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Macroeconomic Trends and Factors of Production Affecting Potato Producer Price in Developing Countries*

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Abstract

Principal component analysis is performed on 33 mainly agriculture related social variables of 40 developing countries. Important components are also put to explain potato producer price. The analysis reveals that the data set contains macroeconomic trends; economic growth, growing importance of the potato and improving infrastructures for the market economy. Although the coefficients for these trends in affecting potato producer price are not statistically significant, it is noteworthy that their signs are in line with observations from earlier research. Economic growth and increasing potato importance are often accompanied with potato price rising in developing countries, whereas improving infrastructures increase availability of food with lower average prices. Potato producer price is statistically significantly affected by four factors of production: land, labour, capital and technology. Relating potato supply constraints of earlier survey literature to principal component interpretation also revealed primary paths how these macroeconomic inputs are being formed in developing countries. Potato suitability allows more cultivated land and greater production with lower price. Agricultural poverty brings limited alternatives and poor terms of trade for farmers, with abundant labour at low wage rate leading to low potato producer price. Better alternative business lowers capital inflow to agricultural land development, entailing low production and high price. Knowledge increases productivity lowering price.

Keywords: Principal components, Economic growth, Developing countries, Supply constraints, Factors of production, Agricultural development

JEL Codes: Q11, Q18, R51, R58, Z12

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1 Introduction

Affordable price of the potato potentially provides major aid for the poorest in a society, whereas business related incentives require that producers receive a price that covers their opportunity cost in choosing potato production. Both of these two opposing needs, should they adequately meet, promise greater importance for the potato; its consumption share and production increases would naturally follow. Inversely, should price of the potato be too high for consumption of the poor or too low for producers; its advance can be stalled. Consequently, in attempts to increase importance of the potato, it is central to understand factors that affect its price.

Earlier research on potato price has uncovered relatively small nuances, usually specific to single countries or market areas in developed countries, that are important for competitive local marketing. Pusateri (1958) lists seventeen primary factors affecting potato price fluctuation in short run. Goodwin et al. (1988) quantitatively establishes that state of origin, package type, season of marketing are such factors of potato quality that do affect potato price in addition to level of potato stocks. Similar factors undoubtedly do operate also in developing countries. In these disadvantaged parts of the globe, however, the price effect of such nuances can stay unnoticed due to inaccuracies of data and poor and unstable social conditions. Still, everywhere, potato acreage choices of the farmers and yield variations are clearly determining total quantity of the production. This level of production is in a quantifiable endogenous relation with producer price of the potato, and their elasticity is usually locally estimated. The literature on supply and price responses should be consulted for such inter-temporal fluctuation effects between production and producer price.

Here we are not interested in production fluctuation effect on year-on-year producer price in some given local conditions, but instead on determinants of producer price level averaged over longer run. We will explore potato price affecting factors in a way that likely either is inapplicable with the data of the developed countries, due to their generally inferior good status of the potato, or remains hidden under noise produced by their welfare. Contrary to this, in developing countries potato serves a favour for the researcher as also country borders noticeably maintain the differential in its price levels, unlike the case with many other commodities (Morshed, 2007). With this initiation, we are attempting to answer in the rest of the paper the research question: *What are the deeper factors or trends in societies that are affecting producer price of the potato?*

We next study the factors of producer price, which is the average price the farmers receive from their potato crop. This production price will be explained by the principal components formed from 40 developing countries' data of social conditions, mostly agriculture related

data. Principal components analysis and regression are often used as exploratory methods without any specified preceding theory (Massy, 1965). Some of the inference on statistical results leading to conclusions is more self-evident, easily acceptable, and requires little explanation. However, there are instances where established theories help in explaining the phenomena and checking the viability of model specification that resulted in exploratory findings. These are appealing reasons to use a theory to aid inference even with such an exploratory method.

According to Sen (1981) food insecurity in developing countries is related to demand side constraints as poor lack purchasing power and access to food. While this can be generally true, we must have a different view concerning specifically potato consumption in relation to our sample of developing countries. Potatoes are not usual import or food aid items for developing countries due to their more perishable nature compared to wheat. The potato become a staple in European temperate countries and supplied them for world dominion during colonial times (McNeill, 1999). Even today potato production in tropics and subtropics is mostly located to remote high altitude regions where it has soil and climate environment closer to European fields. In accordance with this, both older and newer research in developing countries, aimed at increasing potato importance, heavily emphasize the constraints that are on supply side; which are limiting nutritional status of the masses (Upadhya, 1979, p. 12), per capita consumption in the vast majority of developing countries (Scott, 2002, p. 51) and production on subsistence farms (Gebru et al., 2017, p. 2). Therefore this research has its most fundamental theory that it is the supply side that has the essential constraints concerning the potato consumption, also in our set of developing countries. Thus we will check that in our inference those principal components that statistically significantly explain potato price are related to supply side constraints of the potato, and thereby affect its price level.

2 Data

Statistical data for poor countries have been mostly collected from the Food and Agriculture Organization of the United Nations (FAO) [1] and Wikipedia [2] internet sites. The chosen countries have been those for which FAO listed annual producer price for potato and were ranked by FAO as Low Income Food Deficit or Least Developed Countries. These conditions supplied 40 poor countries. The data were collected in spring 2012.

[1] fao.org

[2] wikipedia.org. However, GDP per capita (purchasing power parity) comes directly from the originating source CIA World Factbook, cia.gov/library/publications/the-world-factbook/.

We could easily include potato price data from richer countries. Here we omit such remembering that richer countries have much more developed markets where food is plentiful and easily and quickly imported across border removing more visible potato price differentials between countries. This would undermine our idea of choosing the perishable potato with its locally distinctive pricing. By limiting our research to poor countries and potato we have a chance to reveal deeper determinants and even national characteristic social factors that contribute to the price level without globalization too much diluting effective forces and possibly impairing our sight of the relevant picture.

Potato producer price annual time series from FAO for 2000-2009 was deflated by US consumer price index into year 2000 dollar series. Thereafter an average was taken of the series thus forming averaged potato producer price level for the first decade of the 21st century in selected 40 poor countries. (See Figure 1.)

In addition to potato price we have potentially potato price affecting social data from the 40 countries, mainly related to agriculture. The data have been collected mostly from FAO, but also from the English Wikipedia. For the time series collected, similar treatments were performed as above for potato price, i.e. averaging over the decade. In total we are using 33 social data variables. All of this social data, however, are not averages from time series but instead we have mostly to be content with single observations from some single sampling year or some other approximation given by the sources of FAO and Wikipedia. Table 1 lists the variables with their units. Variable names, which are presented in text and Tables, are easily connected to Table 1. Many variable readings appear to be quite raw estimates, not uncommon to developing countries. The summary information of the endogenous potato price and the 33 exogenous social variables can be found in the Appendix.

Some missing data imputations have been made inferring reasonable replacement values based on homogeneous countries' variable readings or substitutable information. Also internet searches have been made in some cases to approximate a reasonable value. For instance Cambodia had no annual potato production in FAO source even though producer price exists for the whole ten year period. Searching the internet we notice that Cambodians are just very recently increasingly awakening to potato cultivation. Therefore we have a small approximating potato production for Cambodia.

Seven of the variables contain single or double outliers of data, strongest country separating itself from other data being Mongolia. In one case we have imputed an outlier, as missing both maize price and its primary substitute information wheat price, rice price is imputed for Turkmenistan. After these special notices all countries' readings inside the same variable are in a common measurement unit and comparable except that single estimates may be from different year to some countries.

