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Chapter

Solanum tuberosum Yield for Selected Countries

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Abstract

This chapter, aimed at analyzing potato yield among selected countries, has seven sections. The panel analysis of potato production and productivity has shown significant differences among countries. The main panel analysis of the random and fixed effect model indicates a negative influence of land size on yield and a positive influence on production. However, using multilevel mixed effect model, some country specific estimates deviate from main model results. In yield and output equations, the influence of land is positive for some countries and negative for others. Improvement of potato productivity is vital for hunger relief and starvation reduction. Even though, area specific analysis can bring in many determinants of potato production and productivity. A detailed analysis can give the right direction for policy makers in their effort to reduce hunger and starvation as well as improve the living standards of people.

Keywords: World potato share, regional potato production, potato yield, random effect model, fixed effect model, multilevel mixed effect model

1. Introduction

Spreading to about 160 countries of the world, *Solanum tuberosum* or Irish Potato or sometimes referred to as potato, is originated from the Andes of South America [1]. Potato is in the fourth order with respect to production and area harvested after maize, wheat and rice [2, 3]. Potato is one of the most world productive crop with high value as a balanced and nutritious food [2]. Being so important, potato is central to food security [4]. This implies that potato is an ideal crop for starvation related problems when weather is favorable. Smallholder farmers in developing countries like Kenya use almost 25 percent of their nearly 2.4 hectares farm area to grow potato for consumption and commercial purposes [5]. While fresh potato consumption has declined, it is observed that the consumption of processed products has continued to gain popularity [1].

This chapter analyzes potato productivity trend in some selected low and high income countries. In this analysis, the aim is to answer the following two questions. *Has there been an increase in potato production among selected countries? Is the increase in potato production a result of land expansion or yield improvement?* The question of increased potato yield is important because [6] increased population requires increased food production which is constrained by water and land availability. As a result, the increased potato production should be supported by increase in potato yield rather than land expansion. It is clear that with growing population and income, food crop yield must keep expanding to meet global food

demand [6]. The rest of the study is organized as follows. Section two discusses about regional average potato production. Section three discusses about the contribution of potato in world food production. Section four discusses the productivity trend of potato. Section five concludes on the ability of the tuber crop in fighting against starvation.

2. World potato share of food crop

Potato belongs to the root and tuber crops group [7], such as sweet potato, yams, and cassava, which are among leading crops in the world [8]. The group of tuber crops as can be viewed in **Figure 1** comes fourth after cereals, sugar crops primary and sugar cane. However, as highlighted in section one, potato maintained a fourth position after maize, wheat and rice. This reality makes *Solanum tuberosum* (potato) the leading crop in the group of tuber crops because no other tuber crop has outweighed potato other than cereals. The average values provided in the figure, however, are computed from 1961 to 2029. Sugar cane is leading among crops standing on their own rather than in groups. Sugar consumption is very high from industrial consumption to domestic consumption. The crop can be eaten raw, processed to make juice and processed to make industrial and domestic sugar.

The demand for sugar is very high due to the fact that it is highly needed as an ingredient in other processed food. Most of the food people consume have sugar components [10], for instance cakes, bread, and other bites are all mixed with sugar. Juices from other fruits like orange, mango and others processed either domestically of at industrial levels are mixed up with sugar. There are a lot that can function with sugar, even fresh milk, ice cream, candy and chocolate that are favorites of children and people of all demographics must be mixed up with sugar contents. As a result, sugar cane production is highly favored for domestic consumption and industrial input for commercial purposes. It is found [11] for instance that US citizens' purchase is highly based on high processed foods with high contents of sugar. However, even with this high level of demand and high promotion of sugar cane production with large and new plantations being started, sugar cane cannot be promoted to fight against starvation. The crop cannot be consumed alone as food crop, but rather additional and cannot be taken in excess. As it is discussed in the book, "Sweeteners and Sugar alternatives in Food Technology", research is undertaken to find sugar alternatives for food in order to improve consumer health [12].

