, for greenhouse tomato producers to achieve TE, input use would need to improve by 13% to 41% depending on the region.

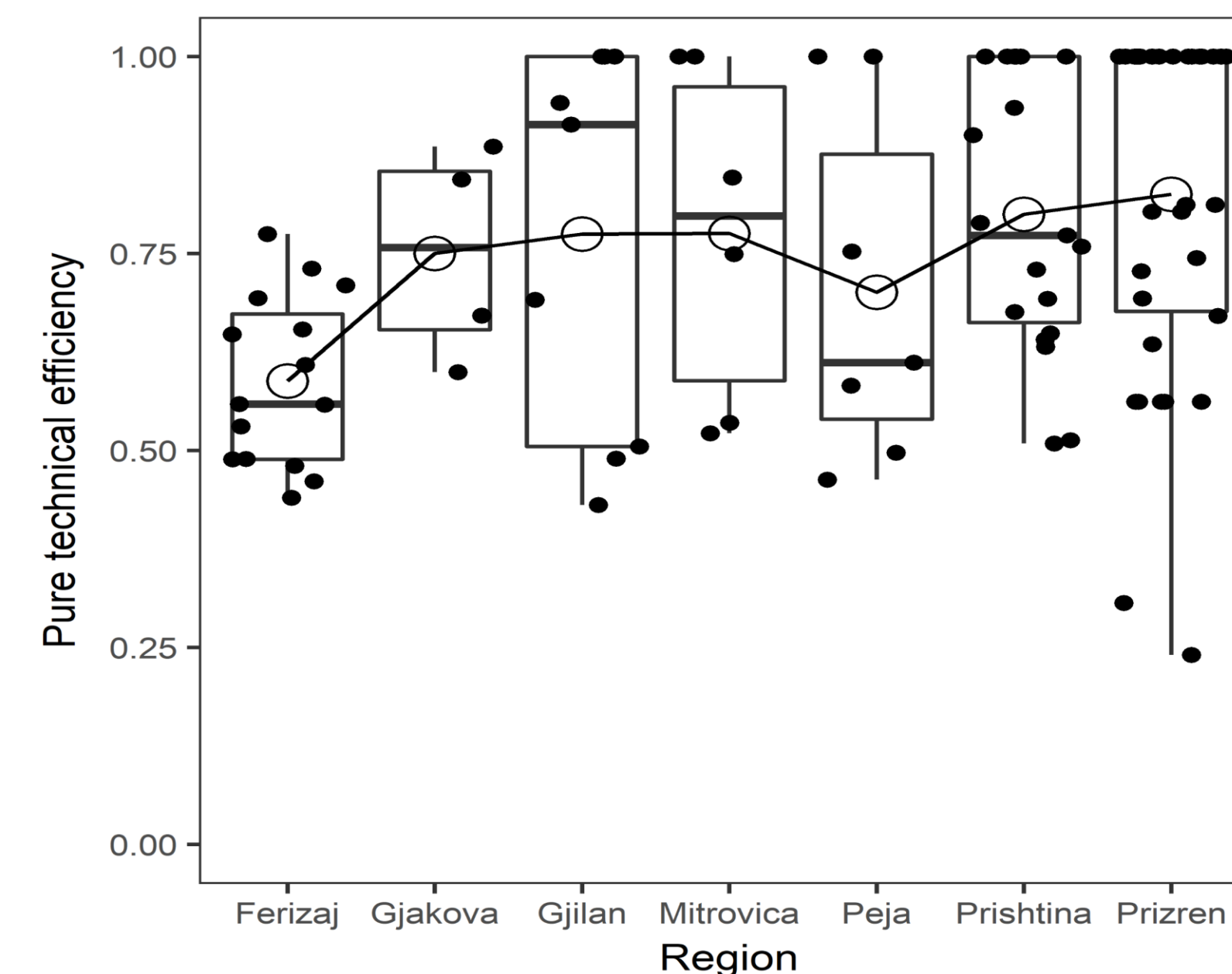


Figure 1. Efficiency representation of greenhouse tomato producing regions.

Comparatively, greenhouse pepper producers had higher efficiency scores. Prishtina (out of 6 pepper regions) was the most efficient region in the production of greenhouse peppers (Figure 2). Improvements in efficient input use ranged, however, across regions from 1% to 16%.

