The effect of maize on economic development: Evidence from Romania

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Preliminary

1. Introduction

Authors studying early economic development have observed that the process was associated with a structural transformation of the society. As economic growth takes hold, people move from villages to towns and take employment in industry or services leading to a decrease in the share of employment in agriculture (Kuznets, 1957). Understanding the factors that drive this transformation is thus an important aspect of economic development. Classical views (Baumol, 1967) based on experience from England, state that economic development is helped by an increase in agricultural productivity, which frees up labour and increases demand for goods produced by the industrial sector. However, other authors argue that in an open economy, increased agricultural productivity can actually lead to the opposite effect (Mokyr, 1976) increasing the income of the agricultural sector and discouraging workers from moving to cities.

An important historical event that can be exploited to add empirical data to this debate is the widespread transfer of crops, diseases, animals, populations, ideas, technology between the New World and the Old World after Christopher Columbus's voyage to the Americas in 1492 (the Columbian Exchange). Authors have conducted empirical studies in order to assess its impact on economic development nowadays (Nunn, 2014). While many studies argue that the effect of the agricultural productivity shock given by the introduction of new crops from the New World to the Old World on long run development is a positive one (Nunn and Qian, 2011) a number of other studies argue that this is not always the case (Chen and Kung, 2016; Bustos, Caprettini and Ponticelli, 2015). Namely, if the new agricultural technology gives a comparative advantage to

agriculture over industry, then it would actually lead to a slowdown in the growth of urbanization. To bring evidence on this, we consider the introduction of maize in Romania at the end of the seventeenth century as a shock to agricultural productivity in order to estimate its effect on economic development as measured by urban population. We hypothesize that, after the introduction of the crop, towns situated in areas that are suitable for maize cultivation had growth rates that were different from towns with low suitability for maize. We expect the effect of maize suitability on urbanization to be negative because the new agricultural technology increased productivity but also required more labor per unit of land creating conditions for an increase in rural population.

Why should we look at the adoption of maize in Romania? One reason is that land conditions are favorable for the cultivation of maize. Thus maize has been the most cultivated cereal in Romania since records began and until today. In fact today, Romania has the largest areas cultivated with maize from the EU so we can expect that the adoption of this crop has had an important effect on the economy. Another reason is that the country offers a very interesting historical setup. While the Romanian territories shared almost the same culture, they had different institutions. While Transylvania was part of Hungary and later the Austro-Hungarian Empire, Wallachia and Moldova were under Ottoman influence. Starting from the seventeenth century they also come occasionally under the influence of the Russian empire, as it was seeking to expand towards the Bosporus.

2. Background and literature

History of maize and its benefits

Columbus introduced maize into Europe in 1493, after his first voyage, when he gave an account of his journey to the court in Barcelona. Over the next century, the new crop gradually spread towards the east. In Romania, maize first reached Transylvania during the seventeenth century. Next it reaches Wallachia between 1678 and 1688, and Moldova by 1693. The story about the introduction of maize to Wallachia says that the export of maize seeds from Transylvania to Wallachia was not allowed. So, in order to get the maize across the border, the Wallachian ruler bought turkeys instead and fed them with corn before crossing the border. Then, as soon as the border was crossed the turkeys were sacrificed and the corn was retrieved.

Being at the meeting point of three empires, wars were very frequent in the period. At the time of the introduction of maize, the preferred strategy of dealing with invading armies was fighting a war of attrition, burning crops and poisoning wells ahead of an advancing enemy. This

made millet the preferred choice of crop for farmers because of the very short growing season which takes around 90 days from seed to harvest. In Romania, as in the rest of Europe, maize took over the zones where foxtail millet was grown (Haudricourt and H é din, 1987:223). Within a century, maize had largely replaced millet as the main crop grown in the Romanian territories.