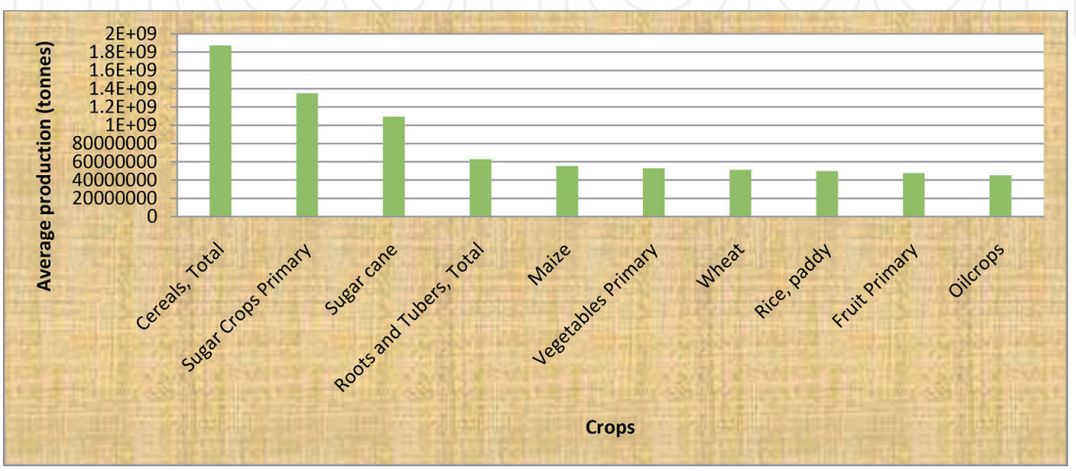


Figure 1.
World's most produced crops. Source: [9]. Note: The values used for the analysis are the average values of FAOSTAT computed from 1961 to 2029 [9].

Therefore, promotion of high yielding food crop is the most important decision among policy makers as it reduces hunger and fight against starvation.

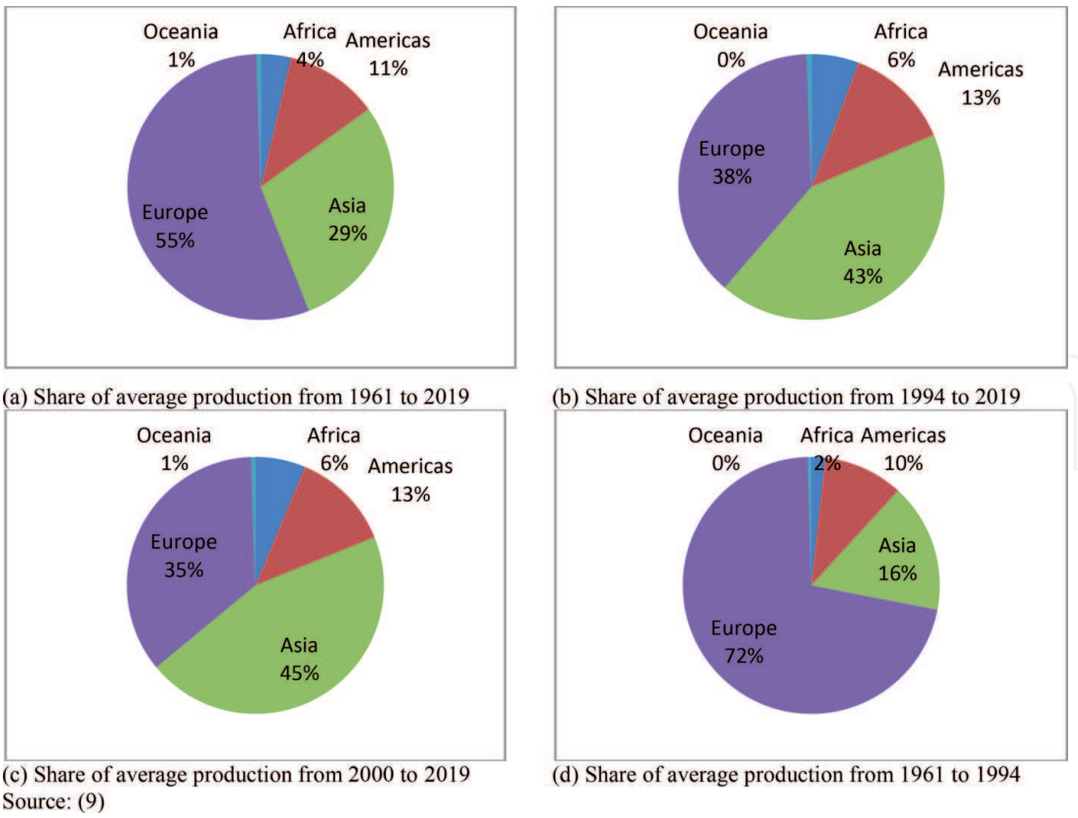
3. Regional potato production

Potato production has spread worldwide. The regional production averages from 1961 to 2019 as shown from FAOSTAT in the table below, indicate a very high proportion of potato coming from Europe. The average is very high for the period mentioned showing that Europe is the leading region compared to other regions. For the period under consideration, Asian region comes second followed by the Americas, that is, North and South America combined with 11 percent. Africa which is one of the least developed regions comes with only 4 percent of the world potato share. The shares are approximated, for instance in the upper right chart of panel (b), Oceania region has a 0.5 percent but due to round off, the figure turned into 0 percent. The region produces on average, about 1736491.5 tones of potato for the period from 1994 to 2019. The periods have been randomly selected to check on consistence of potato production dominance.