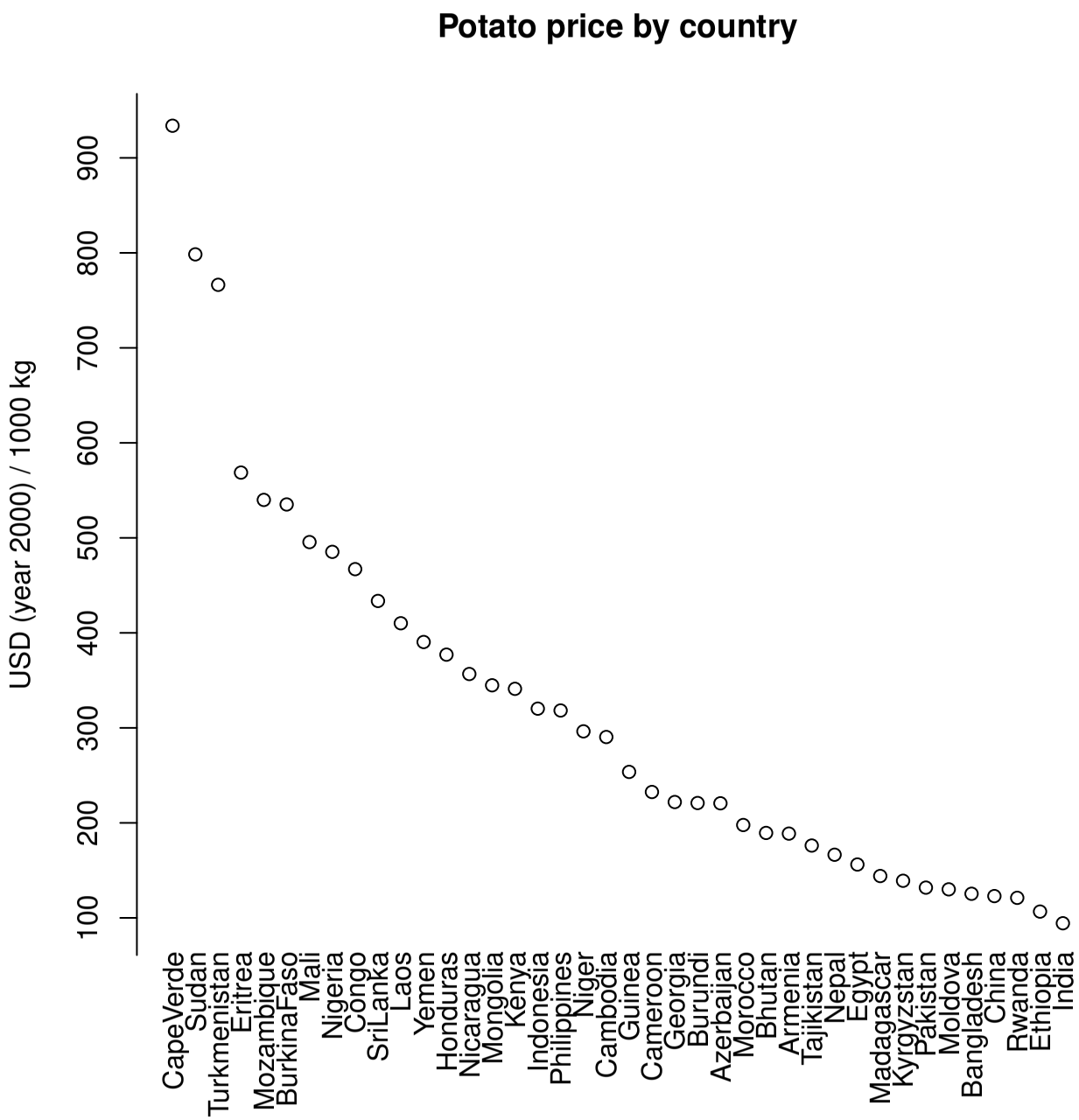

Figure 1: Average real producer prices

Table 1: Exogenous variables

	Variable	Unit
1	Share of Christian church membership or identity	%
2	Population density	$/km^2$
3	Population growth rate	%/year
4	GDP per capita	USD/year
5	Services GDP share	%
6	Human development index	score
7	Total population	millions
8	Life expectancy at birth	years
9	Urban population share	%
10	Undernourished share	%
11	Child mortality	/1000 live births
12	Water use share in agriculture	%
13	Water use share in industry	%
14	Agriculture GDP share	%
15	Agriculture export share of total export value	%
16	Agriculture import share of total import value	%
17	Maize producer price	USD/1000 kg
18	Export value per capita	USD/year
19	Import value per capita	USD/year
20	Potato production per capita	kg/year
21	Potato production per agricultural population	kg/year
22	Agricultural land development value per agr. pop.	USD
23	Machines and equipment value in agriculture per agr. pop.	USD
24	Fixed livestock value in agriculture per agr. pop.	USD
25	Plantation crops value per agricultural population	USD
26	Total capital stock value in agriculture per agr. pop.	USD
27	Arable land share of total land area	%
28	Permanent crops share of arable land	%
29	Pastures proportion to arable land	%
30	Irrigated land share of arable land	%
31	Per capita cereal production	kg/year
32	Per capita meat production	kg/year
33	Per capita fish production	kg/year

Any remaining errors or inaccuracies in the data have their possible bias on the final results lessened by using standardized variables i.e. correlation matrix approach of the principal components analysis which allocates all variables an equal weight. Thus also inference is not invalidated by possible changes in loadings due to data inaccuracies. A change in the principal component axes represents another view into the data and is a property that various factor extraction methods are voluntarily aiming to produce for various needs in many fields of science.

The Appendix provides two sets of correlations. Correlations of potato price to the 33 numbered variables and correlations higher in absolute value than 0.6 between the above listed numbered 33 variables.

On the first variable Christianity, we notice that potato was spread and made known to many countries in our sample during colonial times by the Europeans together with Christianity.

"The potato's global voyage began in earnest in the seventeenth century. Stay-at-home Europeans may have had misgivings about the suspicious new crop, but sailors, soldiers, missionaries, colonial officials and explorers quickly figured out that the potato was a good thing to carry to their foreign outposts. A few small tubers can quickly turn into thousands of tons" (Rhoades, 2001, p. 140).

Late blight first appearance in Europe devastated potato crops of Ireland in 1845 and 1846 bringing the infamous great Irish potato famine. Queen Victoria proclaimed 24.3.1847 as a day of prayer and intercession. Salaman (1987, p. 314) excavates two noteworthy things from special prayers that had been prepared for the occasion. Firstly extreme famine is tightly linked to "heavenly judgements [..] with which Almighty God is pleased to visit the iniquities of the land by a grievous scarcity and dearth of diverse articles of sustenance and necessaries of life." Secondly the word 'potato' does not appear anywhere in prayers, nor are the people of Ireland, who were notably potato dependent, given special attention but removal of judgements is prayed for those "who in many parts of the United Kingdom are suffering extreme famine and sickness."

The potato was already rooted, not only in British but European strategies generally, and signalling warnings against its cultivation was not appropriate. Following repentance and prayers the 1847 potato crop in Ireland avoided late blight, and famine ended. Doctrinal correctness got in doubt at times of food insecurity, especially after but already before late blight arrival; Salaman (1987, pp. 314-315) notes instances of 'soupers'[3], food-aid related converts from Catholic faith.