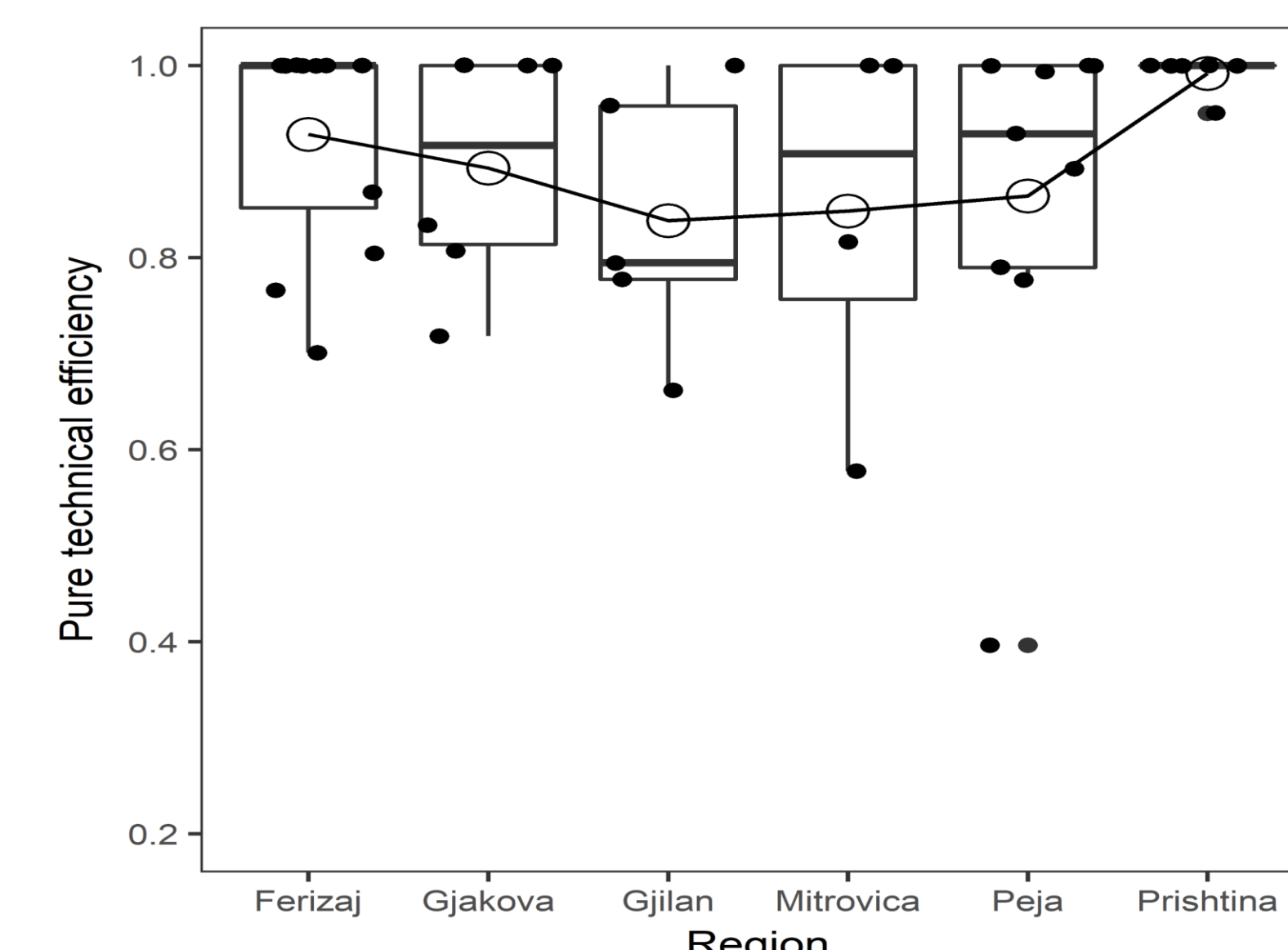


Figure 2. Efficiency representation of greenhouse pepper producing regions.

II. Farm level: input efficiency use analysis

At a farm level, the results revealed that there were percentage-wise fewer inefficient greenhouse pepper producers compared with the greenhouse tomato producers at the lower efficiency levels (Table 1). There was evidence that 33% of the greenhouse tomato farms and 52% of the greenhouse pepper farms were fully efficient, respectively.

Table 1. Summary of greenhouse tomato and pepper farms' efficiencies.