In panel (b), by changing the period of analysis, the world average share of potato production by region also changes. Using the full period data to get the average favors Europe compared to other regions. The European region is overweighed by the Asian region in the period starting from 1994 to 2019. A simulation analysis on the impact of climate change on potato [13], indicate a significant reduction of potato production in Eastern Europe and Northern America. Even though, African region remained in the same position with a very low share of production. The change can be attributed to the improvement in agricultural production technology in Asia. The average production in Asia increased but declined in Europe. For instance, the average production in Europe was 166767397.02 tons in the 1961–2019 period and was 125436231.88 tons in the 1994–2019 periods. While the average production in Asian increased from 87285656.59 to 140597815, respectively. This clearly indicates an improvement in average potato production in the Asian region compared to the average potato production in the European region. Nevertheless, the increased average potato production in Asia is likely to result from both land expansion and productivity improvement. Accordingly [14], China is the world leading potato producer due to land expansion and increase in potato yield (**Figure 2**).

The average share of potato production in panel (b) indicates the Asian dominance. This dominance comes from a great improvement because as it is shown in panel (d), the periods before 1994 a large proportion of world potato came from Europe. About 72 percent of world potato came from Europe and Asia, through that period, produced only 16 percent of world potato. It is clear evidence that Asia worked very hard to reach to the later period's level of potato production. All the periods later after the 1990s, Asian region has dominated the rest of regions in potato production. Even taking the 2000s' average production in panel (c), we still witness potato production dominance by the Asian region compared to other regions. Asia's awake in potato production is very important in increasing the world food security. With improved potato processing technology, potato is becoming a promising food crop suitable for fighting against starvation. Nevertheless, the crop can also be a driver for industrial development particularly in developing countries.

Figure 3 provides a list of countries leading in potato production using the average values computed from 1961 to 2019. The list includes even the Soviet Union which collapsed [15] in 1991. That is why Russian Federation has a shorter span of time from 1991 to 2019.



(a) Share of average production from 1961 to 2019

(b) Share of average production from 1994 to 2019

(c) Share of average production from 2000 to 2019

(d) Share of average production from 1961 to 1994

Source: (9)

Figure 2.
Region production shares of potato. Note: Due to approximations, Oceania seems to have zero share of potato in the world. However, Oceania has in every panel some quantities of potato produced.

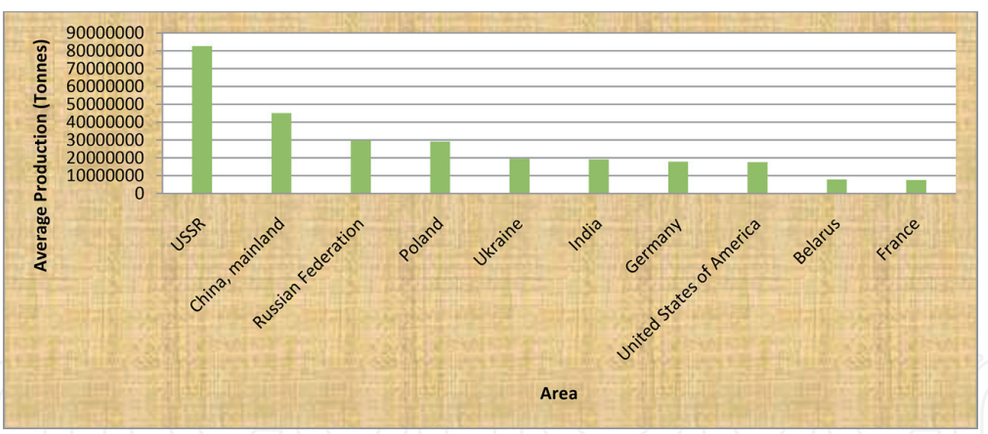


Figure 3.
Top 10 in potato production. Source: [9].

The shorter time period of Russian Federation is likely to be the reason for lower average potato production compared to other countries included in the analysis. The Soviet Union is leading in the average potato production since 1961 to 2019 even though it collapsed in 1991 because the union involved many countries. It is a group of countries rather than an individual country. For individual countries, China mainland is leading in average potato production from 1961 to 2019. Even in the trend analysis, China has a very high level of potato production which is again trending upward at a very high speed. The slope of the production trend is roughly steeper than those of other countries. As a result, even if China's potato productivity is almost half the potato productivity of the USA, total potato production is far larger than that of the USA. This is highly influenced by the increased land under potato production, but also potato productivity [14] in China. The increased land

devoted for potato production in China is due to increased processing of coarse starch which is the most important component of potato processing industry in China. But also other processing industries such as crisps, and French friesare expanding [14].

4. Potato harvestedarea for some selected countries

As shown in the previous section, Africa's potato share has remained stagnant and lagging behind other regions except Oceania. The region is large in geographical size, but with a lower average production compared to other small sized regions like Europe. This is due to the fact that most agriculture practices in Africa is under subsistence farming where farmers grow crops in small plots with poor farming implements. In Kenya for instance [5] farmers cultivate on a land of less than 2.4 hectares with diseases constraint. In this part, six African countries that are, Nigeria, Rwanda, Senegal, Uganda, Tanzania, and Zambia have been selected to represent the region. For Europe, Sweden and Romania have been used as representatives. China, Korea, Japan and Philippines have been used to represent the region of Asia. Nevertheless, Peru, Uruguay, Canada and the United States have been selected to stand for the Americas region. The Oceania has been represented by Australia. As the list shows, the representation is not even but only to provide some light on the production status of the region. The countries as we all know have different characteristics to become a regional representative. But, for analytical purposes, the sample is still worth of knowledge generation. A clear specific country trend analysis can be provided on request. But due to space limitation, the overlay graphical analysis is used to highlight important results.