Generally though, not only in European countries but also their overseas colonies, it

[3]Apparently a mocking name since Esau sold his first-born right for a soup.

was the potato that was through food security bringing not only health but also population growth and urbanization (Nunn and Qian, 2011) which allowed many kinds of trades to prosper. Thus blessing its cultivators and consumers, the potato established a strong connection to Christian religions. Understandably, it was experienced that the potato crop was to depend on repentance and prayers from the Christians and strength of the Christian confession on food security potato allowed. Traces of this connection may very well be seen today although potato production is no longer dependent on European influence.

3 Methods

Economic domain needs special care. In infamous misjudgement of the first half of the 19th century many leading economists clung stubbornly to theoretical constructions, which forcibly demonstrated the survival level wage rate for the poor as inevitable. "So while humanitarian feelings might call for social measures to raise the income of the laboring poor, sound economic thinking argued [4] that such efforts would be futile" (Landreth and Colander, 1989, p. 84). Such a situation where economic theory had lost common sense - and increasingly contradicted factual observations of technological and agricultural expansion brought by the industrial revolution - was culminated in the 1830's and 1840's. The year 1848 brought two far reaching counter-developments to widening class inequality. In amplifying their impact the potato supply shortage played a major role, as continental Europe suffered from late blight. Food insecurity of the discontented masses brought bloody rebellions against authorities, setting the Europe into its widening democratic path; And in another development the 'Communist manifesto' was published. That these two did not remain local and short-lived philosophies can be partially attributed to their success in the proximity of the vast European plains where the potato made great powers and set them in fierce competition for world dominion. "It is certain that without potatoes, Germany could not have become the leading industrial and military power of Europe after 1848, and no less certain that Russia could not have loomed so threateningly on Germany's eastern border after 1891" (McNeill, 1999, pp. 77, 82).

Still the tendency of the economic theory, that builds its equilibrium on rational greed, has been to markedly ignore process in other sciences. "The further features of human behaviour that psychologists and sociologists discover are typically *ad hoc* and have only narrow scope. They are usually not suitable for inclusion in particular economic models and are virtually always disqualified from inclusion within fundamental theory" (Hausman, 1992,

[4] Interestingly, such argumentation might have been one reason why Captain Nemo, the fictional protector of the oppressed by Jules Verne, possessed no economics books in the vast library of his submarine.

p. 274).

Although much used in many fields of science, even marketing research and psychology which likewise study human behaviour bound to transmit to commodity prices, the use of principal components in purely economic contexts has been relatively rare. It is worthwhile to pay some attention to the neglect of the method in economic domain before proceeding. The discouragement for the use of the method for economics can be found in econometrics textbooks (with silence on other factor analytic methods that have also brought fruit in many other fields). An introductory text (Thomas, 1997, p. 244) shortly mentions as one of the major drawbacks for using principal components that "the results obtained by this technique are frequently very hard to interpret in a sensible economic manner". In addition to such unlikely success in the interpretation, Greene (1993, p. 273) lists also the two other drawbacks, which are problematic and sources for bias mainly when the method is used for the case of attempting to avoid multicollinearity and determine coefficient estimates for the original variables. 1) Scale sensitivity of original variables for the results; remedying it through standardizing the variables has substantial effects on results. 2) The choice of principal components is not based on any relationship of the regressors (original variables) to the dependent variable.

The principal components and factor models more generally, however, are experiencing increasing interest and use in econometric contexts as needed robust augmentations to panel data regressions are being explored (Westerlund and Urbain, 2013, 2015). The idea that is popular and seen useful in other sciences, namely interpreting or identifying factors based on their loadings, that also sidesteps the two other worries above, is still largely strange to many economists. We should expect that, properly and carefully implemented, this approach should bring discoveries precisely in the largely neglected economic domain. Bearing in mind thus formed goal to overcome, of acquiring sensible economic interpretations for our exploration, we should firstly possess original variables and data sample which are appropriate for the task. Such carefulness may considerably aid interpretation of the loadings. Secondly economic theories, common sense, observational proofs and simplicity should drive the interpretations.

More detailed coverage of principal components regression properties can be found for example from Massy (1965). A pedagogical approach to applying principal components analysis can be found for example in Everitt and Hothorn (2011, pp. 61-103). In our study principal components analysis will be performed on the collected data and most important principal components are regressed on the potato producer price.

Principal Components Analysis and Regression

Principal component (PC) analysis uses an orthogonal transformation to convert any set of variables into a set of new variables which are linearly uncorrelated with each other. This set of new variables, PC's, is generated as a linear combination of original variables such that the first one, PC1, has the maximal variance of the data. The second component, PC2, has also the largest possible variance but conditional on being orthogonal to PC1. Similarly PC3 is formed through maximizing the variance but conditioned on being orthogonal to all previous PC's, and so on.

We next proceed to construct principal components and their regression for present analysis. Let X be the original 40x33 data matrix (countries representing n=40 rows and social variables representing 33 columns). Let R be the correlation matrix of X with dimensions 33x33. The diagonal matrix Λ contains the eigenvalues of R in the diagonal. The orthonormal characteristic vectors of R are their corresponding eigenvectors. Let these be defined as the matrix V columns. Eigenvalues are the proportions of total variance from our entire data which their corresponding eigenvectors capture. The eigenvalues and eigenvectors of R are received by solving the eigenvalue decomposition of the 33x33 matrices $R = V\Lambda V^T$.

Each column of V represents the principal component loading of the original 33 variables. The Z matrix is constructed for the need to transform the loadings matrix V columns into orthogonal vectors. It is a standardized version of X. Every column in X has all its elements subtracted with the column mean and divided by the column standard deviation of X, giving matrix Z. Equation 1 then establishes a 40x33 matrix of principal components.

$$O = ZV \tag{1}$$

Each of the 33 columns of the principal components matrix O represents the scores of the corresponding principal component for the 40 countries. For the constant to be included in the estimation results to follow, the matrix O is added a column of 1's. Let this 40x34 regression matrix be called Ω. Then we regress the 40x1 vector of potato price y on the matrix Ω (or the K chosen first ones of its columns) receiving the 34x1 coefficient vector θ for unobserved error term ϵ, with $y = \Omega\theta + \epsilon$.

Minimizing sum of squared observed residuals $e^T e$ leads to the OLS coefficient estimates following Equation 2.

$$\hat{\theta} = (\Omega^T\Omega)^{-1}\Omega^T y \tag{2}$$

Since $\hat{\theta} = \theta + (\Omega^T\Omega)^{-1}\Omega^T\epsilon$ and squared standard error of the regression $s^2 = \frac{e^T e}{n-K} = \frac{\epsilon^T M\epsilon}{n-K}$, where $M = I - \Omega(\Omega^T\Omega)^{-1}\Omega^T$ and I is the diagonal identity matrix, the OLS coefficient estimator has following properties.

1. $E[\hat{\theta}] = \theta$ implying it is unbiased.
2. $Var[\hat{\theta}] = \sigma^2(\Omega^T\Omega)^{-1}$.
3. Any linear function $r^T\theta$ has the minimum variance unbiased estimator $r^T\hat{\theta}$ (Gauss-Markov Theorem. [r^T is a transposed vector of restricting coefficients.]).
4. $E[s^2] = \sigma^2$
5. $Cov[\hat{\theta}, e] = 0$
   For testing hypotheses on $\hat{\theta}$ we additionally need to assume that $\epsilon \sim N[0, \sigma^2 I]$ which further implies:
6. $\hat{\theta}$ and e are statistically independent, leading to $\hat{\theta}$ and s^2 being uncorrelated and statistically independent.
7. The exact conditional distribution of $\hat{\theta}$ is N[θ, $\sigma^2(\Omega^T\Omega)^{-1}$].
8. Distribution of $(n-K)s^2/\sigma^2$ follows $\chi^2[n-K]$, with s^2 having mean σ^2 and variance $2\sigma^4/(n-K)$.