The biggest benefit of maize over the cereals from the old world is the high agricultural output per unit of land which averages double that of wheat. Another benefit is that it gives a large amount of carbohydrates, sugar and fat with a short growing season, compared to other plants. Corn flour has the advantage of better mineral content and better taste than millet flour. This, coupled with the fact that it can be cooked in the same way as millet flour, by boiling it in water, led to the replacement of millet with maize in the 'polenta' which is one of the country's national foods. One disadvantage compared to millet is that the growing season is longer by 30-40 more days but that is still shorter than that of wheat. On the other hand, maize does require more labour input than millet. Another advantage that corn enjoyed was that it was exempt from the Ottoman tribute, unlike wheat. Although in the beginning, both in Moldavia and Wallachia but also in Transylvania, the lords tried to slow down the spread of maize by banning the cultivation of maize on wheat fields. Growing maize was later permitted on the peasant's fields and it soon mostly replaced other cultures, the only ones that continued to grow wheat being the manors. Thus, in the countryside the main food for the peasants became maize 'polenta', which they ate instead of bread.

Literature

The impact of maize cultivation in Romania on economic development is discussed in a series of historical studies (Djuvara, 2002, Lampe 1982). However, no quantitative studies have been carried out yet. International evidence which focus on maize as a shock to agricultural productivity exists but is scarce. One reason for this is that, unlike in Romania, maize was not an important staple crop in Western Europe, being used mostly livestock fodder. The impact of other agricultural technologies was more widely analyzed. One well known study is that of Joel Mokyr (1981) which examines the influence of potato adoption on population growth in 1845 for Ireland. Expanding the study by Mokyr, Nunn and Qian (2011) examine how potatoes influenced population growth across Europe, after the introduction of potatoes to the Old World. Looking at a different crop, Schmidt, Jensen and Naz (2015) find that the introduction of clover to Denmark accounts for 8% of the market town population growth between 1672 and 1900. A study that analyzes the effect of maize adoption is that of Chen and Kung (2016). They find that maize accounted for 19% of the population increase after its introduction in 1776 but find a less pronounced effect on urbanization and real wages. Foster and Rosenzweig (2004, 2008) study

the impact of the adoption of high-yielding-varieties of corn, rice, sorghum wheat during the Green Revolution and find that the higher improvements in crop yields have a negative impact on manufacturing growth in villages across India. A study of interest for us analysis is the one by Bustos, Caprettini and Ponticelli (2015) which provide evidence from Brazil that the introduction of less labour intensive crop like GE soy leads to an increase in industrialization rates while a more labour intensive crop like second harvest season maize has the opposite effect. Their explanation is that when a less labour intensive crop is introduced people move to the cities to search for a new job, while if a more labour intensive crop is introduced, people will have an incentive to remain and work in the countryside.

3. Data

The data on city populations are compiled from multiple sources. The primary sources are the National Archives of Romania, National Library of Romania and Romanian Academy. This set of data is combined with the one from Bairoch (1988) resulting a total of 1127 observations for 183 different cities and towns and 1071 observations from 219 villages in the period 1000-1920, although the process of data collection for the urban as well as for rural sector is still in progress. Table 1 shows the number of observations across periods for urban and rural areas accompanied by the number of observations per regions: Dobruja, Transylavnia, Moldova and Wallachia

Period	Urban	Rural
under 1250	18	1
1250-1350	11	0
1350-1450	7	5
1450-1550	24	6
1550-1650	49	23
1650-1725	45	34
1725-1775	55	79
1775-1825	95	206
1825-1875	432	422
over 1875	391	295

Regions	Urban	Rural
Dobruja	8	3
Moldova	114	152
Wallachia	494	428
Transylvania	511	488

Table 1. Number of observations across periods for urban and rural areas and number of observations per regions: Dobruja, Transylavnia, Moldova and Wallachia. *Source:* author's calculations

It can be observed that the best records of city population are available after 1825. More observations could be found in Transylvania perhaps due to a better organized state administration. Many observations are also available for Wallachia because that is where the state administration got centralized in the 19th century. Rural observations are of lower quality: they are tightly clustered in position and in time because each record in the archives covers a number of closely situated villages over a period of a few years. The average population stays the same because more records of less important towns become available towards the end of the period.