The graphical analysis of area harvested, quantity produced and the land productivity is provided in this section. It is important to have production area expansion especially in low income countries due to low agricultural mechanization. The increased technology leads to increased production without necessarily expanding the area under potato cultivation. From appendices, the trend shows that on average almost every country increased the area under potato production although with some variations of up and downs. For instance, in the late 1990s, Nigeria expanded potato production area which had previously been almost constant from 1961. An expansion from less than 50,000 hectares to about 200,000 hectares is significant in increasing production quantities. The potato production area trends in Rwanda, Tanzania, and Zambia are shown with hump shaped structure reaching peaks in late 2000s and dropping in around 2010s. The likely explanation of this drop is poor weather condition because the area provided here is that which has been harvested with potato. So, it is likely that the cultivated area did not shrink but due to unfavorable weather conditions, the harvested area declined.

Potato production in Europe has also been declining in terms of the world average potato share. For the selected countries, however, Israel is also termed as a European country in the analysis here. Israil cannot be accepted in Europe due to its geographic position. But for analytical purpose, it still works better to place Israel in Europe. An important point to stress here is that we have the ability to talk about Israel potato production regardless of the region we place the country. The analysis just takes few of the selected countries to show how area harvested has been trending throughout the analysis period. The selection is not based on any scientific reasoning but rather a random selection made discretionarily.

The analysis shows a quit unique trending for each of the countries involved. However, unlike other European countries which have shown some hump shaped curves, Sweden has reduced the land size for potato production by time. Even

Romania has also decreased the land size for potato production. Although, it is the area harvested with potato, the reduction of land size can be an appropriate explanation for harvested area shrinking. The reason comes from the fact that Europe has a high agricultural technology which improves productivity thereby reducing the area to be cultivated with crops. The reduction in area under potato harvest explains why world potato share of Europe has been declining by time.

The harvested area for Canada has been low but then increased shortly just to return to the lower levels making a hump shaped curve. Peru has shown increasing interests after dropping down in the 1990s then rising throughout. The United States of America and Uruguay have almost the same potato harvest pattern of fluctuations but continually dropping down. Even though, as it can be seen, the two have a significant difference in terms of absolute potato harvest area. The Uruguay's harvested area is almost ten times less than the one of the USA. So, even if the harvested areas of both countries have been declining in the same trending pattern, the USA produces large quantities of potato compared to Uruguay and the rest of included countries in the regional analysis.

After we have traced the trend of potato harvested areas for Americas, Africa, and Europe, it is also important we slightly analyze the case for some Asian countries. In this case, China, Japan, Korea, and Philippines have been used to provide a glimpse of the Asian region. However, as noted before, they are not used as reflecting what is happening in Asia but rather their analysis presents a representative of the region.

In the harvested area, China has been expanding the size annually, the pattern which is also experienced with Philippines. Even though, China's area is far larger than Philippines' harvested area. The rest of the included countries, that is, Japan and Republic of Korea have continually experienced potato harvested area shrinking. The increased technology in the countries allow for the reduction of planted area with either increased or constant potato output. In the next section, the trend