Assuming normality on the error term, that allows testing the null hypothesis $\theta_i = 0$ (subscript i denoting the i^{th} coefficient of the vector), and the last three properties lead to t distributed test statistic with n-K degrees of freedom $t[n-K] = \frac{\hat{\theta}_i}{[s^2(\Omega^T\Omega)^{-1}_{ii}]^{\frac{1}{2}}}$, where the subscript ii signifies the i^{th} diagonal element of the inverse matrix. If the absolute value of t[n-K] is greater than $t_{\lambda/2}$ (that is approximately 2.04 for our sample size and number of predictors as we are using the standard λ=0.05 risk level) the null hypothesis is rejected and the parameter coefficient is statistically significant. We utilised Everitt and Hothorn (2011, pp. 63-92) and Greene (1993, pp. 292-293).

4 Results

Importance of the components and the regression results

Principal components analysis is performed on the 33 variables which are listed in Table 1. As noted in the previous section, eigenvectors represent the principal component loadings of the original variables. Each eigenvector has a corresponding eigenvalue that is representing share of the total data variance. Figure 2 shows all the 33 eigenvalues.

One natural way to select the exogenous components for the regression is to choose the components that amount to a high cumulative proportion of variability of the original

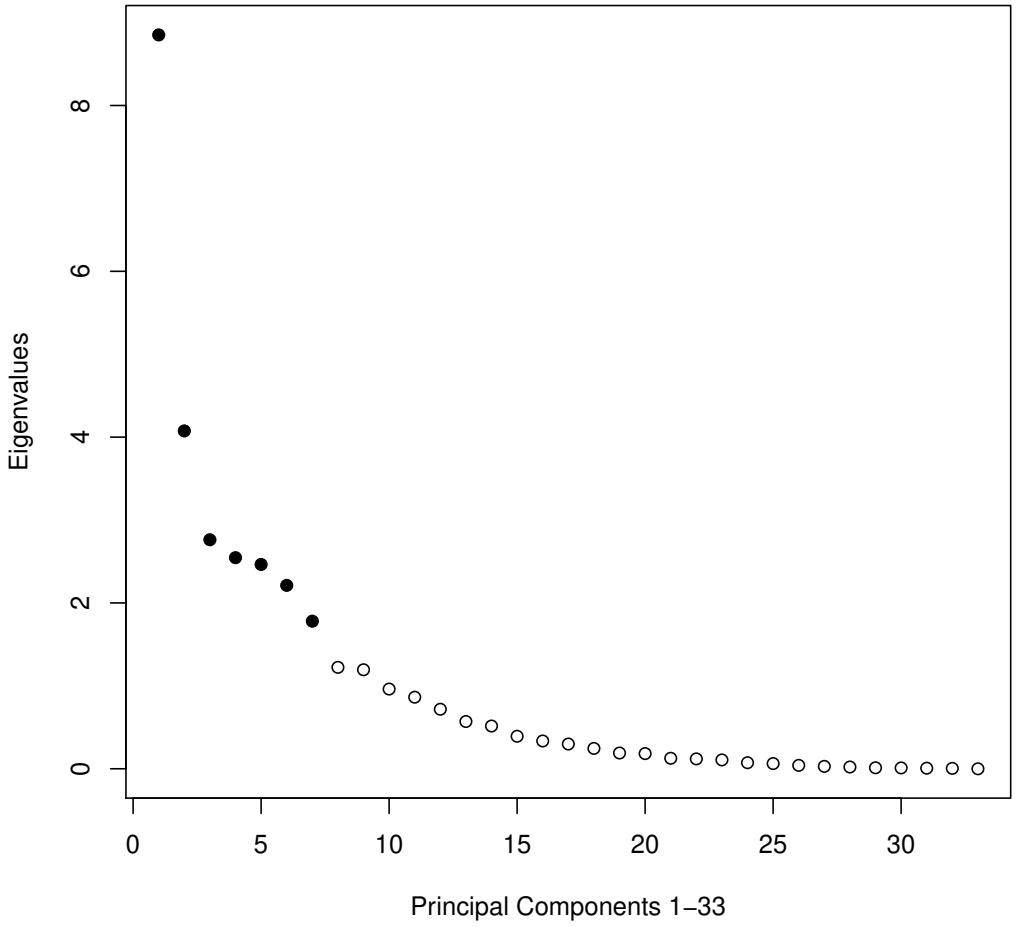

Figure 2: Eigenvalues: 7 first principal components are selected for the regression, the 7th being still statistically significant in explaining potato price.

explanatory data. This would mean the first components, and in this case 7 first ones are selected. Their importance in terms of variance that they hold of the 33 original data variables is shown in Table 2. A consideration can be also given to components that have strong explanatory power on the endogenous variable potato price. The Appendix presents the full result of 33 principal components and their regression on the potato price.

Table 2: Importance of components

	Standard deviation	Variance	Proportion of Var.	Cumulative Prop.
PC1	2.975	8.851	0.268	0.268
PC2	2.019	4.075	0.123	0.392
PC3	1.662	2.762	0.084	0.475
PC4	1.596	2.546	0.077	0.553
PC5	1.570	2.465	0.075	0.627
PC6	1.487	2.212	0.067	0.694
PC7	1.334	1.781	0.054	0.748

The principal component loadings of the original variables that the 33 eigenvectors contain are listed in the Appendix. The eigenvectors are transformed to orthogonal principal components according to the Equation 1. The OLS estimates of the principal components regression on Potato Price are obtained with the Equation 2. (See Table 3.)

Table 3: Potato Price Regression

Endogenous: Potato Price, Exogenous: Principal Components 1-7 (scores)

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	320.2537	24.7467	12.94	0.0000 *
PC1(Poverty)	-0.5528	8.4238	-0.07	0.9481
PC2(Agricultural poverty)	-25.9870	12.4158	-2.09	0.0444 *
PC3(Knowledge)	-41.4537	15.0793	-2.75	0.0097 *
PC4(Potato importance)	0.7936	15.7064	0.05	0.9600
PC5(Market economy infrastructure)	-5.5964	15.9635	-0.35	0.7282
PC6(Better business)	60.1525	16.8496	3.57	0.0012 *
PC7(Potato suitability)	-52.6166	18.7818	-2.80	0.0086 *

Residual standard error: 156.5 on 32 degrees of freedom.
Multiple R-squared: 0.5051, Adjusted R-squared: 0.3969.
F-statistic: 4.666 on 7 and 32 DF, p-value: 0.001082.
Statistically significant = *.

The last Principal Component above 5 % risk level is still PC7. As the principal components are uncorrelated with each other, we may freely choose the principal components for the regression, as removing any of them does not change the explanatory coefficients of the remaining ones. Table 4 presents explanatory shares of the chosen seven principal

components in the regression. Having regressed the principal components on potato price an interpretation can be presented on potato price formation that takes into account the results of the data and bases on the theory of supply constraints.