In order to pursue our difference and difference strategy, data on crop suitability was taken from the GAEZ database (Global Agro-Ecological Zones) of the UN Food and Agriculture Organization. This database aims to provide reliable knowledge at a global level about the available the agricultural resources in order to help with the sustainable management of these resources. In order to estimate the available agricultural resources, the globe is divided in squares of a resolution five arc-seconds and for each of this squares, a crop suitability is assigned. The suitability is calculated based on climate, soil and terrain data. Climate data includes temperature, precipitation, wind speed, sunshine hours, humidity and we used suitability levels calculated for: rain fed crops (no irrigation), a low input of labour, technology and climatic data from the 1961-91 base period. Figure 1 displays the suitability for maize and the city distribution across Romania.

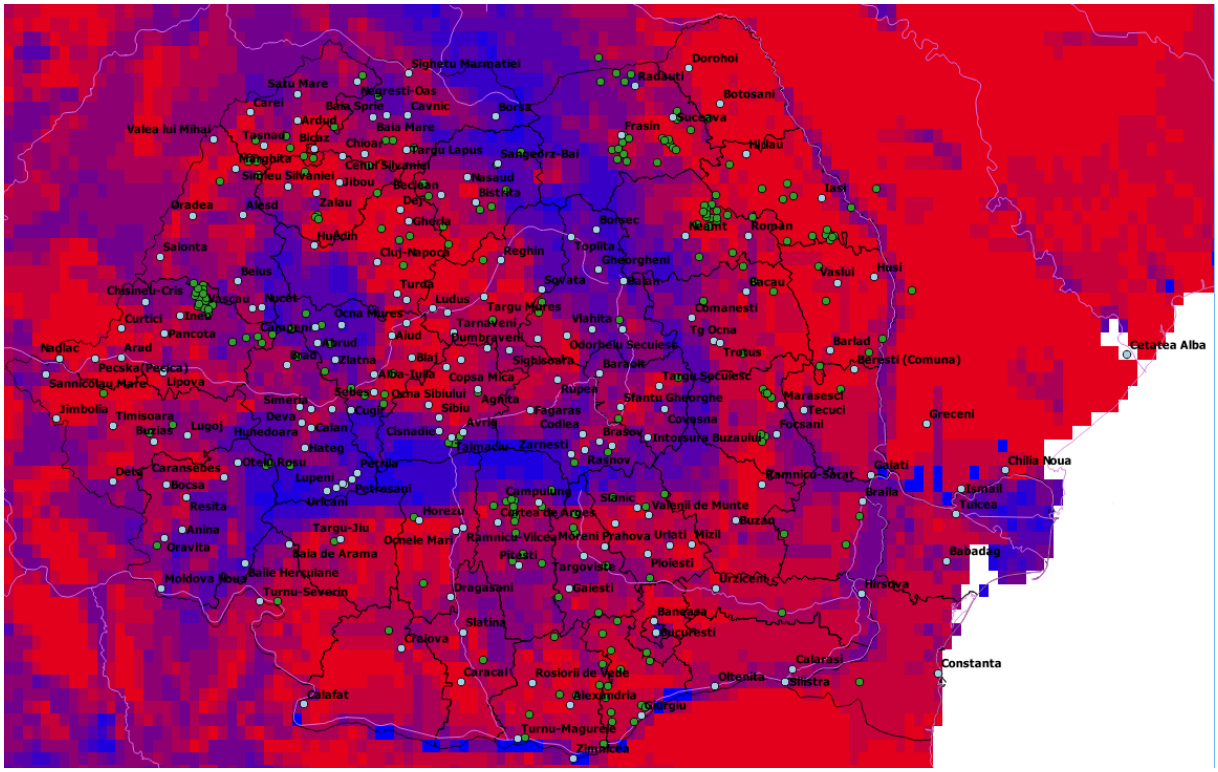

Figure 1. Maize suitability and cities. *Source:* GAEZ database

Areas in red color are the most suitable for maize cultivation, whereas the blue areas are less suitable, providing variation across the three Romanian Principalities. For each city, crop suitability is taken as average suitability on a 30 km radius around the town. Distance from rivers and distance from the sea were also calculated to be used as a proxy for trade.