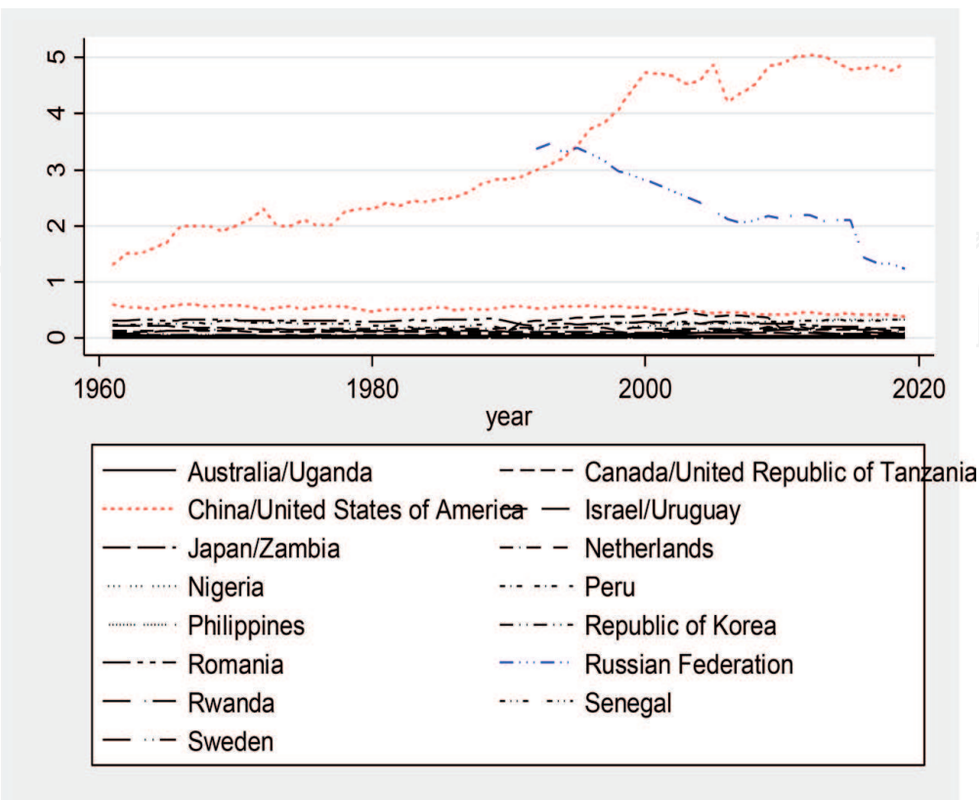


Figure 4.
Area harvested with potato. Source: [9].

analysis of potato land productivity is provided. This is the focus of the chapter which however becomes more informative after the harvested area trend analysis. Increased potato productivity is at the center of starvation and poverty reduction.

From **Figure 4** above, the red colors are for China and the USA with larger sizes being recorded for China. The upper red line is for China while the lower red line is for the USA showing a very huge difference between two countries. After Soviet Union collapsed, Russian Federation started operating independently with potato allocated land of the size of China. But the size of potato cultivated land in Russia has been continually declining, whilst that of China's has been continually increasing. However, in terms of land productivity, China is far less than the USA as the analysis in the following section shows.

5. Potato productivity for selected countries

Before we consider productivity, it is important to have a total production analysis. As it is shown in **Figure 5** below, total production trend almost resembles area under potato production in **Figure 4** above. The red lines again stand for China and USA, and the blue line is for Russia. Just like for land under potato production, total potato production when Russian Federation started operating independently was the same as that of China. However, the production for Russia has been downward trending following potato production land shrinking. Potato production for the USA has been lower than the production for China. Apart from China, Russia and the USA, potato production trends for the remaining countries lie below 20 million tones.

But, contrary to total production analysis, potato yield trend analysis shows a different picture. The productivity analysis shows very different outcomes whereby countries with increasing harvested areas have experienced lower productivity than countries with declining harvested area. In other words, countries which have

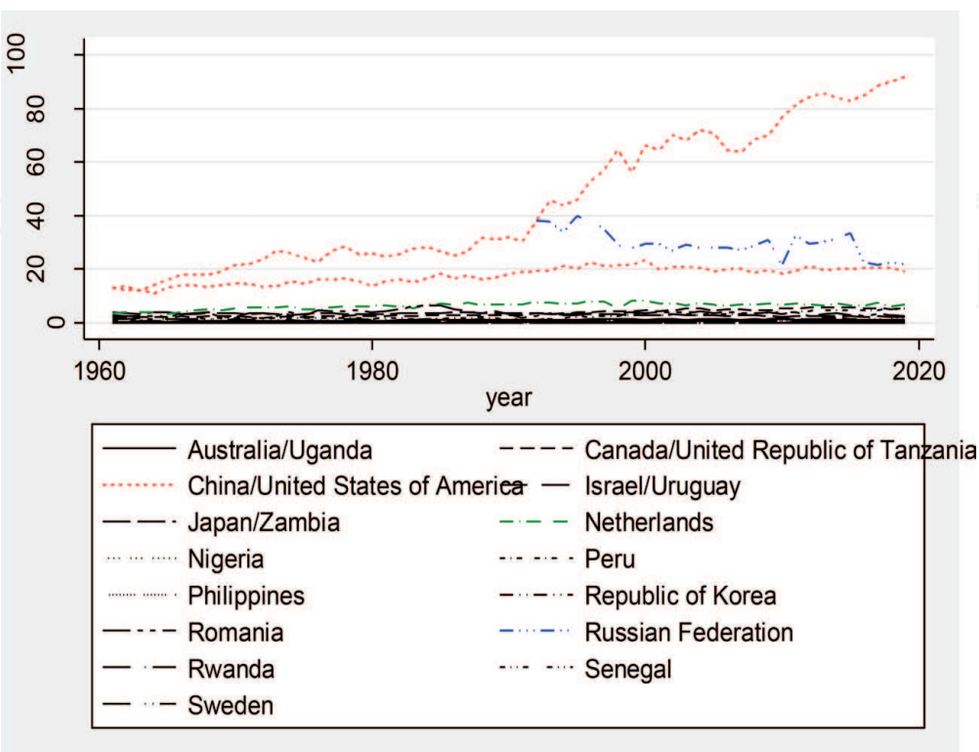


Figure 5.
Potato production among selected countries. Source: [9].

experienced increasing productivity, have discretionarily reduced the size of their potato farming land. For instance, the red lines in **Figure 6** again stand for China and the USA. But this time, it is the lower line which represents China and the upper line standing for the USA. As it can be seen, from almost 2012 or later, the USA is leading in terms of potato productivity. For low income countries like Uganda which is represented by the blue line, productivity is very low. Uganda and Australia which are represented by the blue lines have a very big difference with Australia's potato productivity being far larger than that of Uganda.