Tomato input-oriented efficiency		Pepper input-oriented efficiency	
Efficiency (E) range	% of farms	Efficiency (E) range	% of farms
0.2 ≤ E < 0.3	1.1	0.3 ≤ E < 0.4	2.4
0.3 ≤ E < 0.4	1.1	0.4 ≤ E < 0.5	0.0
0.4 ≤ E < 0.5	9.6	0.5 ≤ E < 0.6	2.4
0.5 ≤ E < 0.6	16.0	0.6 ≤ E < 0.7	2.4
0.6 ≤ E < 0.7	16.0	0.7 ≤ E < 0.8	16.7
0.7 ≤ E < 0.8	11.7	0.8 ≤ E < 0.9	14.3
0.8 ≤ E < 0.9	7.4	0.9 ≤ E < 1	9.5
0.9 ≤ E < 1	4.3	E = 1	52.4
E = 1	33.0	Total	100.1
Total	100.2		

Of all the greenhouse tomato farms, 16% were scale-efficient and 84% were facing decreasing returns to scale (DRS). Relatedly, greenhouse pepper SE inferred results showed that 26% of the farms were scale-efficient, which indicated a 10% higher SE compared to the greenhouse tomato farms. Under the scale of production, 7% were operating in the area of increasing returns to scale (IRS) and 67% in the area of DRS.



Figure 3. Greenhouse vegetable farms in Kosovo.

III. Regression implications

The production-related (external) variables used in the linear regression were found to be different among greenhouse tomato and pepper farms. In the linear model for the greenhouse tomato farms with TE scores as the scalar dependent variable, three variables were found statistically significant at the 5% level and four were not (Table 2).

Table 2. Greenhouse tomato linear regression implications

Greenhouse tomato model (n. of observations = 94)				
Variable	β	SE	Lower (95% CI)	Upper (95% CI)
Crop nutrition training	-0.144 *	(0.074)	-0.288	0.001
Power source	-0.188 ***	(0.053)	-0.292	-0.084
Rows per greenhouse	0.012 ***	(0.004)	0.005	0.019
Wholesale price	-0.364 **	(0.169)	-0.694	-0.033
Irrigation in euro value	-0.0001	(0.0001)	-0.0003	0.00003
Education in years	-0.017 *	(0.009)	-0.034	-0.0001
Family members	0.005	(0.007)	-0.007	0.018
(Constant)	0.802 ***	(0.145)		
R ²			0.309	
Adjusted R ²			0.252	

Note: β, regression coefficient, SE, standard error, CI, confidence interval. The statistical significance of the variables is denoted by * p < 0.1, ** p < 0.05, *** p < 0.01.

In the greenhouse pepper model, three variables were found to be significant at the 5% level and four were not (Table 3). Some variables had significant impacts on the optimal use of inputs among greenhouse tomato farms and others among greenhouse pepper farms. In general, variables included in the final models differed across each crop.

Table 3. Greenhouse pepper linear regression implications

Greenhouse pepper model (n. of observations = 42)				
Variable	β	SE	Lower (95% CI)	Upper (95% CI)
External revenue	-0.015	(0.083)	-0.177	0.148
Farmer market price	0.044	(0.062)	-0.077	0.166
Other crops grown	-0.145 ***	(0.050)	-0.244	-0.047
Well depth in meters	0.023	(0.014)	-0.004	0.050
Irrigation in euro value	0.0005 **	(0.0002)	0.0001	0.0009
Education in years	0.007	(0.014)	-0.021	0.034
Family members	-0.054 ***	(0.017)	-0.087	-0.020
(Constant)	0.905 ***	(0.290)		
R ²			0.462	
Adjusted R ²			0.351	

Note: β, regression coefficient, SE, standard error, CI, confidence interval. The statistical significance of the variables is denoted by * p < 0.1, ** p < 0.05, *** p < 0.01.

Conclusion

The study aimed to analyze greenhouse tomato and pepper input efficiency use in Kosovo at a regional and farm level.

It was identified that the inefficient input use in the production of greenhouse tomatoes and peppers was caused by two primary factors.

- I. Disproportionate use of inputs
- II. Disadvantageous market conditions

Often the first factor leads to a loss of production, which may be avoided by reducing the use of inputs to the same level of the scale efficient input values.

The other factor concerns the disadvantageous market conditions where pressure from imports and low prices set from vegetable wholesalers heavily affect greenhouse tomato production.

In sum, the study revealed that under the given greenhouse tomato and pepper production levels, there would be a large opportunity for the technically-inefficient regions and farms to improve their performance through the use of inputs.

References

1. Judah, T. Kosovo: What Everyone Needs to Know; Oxford University Press: Oxford, UK, 2008.
2. Zuzaku, A. Marketing research is path towards the development of agriculture in Kosovo. In Economic and Social Development: Book of Proceedings:2014; pp. 488– 496.

Acknowledgments

We thank the Department of Agricultural Economics and Agribusiness of the University of Arkansas in Fayetteville, Arkansas, and greenhouse tomato and pepper farmers throughout Kosovo.

Other

*Poster information is based on the article published by the authors. The article is cited below.

Frangu, B.; Popp, J.S.; Thomsen, M.; Musliu, A. Evaluating Greenhouse Tomato and Pepper Input Efficiency Use in Kosovo. Sustainability 2018, 10, 2768.