4. Empirical strategy

To quantify the effect of the agricultural technology shock, we implement a difference in difference estimation strategy. The objective is to compare the relative differences in the growth of urbanization before and after the introduction of maize between the regions that were suitable for maize and those that were not. On top of that we estimate a flexible model to check when the effects on urbanization start to become statistically significant. The regression equation for the base model is the following:

$$ln(pop_{it}) = \alpha_r + \alpha_t + maize_i adoption_{1700,t}\beta + \varepsilon_{it}, \quad [1]$$

where: the independent variable represents the natural logarithm of city/rural population regressed on: fixed effects for region and year; *maize* represents the average maize suitability on a 30 km radius; *adoption* takes the value of 1 after the date of adoption of maize; β measures the impact of maize on city population, and ε is the error term.

We also add controls variable for other crops, distance from rivers, sea, ruggedness, elevation, latitude, and distance from Bucharest and Vienna. Flexible model with interactions for all periods were also estimated so that in the end, further robustness checks could be performed.

5. Results

Table 2 gives an overview of the regression results. Column 1 presents the results for the base model with year and region fixed effects. In column 2 different control variables were added, to account for factors such as distance from the sea, distance from the river, elevation, ruggedness, latitude, and distance from the capital (Bucharest). Further, in column 3 the model controls for distance to trading partners, Vienna and Istanbul. Column 4 brings controls for different old world crops, like barley, wheat, oat, rye, while column 5 presents a model which controls for another new world crop, namely the potato. The model in column 6 controls for the crop being replaced by maize, the millet and the results in column 7 are presented in the light of controlling for cities which are administrative centers. To allow for regional differences, the last column shows that the effect of maize was significantly more pronounced in Wallachia then in the other regions, probably because of the shorter distance to trade routes (more exports). All these models show that maize suitability had a significant effect on the city population, leading to a decrease of as much as 10% in city population per suitability level.

	Dependent variable							
	Log population							
	1	2	3	4	5	6	7	8
maize x adoption	-0.356***	-0.118*	-0.1365***	-0.243***	-0.408***	-0.247***	-0.212***	-0.303***
	[-11.228]	[-1.672]	[-3.176]	[-3.179]	[-8.650]	[-7.313]	[-7.785]	[-7.855]
maize x adoption x Moldova								-0.123
								[-1.351]
maize x adoption x Wallachia								-0.097**
								[-2.114]
Observations	1127	1127	1127	1127	1127	1127	1127	1127
R-squared	0.274	0.4348	0.4599	0.2735	0.2749	0.3126	0.4936	0.2775
t-statistics in brackets								
*** p<0.01, **p<0.05, *p<0.1								
Fixed effects for:								
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance from river	No	Yes	No	No	No	No	No	No
Distance from sea	No	Yes	No	No	No	No	No	No
Elevation	No	Yes	No	No	No	No	No	No
Rugedness	No	Yes	No	No	No	No	No	No
Latitude	No	Yes	No	No	No	No	No	No
Distance from Bucharest	No	Yes	Yes	No	No	No	No	No
Distance from Vienna	No	No	Yes	No	No	No	No	No
Distance from Istambul	No	No	Yes	No	No	No	No	No
Region capital	No	No	No	No	No	No	No	No
Administrative center	No	No	No	No	No	No	Yes	No
Wheat suitability	No	No	No	Yes	No	No	Yes	No
Barley suitability	No	No	No	Yes	No	No	No	No
Oat suitability	No	No	No	Yes	No	No	No	No
Rye suitability	No	No	No	Yes	No	No	No	No
Potato suitability	No	No	No	No	Yes	No	No	No
Millet suitability	No	No	No	No	No	Yes	No	No

Table 2. Regression results for the urban population

Same exercise was performed with rural population as a dependent variable, and the numbers obtained are displayed in table 3. Results from some of the regressions show a significant positive impact of maize suitability on rural population, but the results do not pass the robustness checks. Although better data on village populations could improve the results, the interpretation for the below table is that maize did not have a negative impact on rural populations, like in the case of urban ones.