The country specific trend analysis in appendix shows that the USA and Uruguay have been experiencing a growth in potato productivity which led into a declining potato harvested area. However, the productivity level of the USA is far larger than the productivity of Uruguay. Japan with a declining harvested area has very high productivity levels compared to China for instance which has experienced increasing harvested area. Productivity in Japan has gone up to higher levels than 30 tons per hectare while that of China has not managed to reach even 20 tons per hectare. As shown in **Figure 3**, China is leading in tuber crop production. Nevertheless, in appendix B, China has the highest level of potato production far larger than the rest of the countries involved in the analysis. It is therefore, clear that the increased production level has been influenced by land expansion. An improvement in China's productivity level to that of the USA for instance without shrinking the potato cultivable land will improve food security to a large extent. As a result, increasing productivity is necessary for development as the remaining land can be utilized for other development purposes. The increased potato and other crop yield is important [6] to spare land for nature conservation.

The next section provides panel regression analysis on the relationship between output and harvested area, as well as yield and harvested area. The importance of this analysis is its ability to tell on the statistical significance of the relationship between output or yield and harvested area. Nevertheless, the panel estimation is

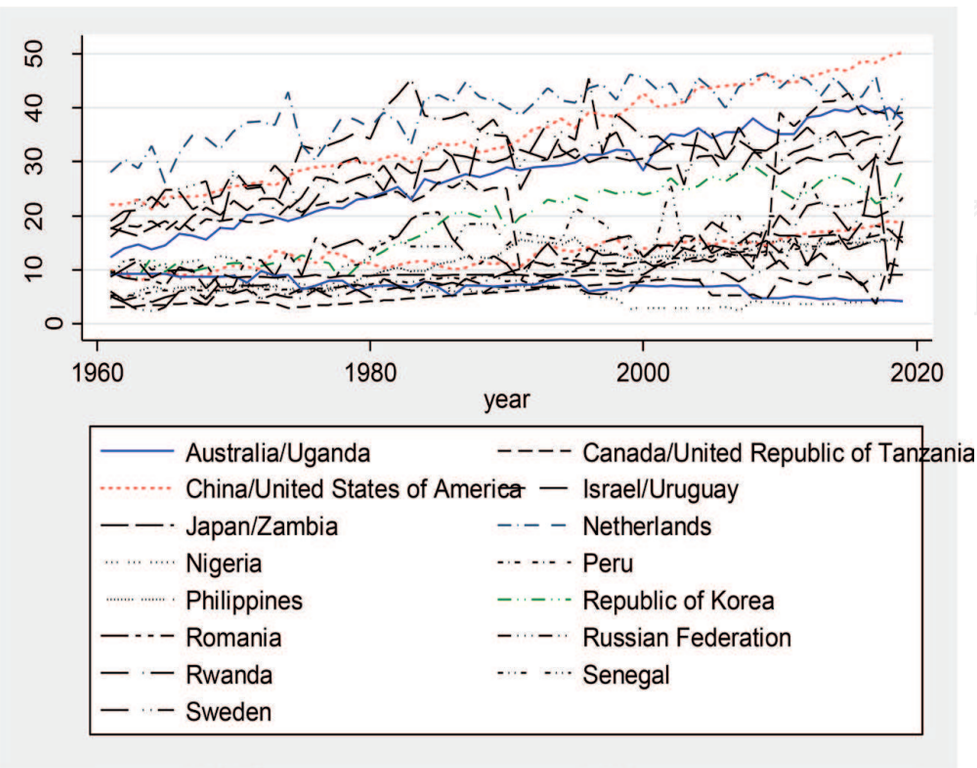


Figure 6.
Potato yield for selected countries. Source: [9].

followed by the post estimation test for random effect. This helps to identify the appropriate model for the coefficient estimation in the study.

6. The effect of land on potato production

6.1 Post-estimation test

After running the random effect model, the test for a zero variance hypothesis is imperative. This is because the random effect assumes a zero correlation between the error term and the independent variable. The zero correlation hypotheses are tested using Breusch and Pagan lagrangian multiplier test for random effects. From the tests, we reject the null hypothesis or zero variance because the test is statistically significant at all levels of significance. Nevertheless, the null hypothesis of zero correlation between the independent variable and the error term is rejected for both output and yield equation. The procedure involves testing whetherthe following equations holds or not.

$$Yield[Country, t] = Xb + u[Country] + e[Country, t] \quad (1)$$

$$Output[Country, t] = Xb + u[Country] + e[Country, t] \quad (2)$$

Where, X is the natural logarithm of land which is the only independent variable used in the analysis, b is the land elasticity of yield in the first equation or output in the second equation. The variance of the model due to country specific differences is represented by u[Country], and the variance of the model due to country differences and time differences is represented by e [Country, t].