Table 4: Explanatory power

	R-squared	Cumulative
PC1	0.0001	0.0001
PC2	0.0678	0.0678
PC3	0.1169	0.1847
PC4	0.0000	0.1847
PC5	0.0019	0.1866
PC6	0.1971	0.3837
PC7	0.1214	0.5051

We pause to evaluate the model fit in Figure 3. Roughly half of the variation in potato price has been explained by selected principal components. The largest residual error can be attributed to the economy of the Cape Verde expanding greatly because of tourism from European countries in the decade of our study (López-Guzmán et al., 2013). It seems to have increased the demand from potato accustomed tourists beyond the ability of local supply to respond. It is expected that such demand side phenomenon in the archipelago remains unexplained by our model. At the other end we notice that our model fit is underestimating the potato producer price in Bangladesh. Compared to rice, potatoes in Bangladesh serve as a relative expensive source for energy, but are preferred for diet diversity, vitamins and taste variety (Reardon et al., 2012, p. 25). Again a relatively rare demand side phenomenon for developing countries which unsurprisingly remains unexplained by our exploratory model. Also the government has a part in the potato phenomenon in Bangladesh through seeking agricultural sector diversity to complement rice production, favouring other food stuffs including potato (Rahman et al., 2016, p. 2).

Countries that have their average potato price vertically closer to model fitted price line are better conforming to model explanation. The residual errors can be thought to increase in value for higher model fitted price. Such may be a chance occurrence, however, and residual outliers could have happened as well at lower fitted prices. Nevertheless, for the concern of model heteroskedasticity, it was verified that all statistical significances remained unaffected by using instead White's heteroskedasticity consistent standard errors.

Our model results can aid to find reasons for the potato producer price in different countries from the interpretation of the statistically significant principal components by relating the country situation to characteristics presented by these components. Still it should be remembered that our model is a statistical fit, not an exact deterministic relation,

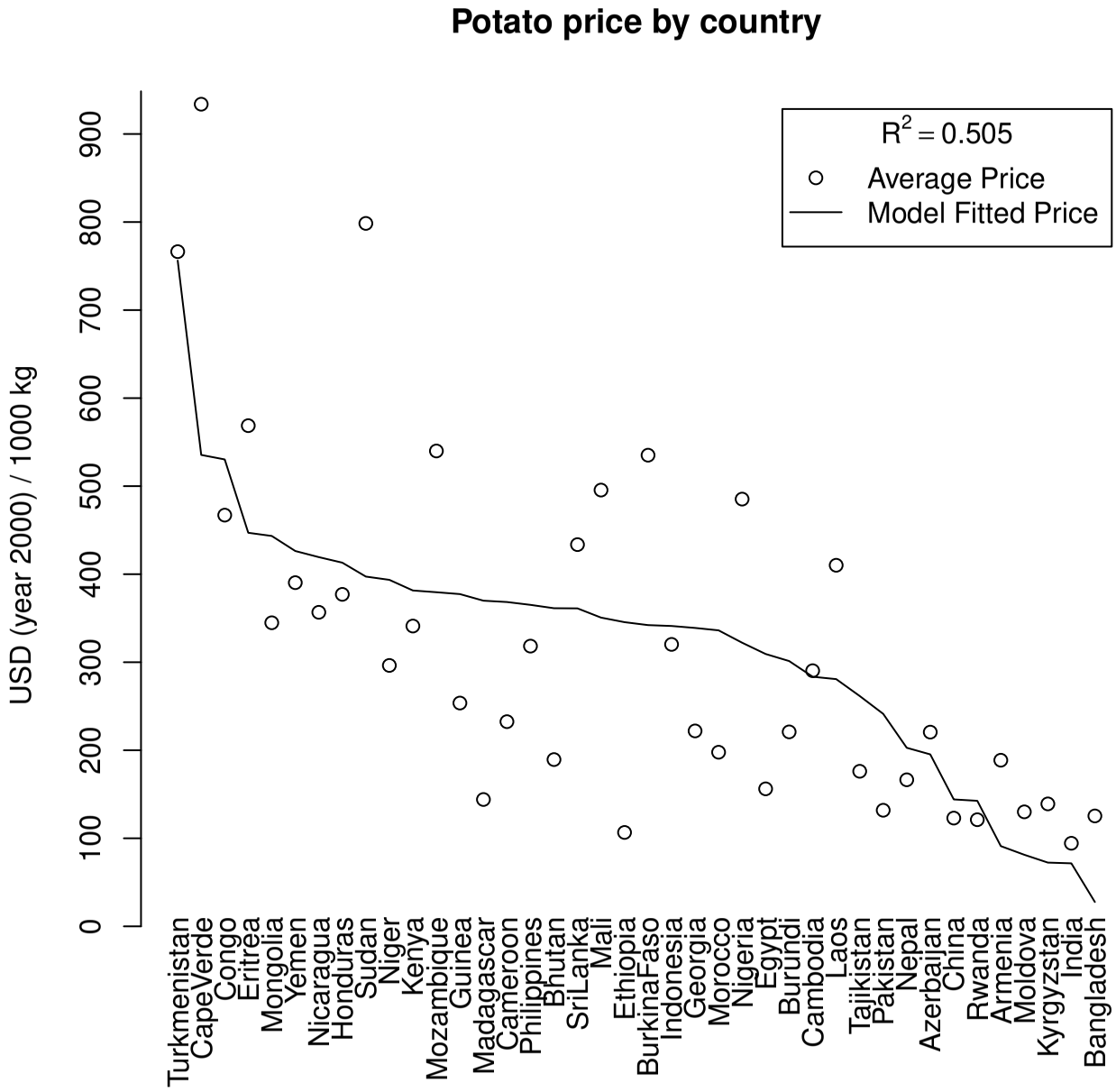

Figure 3: Average real producer prices with model fit

and estimation errors in collected data are likely to exist for sampled countries and variables. Also principal components loadings to be presented next are not in each aspect characteristic to every individual country separately in our sample but represent a typical data pattern, which also should be weighted carefully when considering individual country policy needs. The strength of principal components methodology is in its ability to look beyond the original data into a greater view, that can be beneficial in developing country conditions where many official statistics may be corrupt. The dependent variable potato producer price, however, especially averaging over a decade, is on approximate likely one of the most trusted of the statistics in developing countries. It is simple to observe and the often relatively unimportant consumption share of the potato lowers incentives to rethink and scale measurements towards expert opinion.

Principal Components

Next we give the presentation of inference for naming of the principal components 1-7 in the Tables 2, 3 and 4.

If the direction of the effect on the potato price is negative for a principal component, (-) is marked in the data table of that specific principal component. Similarly (+) marks positive effect on the potato price. The signs are directly taken from the coefficients of the regression in Table 3. We still need to decide on the limit for meaningful loadings, usually an integer multiple of 0.10 that leaves some loadings for all important PC's. We therefore include only those loadings which satisfy

$$|loading| > 0.20.$$

Inferring the meaning of the most important principal components is what should interest us most here. Equipped with results of the regression of the principal components, especially their effect sign and significance on potato price, together with accepted principal components loadings we are now ready for the task of interpretation.

PC1: Poverty

Poverty explains 0.0 % of the potato price regression (Table 4), but has 26.8 % share of the total explanatory data variation (Table 2).

Table 5 shows the loadings of this principal component.

Our first principal component is not statistically significant in predicting potato producer

Table 5: PC1: Poverty (-)

Original variable	Loading
PGrowthRate	0.272
PerCapGDP	-0.270
Hdi	-0.304
LifeExp	-0.255
PopUrbanShare	-0.202
ChildM	0.238
AgricultureGDP	0.222
ImportVPerCapita	-0.295
TotalAgriCapitalStockVPerAgriPopu	-0.218
MeatProductionPerCapita	-0.211

price. Its loadings are characteristic of conditions of poverty and opposite to those usually encountered with economic growth, a macroeconomic trend that has foremost visibility as a candidate to help solve developing country problems.