	Dependent variable					
	Log population					
	1	2	3	4	5	6
maize x adoption	0.075***	0.001	-0.052	-0.086	-0.000	0.063***
	[4.247]	[0.028]	[-1.625]	[-1.415]	[-0.016]	[3.349]
Observations	1071	1071	1071	1071	1071	1071
R-squared	0.366	0.426	0.398	0.374	0.369	0.375
t-statistics in brackets						
*** p<0.01, **p<0.05, *p<0.1						
Fixed effects for:						
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Distance from river	No	Yes	No	No	No	No
Distance from sea	No	Yes	No	No	No	No
Elevation	No	Yes	No	No	No	No
Rugedness	No	Yes	No	No	No	No
Latitude	No	Yes	No	No	No	No
Distance from Bucharest	No	Yes	Yes	No	No	No
Distance from Vienna	No	No	Yes	No	No	No
Distance from Istambul	No	No	Yes	No	No	No
Wheat suitability	No	No	No	Yes	No	No
Barley suitability	No	No	No	Yes	No	No
Oat suitability	No	No	No	Yes	No	No
Rye suitability	No	No	No	Yes	No	No
Potato suitability	No	No	No	No	Yes	No
Millet suitability	No	No	No	No	No	Yes

Table 3. Regression results for the rural population

In table 4, a flexible model presents a significant negative influence of maize suitability on city populations starting from 1750, showing that it took 50 years after adoption for effects to become significant. Increased trade with grains at the end of the 19th century enhanced the effect, causing more people to stay in the countryside and work the land instead of moving to cities.

y1300*maize	y1400*maize	y1500*maize	y1600*maize	y1700*maize	y1750*maize	y1800*maize	y1850*maize	y1900*maize
0.041	-0.74	0.144	-0.203	-0.146	-0.468***	-0.221**	-0.192***	-0.409***
[1.031]	[-1.235]	[0.506]	[-1.120]	[-0.747]	[-2.670]	[-1.969]	[-5.333]	[-7.779]

Observations: 1227
R-squared: 0.2911
t-statistics in brackets
*** p<0.01, **p<0.05, *p<0.1

F-test for overall significance: 23.02***
F-test for equality of periods: 1.159

Table 4. Regression results. Flexible model.

6. Conclusion and discussion

The results show that maize had a significant negative effect on urbanization, by observing a decrease of as much as 10% in population per suitability level with the strongest effects shown after 1850, possibly because of improved trade relations in the second half of the nineteenth century. We add empirical evidence to the theory that not all improvements in agriculture lead to increases in urbanization, with more labour intensive agricultural technology giving people a smaller incentive to move to cities.

One way to reconcile the two views on the relationship between agricultural productivity and economic development is to look at the timing and location of the events analyzed in the studies arguing for the two sides. Papers bringing evidence that increased agricultural productivity has a positive effect on economic development looked mostly at Western Europe at events further in the past. On the other hand, studies that see the opposite analyze more recent productivity shocks in Eastern Europe or Brazil (for example). Considering this, one explanation could be that when the new crops were introduced in Western Europe, there was less trade because the means of transport (especially over land) were less developed and the leaders of the time pursued a policy of mercantilism, thus the economies worked more like closed economies. When the new crops reached Eastern Europe, trade links were already improving and political views on trade had changed so the economies in these countries were closer to open economies.

For example maize was introduced in Spain in 1593 but only reached Romania around 1700 and spread in the century to follow. This would mean that while the productivity shock had a positive impact on economic development and urbanization in Western Europe, trade conditions could have changed enough by the time that the technology reached Eastern Europe to actually create a negative impact on urbanization here. This can be one mechanism for explaining the divergence between Eastern and Western Europe. Additionally, the structural difference is even visible today, when around 30% of the population in Romania is employed in agriculture, while that number is around 1% in the UK.

Further work aims to enrich the present dataset, to look at employment structure, wages, and to improve the model with other specifications and further control variables.

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