In the random effect model, the assumption is that the equation does not hold because there is no influence of country specific differences. The crucial difference [16] between random effect and fixed effect models is whether the unobservable individual elements are correlated with the regressors in the model. However, the results show clearly that country specific differences influence the variation of the dependent variable since $Var(u) \neq 0$ for all the equations estimated, that is yield equation as well as output equation.

6.2 Estimation results

Estimates of both random effects and fixed effects models are provided in **Table 1** below. The difference in the magnitude of their coefficients, however, is not significant. Potato yield is negatively affected by land size because land is in the denominator of the ratio. This implies that any increase in the denominator affects the yield ratio negatively. The results contend with the yield trend analysis where countries with high yield growth rates have also reduced potato harvested area significantly. However, land expansion is better for higher levels of potato output.

Something worth noting in the table above is the similarity of standard errors for each model. That is, random effect model estimation provides similar standard errors for both equations and the same applies for fixed effect model. Nevertheless, even the intercept coefficient is similar for that matter. Similarities are also noted in the variance parameters provided in the lower part of **Table 1**. This similarity tells us on the similarities of the equations due to the fact that the yield equation has both output and land as it is for the output equation.

	Random Effect Model		Fixed Effect Model	
Variable	**Output**	**Yield**	**Output**	**Yield**
Land	.922*** (.014)	−.078*** (.014)	.916*** (.015)	−.084**** (.015)
Constant	3.50*** (.209)	3.50*** (.209)	3.56*** (.156)	3.56*** (.156)
sigma_u	.628	.628	.678	.678
sigma_e	.328	.328	.328	.328
rho	.786	.786	.810	.810

Source: [9].
*Note: *** implies statistically significant at 1 percent levels of significance and standard errors are in parentheses.*

Table 1.
Random effect and fixed effect estimates.

Since we have involved many countries of different characteristics in terms of mechanization, it is important to have estimates for each of the countries in the sample size. Nevertheless, it is true that these countries differ in terms of potato production level, productivity and the size of land apportioned to potato production also differ from country to country. The multilevel mixed effect model is applied to get country specific effect. The approach uses overall data to get estimates for a specific country.

So, even if a country or unit of analysis has lower number of observations, no estimation problem will result due to insufficient number of observation. For instance, for the sample used in the analysis, Russian Federation has 28 observations which is less than the minimum requirement of 30 observations. But, due to the application of multilevel mixed effect model, estimates for Russia have no observational problem just like the rest of the countries which have each 59 observations. The results show differences in intensity of influence of the land size on potato output or yield level.

The country specific estimates show differences in the influence of land on either yield or output. Some countries show results contrary to the main model estimation results in **Table 1**. For instance, yield is negatively affected by land size in the main model estimation. But, country specific estimations show some positive effects of land on potato yield. Potato yields for countries like China, Israel, Netherlands, Peru, Philippines, Senegal, Tanzania, and Zambia, are positively influenced by land size. For these countries, an increase in land size helps to increase potato yield. It can be interpreted that for these countries, although there has been expansion of land under potato production, production of potato has increased at a higher rate than the land expansion rate. Therefore, the pulling down effect of land expansion has been outweighed by the pushing up effect of production increase. It can therefore, be argued that potato yield has been growing at a higher rate than the land expansion rate. An investigation in Yunnan province [17], suggests the use of mixed cropping for developing countries where farming is dominated by small-scale farming. Their findings revealed an increased crop yield between 33.2 percent and 84.7 percent for the same season due to mixed cropping.

For the rest of the countries, potato yield is negatively affected by land size whereby increased potato yield has led to a reduction in the size of land under potato production. It is best to interpret the results that way rather than saying that in order to increase potato yield the area under potato production must be reduced. It is of course the increased potato productivity that influences a particular country to reduce the size of land under potato production. The findings contend with [18] where increased food crop yield corresponds to reduced food crop grown area.

Alternatively, these countries have reached the saturation levels of potato productivity that increases in land size increases potato production but at a rate lower than expansion rate. But, as we have seen in the trend analysis, most of these countries have reached to a point where no improvement in productivity or productivity has been fluctuating around a constant acting as if stationary without increasing or decreasing trend. But, some of the countries have shown increasing yield trend while declining trend of land under potato production.

On the output side, some countries have their potato production being negatively affected by land size. From **Table 2**, it is clear that potato productions in the USA and Australia are negatively influenced by increases in land under potato cultivation. The implication here is that, even with a shrinking cultivated land size, total production in these two countries has increased. As a result, their potato productivity is very high as comparedto other countries. High agricultural technology in these countries, has led into high improvement in potato production that reduction in the area under cultivation does not reduce potato production. When all countries reach to this level of potato productivity, hunger and starvation will remain history in the world.