In conditions of poverty we observe that per capita GDP, import value and meat consumption are low. Low capitalized agriculture forms a great share of GDP and urbanization has not occurred, also the measure for human development is low. Population growth rate is high likely due to high fertility despite life expectancy being low and child mortality high. The ongoing trend in the developing world is economic growth (and not impoverishment). Higher incomes generally lead to rising potato demand in developing countries (Horton, 1987, p. 70) and thus higher potato prices can follow economic growth. Therefore, it is comforting for the validity of our method choice and specifications to note that the potato price effect sign is negative for PC1=Poverty implying that the sign is positive for economic growth.

PC2: Poverty of agriculture

Poverty of agriculture explains 6.8 % of the potato price regression (Table 4) and has 12.3 % share of the total explanatory data variation (Table 2).

Table 6 shows the loadings of the second principal component.

The tree uppermost loadings are relating the values of livestock, plantation crops and total agricultural capital stock respectively in the numerator to number of workers in agriculture in the denominator. Their negativity signals that number of workers or labour used in agriculture is great compared to value of holdings.

The three lowermost loadings indicate that arable land is largely irrigated for cultivation instead of allowing it as animal pastures, giving low meat production per capita. These

Table 6: PC2: Poverty of agriculture (-)

Original variable	Loading
LivestockValuePerAgriPop	-0.380
PlantationCropsVPerAgriPopulation	-0.361
TotalAgriCapitalStockVPerAgriPopu	-0.300
PasturesProportionToArableLand	-0.403
IrrigatedShareOfArableLand	0.237
MeatProductionPerCapita	-0.221

reasonably allow inferring also the typical land ownership structure. Namely that most and best lands are concentrated into hands of wealthier farmers - who use masses of landless labour workers in their fields - since irrigation is usually used in larger farms while poorer small scale farmers would wish diversify into owning some animals to cope with agricultural seasonality or as an insurance against poor crop (Antazena et al., 2005, p. 195).

Postponing sales through cold storage to obtain better price was found likelier in Minten et al. (2014) for wealthier farmers, who have other income and who have more to sell. Consequently where there are very many poor small farmers they are likely to sell their produce and labour cheaply.

Poverty of farmers lowers the potato producer price as poor farmers are forced to accept the terms of trade of the potato purchasers as they have no negotiating power and lack choices for other livelihoods such as meat production.

The effect of the PC2 on potato price is negative. The coefficient is statistically significant at the 5% risk level. Agricultural poverty is related to supply side constraints as poor potato cultivators often experience marketing constraints. Summarizing PC2, Poverty of agriculture, effect on potato price: Wealthy agricultural sector entails that the potato price is high.

PC3: Knowledge

Knowledge explains 11.7 % of the potato price regression (Table 4) and has 8.4 % share of the total explanatory data variation (Table 2).

In the third principal component with loadings shown in Table 7 potato price is low.

Potato production and consumption are high. Maize price is also low although cereal production is low. This low dependence on cereals indicates that there exists technology or means for conserving perishable potatoes until the new potato crop arrives, possibly even for export as indicated by high share of low valued agricultural exports. Water may be

Table 7: PC3: Knowledge (-)

Original variable	Loading
Christian	0.440
WaterUseAg	-0.237
WaterUseIn	0.208
AgricultureExport	0.345
MaizePrice	-0.280
ExportVPerCapita	-0.247
PotProdPerCap	0.202
PotProdPerAgriPop	0.238
ArableLandShareOfLandArea	0.298
CerealProductionPerCapita	-0.249

used more for industries instead of agriculture as abundant arable land may benefit from European-like climate, disease environment and rainfall. Such circumstances, which following Acemoglu et al. (2001) were instrumental to mass migration from Europe, are also most benefiting from centuries of time-tested knowledge heritage that has accrued on European potato culture, seeds, field rotation and other technology. The share of Christianity in earlier times often strongly correlated with potato cultivation as European values were transmitted or Europeans migrated in masses to colonies, bringing the potato with them.

The negative coefficient for PC3 is statistically significant. Knowledge is related to supply side constraints since its lacking translates into missing potato technology or knowledge on proper cultivation practices. Summarizing PC3: Knowledge implies that potato price is low.

PC4: Potato importance

Potato importance explains 0.0 % of the potato price regression (Table 4) and has 7.7 % share of the total explanatory data variation (Table 2).

Table 8 shows the loadings of the 4th principal component. It has the following characteristics.

Producing maize is expensive and permanent crops share of arable land is low. In a sparsely populated country one likely reason is poor geography for cereal cultivation. Also fish production is negligible. But agriculture is still badly needed as seen from its high share of GDP. Fortunately potato is bringing great harvests, probably helped by appropriate agricultural machines and equipment.

PC4=Potato importance. It should be noted that higher potato importance means higher potato price. Although the coefficient is not statistically significant its sign strengthens the

Table 8: PC4: Potato importance (+)

Original variable	Loading
PDensity	-0.217
Population	-0.276
AgricultureGDP	0.213
MaizePrice	0.246
PotProdPerCap	0.338
PotProdPerAgriPop	0.335
MachEquipVPerAgriPopulation	0.365
PermanentCropsShareOfArableLand	-0.232
FishProductionPerCapita	-0.438

validity of the model, since the existence of supply constraints logically means that increasing production is usually lagging increasing demand. Fuglie (2007, p. 362-363) considers the issue of higher productivity leading to over-supply and lower market price, but opposing it notes that in most developing countries the potato is considered a high-value and high-profit crop with strong and elastic market demand. Therefore in many developing countries a macroeconomic trend can occur where potato importance, production and consumption share are growing together with higher price. The relative importance of potato has not been in stable advance across decades in all of our chosen countries, however, but has also been backtracking during the decade of our study.

PC5: Market economy infrastructure

Market economy infrastructure explains 0.2 % of the potato price regression (Table 4) and has 7.5 % share of the total explanatory data variation (Table 2).

Table 9 shows the loadings of the 5th principal component. High services share of GDP, high life expectancy and low child mortality, and also water use in agriculture instead of industries are clearly seen in this principal component. Christian share is low and export value is low so there is no usual dependence on valuable exports of natural resources, common to developing countries with extractive colonial institution heritage. Incentives to land development are in place and agricultural imports are answering to remaining nutritional needs. In these conditions potato price is low. The coefficient is not statistically significant.

Improving infrastructures for market economy is a macroeconomic trend in developing countries. Also earlier centrally planned infrastructures are being upgraded to service market forces; implementing capitalist reforms, agriculture and trade liberalization, to thus meet challenges of increasing competition brought by globalization. The process has pre-

Table 9: PC5: Market economy infrastructure (-)

Original variable	Loading
Christian	-0.202
ServGDP	0.265
LifeExp	0.245
ChildM	-0.260
WaterUseAg	0.423
WaterUseIn	-0.304
AgricultureImp	0.219
ExportVPerCapita	-0.373
IrrigatedShareOfArableLand	0.218

sented considerable difficulties for many countries. Nyairo (2011) investigated impact of the market liberalization on food security in developing countries, noting that countries with vibrant economic structures came off better than those with firm socially founded system. Studying post-socialist countries BenYishay and Grosjean (2014) observed that poor institutional quality and richness in natural resources at the beginning of market liberalization exposed the process to malicious interest groups and corruption, hindering it. High value export sector, declining due to increasing competition, is also a cause to eroding food import potential. Food security remains a challenge in many developing countries several decades after agricultural market and economic liberalization (Nyairo, 2011, p. 11).

The principal component loading of Christian share seems to capture that countries with colonial institution heritage (Acemoglu et al., 2001, 2002) and also accepting Christian religion have not been as successful in implementing market economy reform as those who more stubbornly rebelled European rule and leadership under their colonial period. Accepting the religion of colonial masters plausibly opened the minds to accepting their authority and retaining the usually extractive institutions at independence. Prime examples of rebels include communist China and Vietnam, where markets have been opened but without major inroads for other western values such as democracy or religion.

Although the negative coefficient is not statistically significant, we notice that more market oriented infrastructures, aimed to be better positioned for globalization, may produce food cheaper. PC5 is also related to potato supply constraints. Lacking market infrastructure is a marketing constraint also to potato supply, discouraging cultivation, thus indirectly reducing production and increasing price.

Summarizing, PC5 = Market economy infrastructure, effect on potato price: Market economy infrastructure entails that the potato price is low.

PC6: Better business

Better business explains 19.7 % of the potato price regression (Table 4) and has 6.7 % share of the total explanatory data variation (Table 2).

Table 10 shows the loadings of the 6th principal component. It is the strongest PC in explaining potato price, with positive coefficient being significant with p=0.0012. The interpretation is following Smith ([1776] 1904).

Table 10: PC6: Better business (+)

Original variable	Loading
Christian	0.260
PDensity	-0.333
Population	-0.294
PopUrbanShare	0.313
AgricultureImp	0.348
ArableLandShareOfLandArea	-0.395
CerealProductionPerCapita	-0.231

The characteristics are relatively poor geography for cultivation through negative loadings on population density and arable land share of land area. Cereal production is low. The level of urbanization is high with likely reasons being insecurity of the countryside, uncertainty in land ownership, extractive agricultural taxation or trade policies favouring food imports to own production. Extractive colonial institution inheritance can be inferred from high Christian share and poor geography (Acemoglu et al., 2001). The reasons for better business are explored in the Books III and IV of the Wealth of Nations.

> What circumstances in the policy of Europe have given the trades which are carried on in towns so great an advantage over that which is carried on in the country that private persons frequently find it more for their advantage to employ their capitals in the most distant carrying trades of Asia and America than in the improvement and cultivation of the most fertile fields in their own neighbourhood, I shall endeavour to explain at full length in the two following books (Smith [1776] 1904, par. II.5.36).

In summary, urbanization is maintained through imported food since better alternative businesses discourage improving land for cultivation. Such production disincentives are a constraint to supply and low production causes potato producer price to remain high.

PC7: Potato suitability

Potato suitability explains 12.1 % of the potato price regression (Table 4) and has 5.4 % share of the total explanatory data variation (Table 2).

Table 11 shows the loadings of the 7th principal component.

Table 11: PC7: Potato suitability (-)

Original variable	Loading
ServGDP	-0.406
AgricultureExport	-0.225
AgricultureImp	0.215
MaizePrice	-0.471
PotProdPerCap	0.259
PotProdPerAgriPop	0.288
MachEquipVPerAgriPopulation	-0.298

Here potato is produced in great quantity, without expensive machinery and equipment, although agricultural imports may be the cause for discouragingly low substitute maize price. Potato has therefore very suitable growing conditions. Share of the agriculture in total exports is relatively small, which is unsurprising given that potato rots easily. Services GDP share is small, implying that the two remaining shares, agriculture and especially industry, have greater shares. The potato has supplied calories for industrial expansion. Nunn and Qian (2011, pp. 605-607) developed a model to demonstrate how increased agricultural productivity brought by the potato increased labour in manufacturing. Services sector may not only have lower share as implied by its loading but also lower absolute size with abundance of the potato since South Asian success of subtropical lowlands cultivation (Maldonado et al., 1998, p. 76) has not been generally replicated in developing countries. Rämö (2016, pp. 338, 361) connects inaccessibility and remoteness of settlements in Indian Himalayas with lack of services and subsistence potato farming. In a Bolivian community potatoes are accepted as informal cash for medical services (Hope, 2003).

The coefficient is significant, showing negative impact on potato price. This is unsurprising due to high level of potato production. The 7th principal component can be named potato suitability. It is related to supply constraints for the potato through soil and environmental constraints. These include unpredictable rainfall, viruses, pests and diseases which make potato naturally less suitable for tropics in particular - unless considerable capital through irrigation, fungicides, pesticides, and good quality planting materials such as potato seeds is applied, together with locally specialized technology and knowledge in their proper use.

5 Summary discussion

Before entering the discussion on determinants of potato producer price, we also shortly note that a neglected but in hindsight rather obvious historical connection of potato production and Christianity was discovered. A basis for potato cultivation in many developing countries comes from their colonial period where Christian religions had a role as explained in Data Section. Our results for especially PC's Better business and Knowledge distinguish two hands of an average Christian of the colonial times by their works. The one hand extracted material and human resources while the other brought food security and shared skills in potato cultivation. Both have left heritages, which are still enduring, to many developing countries. Their effect on current potato production through inputs use is opposite to each other.

Land, labour, capital and technology

Exploring orthogonal maximal variance dimensions of our social data we have ended up finding and studying seven principal components of which four do statistically significantly affect the potato producer price at 5 % risk level. Table 12 summarizes these four explainers of potato price level in the order of statistical explanatory significance with simple examples.

Table 12: Summary of Principal Components that are Macroeconomic Factors of Production

Principal Component	Simple Examples with Effect on Potato Producer Price, (-) or (+)
Better business	Capital into urban business advantageous over improving land (+)
Potato suitability	Land allocated since potato especially suitable for cultivation (-)
Knowledge	Technology on potato and knowledge of cultivation practices (-)
Agricultural poverty	Masses of cultivators having poor terms of trade at farm gates (-)

We have so far named the statistically significant principal components based on their loadings paying attention that they should be related to supply constraints of the potato. Studying the Table 12 examples we should take note that they have another, more familiar, interpretation as macroeconomic or nation level factors of production. Better business PC measures tendency of capital inflow into urban business instead of rural agriculture. Its inverse is therefore a measure for Capital input. Potato suitability PC measures potato suitability and is therefore a measure for Land input. Knowledge PC is measure for Technology input. Agricultural poverty PC is a measure for Labour input since masses of agricultural labourers are available at near subsistence pay for their work or produce. Increase in each of the four inputs - land, labour, capital and technology - allows increasing agricultural production generally or potato production directly. These added positive inputs have naturally

an opposite effect on potato producer price due to supply increases in potato.

Consider the standard agricultural production function f, presented in unspecified functional form, $Production = f(Land, Labour, Capital, Technology)$. Supply and demand curves cross each other at market equilibrium price. Increasing production by added inputs will shift the supply curve such that lower price is achieved at new equilibrium position with the demand curve. Demand curve may also shift due to changes in buying power, in potato consumption trendiness or in consumer access. These demand changes may be negligible for potato price if it remains uncompetitive versus substitutes due to potato supply constraints that are common in many developing countries. The function g of price, $Price = g(Land, Labour, Capital, Technology) = \theta_0 + \theta_1 Land + \theta_2 Labour + \theta_3 Capital + \theta_4 Technology$, then can explain up to half of the cross-border variation in the producer price, only taking into account statistically significant PC's which are macroeconomic inputs for production, as estimated with PC-regression in this study.

The interpretation of these four principal components as factors of production is further crediting the stability of our theory, method and findings. The results received through exploring this specific economic domain with this method are what we should expect to find affecting potato producer price. It is worth noting that geography plays a role in these principal components, either directly or it was used in inference. All four are also related to potato supply constraints established in its wide literature.