	Yield		Output	
Country	**Coefficient**	**Constant**	**Coefficient**	**Constant**
Australia	−1.46***(.333)	18.7***(3.50)	−.463***(.333)	18.7***(3.50)
Canada	−.609***(.070)	10.3***(.848)	.391***(.070)	10.3***(.848)
China	.484***(.035)	−4.69***(.515)	1.48***(.035)	−4.69***(.515)
Israel	.122**(.048)	2.36***(.433)	1.12***(.048)	2.36***(.433)
Japan	−.543***(.042)	9.64***(.486)	.457***(.042)	9.64***(.486)
Netherlands	.818***(.155)	−6.12***(1.85)	1.82***(.155)	−6.12***(1.85)
Nigeria	−.211***(.010)	3.85***(.106)	.789***(.011)	3.85***(.106)
Peru	.694***(.201)	−6.42***(2.50)	1.69***(.201)	−6.42***(2.50)
Philippines	.801***(.045)	−4.45***(.384)	1.80***(.045)	−4.45***(.384)
Republic of Korea	−.996***(.073)	13.2***(.759)	.004**(.073)	13.2***(.759)
Romania	−.488***(.184)	8.65***(2.31)	.512***(.184)	8.65***(2.31)
Russian Federation	−.515***(.066)	10.1***(.964)	.485***(.066)	10.1***(.964)
Rwanda	.284***(.038)	−1.10***(.412)	1.28***(.038)	−1.10***(.412)
Senegal	.252***(.087)	.975***(.568)	1.25***(.087)	.975***(.568)
Sweden	−.421***(.049)	7.78***(.518)	.579***(.049)	7.78***(.518)
Uganda	−.176***(.049)	3.75***(.511)	.824***(.049)	3.75***(.511)
United Republic of Tanzania	.248***(.031)	−1.02***(.332)	1.25***(.031)	−1.02***(.332)
United States of America	−1.63***(.191)	24.9***(2.51)	−.628***(.191)	24.9***(2.51)
Uruguay	−.830***(.046)	10.1***(.436)	.170***(.046)	10.1***(.436)
Zambia	.240***(.048)	.781***(.314)	1.24***(.048)	.781**(.314)

Source: [9].
Note: ***, **, and * are levels of significance at 1, 5, and 10 percent respectively. Standard errors are given in parentheses.

Table 2.
Multilevel mixed effects model estimates.

7. Conclusion

The chapter aimed at answering two questions that is whether there has been an increase in potato production among countries involved in the analysis, and whether this increase is due to productivity or land expansion. From the findings, it is clear that, on average, potato production has been increasing from 1961 to 2019. However, potato production increment for some countries has been due to productivity increase, while for others, production increase has been a result of land expansion. For some countries like Tanzania, however, potato yield has been positively influenced by potato cultivable land expansion. For almost all countries except Australia and the USA, potato production has been positively influenced by potato cultivable land expansion. As it has been emphasized [19], potato production increase should come from yield increase rather than land expansion.

The crop is highly produced in developed countries compared to developing countries. Potato productivity for most developed countries has been increasing compared to potato productivity among developing countries. Higher per hectare productivity in developed countries is a result of agricultural mechanization. The application of appropriate farming technologies, which are more advanced, influences more output coming from one hectare. Low potato productivity in developing countries can be explained by low farming technology which forces countries to expand farming land in order to increase production. Given the availability of improved technology and farming techniques in developed countries, developing countries can adopt the technology to increase their own potato productivity. With high technology adoption among low income countries, both potato production and yield are expected to increase in the near future at a higher rate thereby fighting against hunger and starvation.

Potato is an ideal food crop to fight against hunger and starvation especially in low income countries. However, in order for potato to help reducing starvation, countries particularly low income countries must invest in advanced farming technologies to increase potato productivity. Higher potato productivity will avail food at a lower cost, increase employment from industrial processing and therefore improve the living standard of people. Nevertheless, for developed countries with high productivity, potato production land reduction decisions should be revised. This means that since productivity is increasing in developed countries, more land should be available for potato production to ensure food security even in countries with low productivity. Countries with low productivity can access food from high income countries at an affordable price. So, reduction of land under potato production does not match with food security improvement strategy. Even though, if all countries reach to a level of technology where land size reduction leads to increased production and higher potato productivity, then it will be optimal to reduce potato cultivable land for other uses. At this stage, starvation will be something of the past.

This chapter has analyzed potato production and productivity in relation to potato harvested area which is the approximation of potato grown area. There are more factors which influence potato production such as labor, machineries, irrigation, fertilizer application, and spacing which are not included in the current chapter. Future, studies should incorporate these factors to make a detailed analysis. Nonetheless, focusing the analysis on a small area is more appealing as it can include social and economic characteristics of the farm manager which are more important in influencing potato production. From these specific analyses, policy recommendations can be more useful for farmers which are mainly smallholders in developing countries to improve food security by applying more advanced farming technology.

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