Land input is related to relative producer prices for potatoes versus other commodities but also to soil and environmental constraints which translate into incidence of pests and diseases. Potato can succeed in various types of climate and soil with specialized care. In practice, as equipment is often lacking, some environments are less suitable for cultivation than others. Low soil fertility is a constraint to production. Diseases and pests are also recognized as constraints to supply in developing countries. These constraints are related to low potato suitability. By the way of restricting supply, they are also restricting potato consumer base as price remains too high for the poorest.

Capital input is related to constraints due to costs of fertilizers, pesticides, good quality planting material and seed; and unavailability or costs of farm credit. Potato cultivation especially suffers from being considered a poor business in developing country conditions. Quality seed is hard to get, crop losses occur and price fluctuations can transform even successful farming into a risky business venture. This is restricting potato production and holding producer price higher, effectively for its part also making potato unaffordable for the poorest.

Technology input is related to unavailability of technology and technical assistance for potato production or lack of knowledge on agronomic practices. Lack of farmer knowledge

on proper agronomic practices and unavailability of technology such as seed potato quality, soil fertility and disease controlling are production constraints established in earlier survey literature. Restricted supply due to missing knowledge means lower yields and higher potato price, which here also translates into potato losing market share among the poorest.

Labour input is usually not the weakest link in developing countries concerning potato production, and for its part can increase production and lower price. Coexisting together with high agricultural labour allocation are marketing constraints as masses of labourers translate often to poor pay for their work and produce. The poor terms of trade directly suppress the potato producer price. These obstacles the poor farmers face are withholding badly needed capital from accruing into potato farming, thus retarding production. Retarded production is restricting potato consumption from the poorest in such measure as supply is still constrained. Potato dealers are often seen by cultivators as marketing constraints which is pointing out to poor terms of trade faced by the poor potato producers in many developing countries.

Macroeconomic trends

Three principal components do not attain statistical significance in explaining potato price. Table 13 lists them with simple examples and effect on potato producer price. Notice that we are here presenting PC1 turned upside down, from poverty to economic growth, in order to observe all three examples in line with ongoing trends in developing countries.

Table 13: Summary of Principal Components that are Macroeconomic Trends

Principal Component	Simple Examples with Effect on Potato Price, (-) or (+)
Economic growth	Buying power brings increasing potato demand (+)
Potato importance	Increasing demand surpasses also growing supply (+)
Market economy infrastructure	Efficiency of markets lowers production costs (-)

We notice on the first of the macroeconomic trends, namely Economic growth, that its effect on potato producer price is positive. Rising potato demand in developing countries is the expected reaction to economic growth (Horton, 1987, p. 70). Added incomes can lead the people of developing countries diversifying their consumption habits, increasing the potato demand and use, and price.

On the second of the macroeconomic trends, namely Potato importance, we notice that increasing potato use is accompanied with increase in price. This is in line with the theory of supply constraints that we started with in the introductory section. It is the supply that is mainly limiting potato use, not demand. When potato importance is growing, increases

in supply due to successful removal of its constraints will be met with unleashing of even greater potato demand (Fuglie, 2007, p. 362-363). Our results indicate that, such removal of supply constraints in developing countries may result in producer price increase as it allows growing importance of the potato.

The four statistically significantly price affecting PC's of the Table 12 are related to potato supply side constraints. The first two macroeconomic trends of the Table 13 seem to be related to the demand side of the potato in developing countries, representing increasing and dormant buying power, respectively. The third macroeconomic trend presents a more complex picture. It is affecting improvements to infrastructure for market economy. The part of it in developing countries that receives direct demand from population masses is related to food availability. On the one hand, lowering of substitute prices and increased imported food present a production constraint to potato since potato producer price becomes constrained by low priced substitutes at market. On the other hand, if potato has an important role in the society, also potato farmers receive easier and cheaper access to fertilizers, pesticides and potato seeds, thus removing production constraints. Both hands can therefore work to decrease potato producer price, explaining the sign of the macroeconomic trend effect on potato price. Improving market economy infrastructure may sometimes allow also removing of potato marketing constraints giving producers more choices on available markets or cold storage, especially if potato has an important position in the society, increasing potato producer price.

We should take the fact that the three macroeconomic trends are less determinate in affecting potato producer price than the four factors of production as a further indication of correct model specification. The three trends are affecting the demand side, namely into purchasers' access to potato or food more generally and their purchasing power, whereas for the potato in developing countries, the constraints that affect production directly are bound to affect producer price with higher determinacy.

Potato solution

What could be done to empower the two vulnerable groups of the developing countries, urban poor and poor potato producers? The former represent potential consumers and are generally better off with increased availability of affordable potatoes. The latter in order to escape poverty need also that the prices they receive would not spiral downwards, at least not proportionally faster than they are able to increase their own production. The question is relevant not only to welfare of the people concerned but also more broadly as an important determinant of the potato's status in developing countries. Empowering poor

cultivators and consumers with potato works directly for their aid, which is wise remembering the social dangers of neglecting food security. Economic growth in itself is affecting often increases in potato price which may lead poorer people farther from potato use. Market economy infrastructure advances may generally lower potato price, but support policies targeted to potato related infrastructures could amplify the effect and make potato business more attractive.

Ongoing macroeconomic trends in developing countries may be working on average to support potato demand although largely missing its potential amongst the poorest, and in case of market economy infrastructure advances, to affect potato supply constraints in a more complex way as above discussed. The four statistically significant supply constraint related factors of the potato producer price in Table 12 promise in any case a more effective avenue to find solutions.

Capitalizing poor potato growers, helping them to improve their equipment though farm credit or low-priced access to fertilizers, pesticides, good quality planting material and seed, would seem a natural solution. Such may also bring promising short run results in potato productivity and lower prices. For understanding how long run benefits could remain in developing country conditions, we need a more sophisticated view which is opened through examining how the capital input is formed through the typical data pattern of developing countries presented by loadings of Better business principal component. We notice that the path leading to low capital input in developing countries is primarily due to better business alternatives and capital finding its way into business in cities rather than into countryside. If such business atmosphere is not changed it is obvious that any added capital inputs to potato cultivation are in danger of being only temporary. The inputs may be even sold by the farmer and proceeds directed to some urban business opportunity that is less vulnerable to thefts, spoilage, price risk, taxation or land extraction. Due to these reasons, acquiring national policy changes is often needed as well in order to reap lasting benefits from addressing growers' capital input related supply constraints.

Similarly for gaining insights on land allocation to the potato production, we can examine the principal path of land allocation through Potato suitability principal component formation. It seems from its loadings that land allocation is mostly naturally limited through soil and environmental constraints. Particularly land allocation is higher where machines and equipment are lacking and agricultural imports are needed. Conquering lowlands of subtropics and tropics for potato cultivation through appropriate technology and capital inputs is still in very early stages. Naturally many countries would be aided in this respect if policy problems that discourage capital inflow into countryside would be solved.

Likewise concerning technological allocation to the potato production, the primary path

to it is presented in the loadings of principal component Knowledge. Technological input use has not yet established strong presence in lowlands of subtropics and tropics. Furthermore where technology input is used, it is rather accrued experience and knowledge as evidenced by high Christian share and not necessarily technology being tied to more valuable capital inputs. It is obvious that great potential is offered in potato expansion through technological inputs where potato is naturally less suitable. This has been experienced in recent decades in lowlands of India and Bangladesh. Also China has had success in adopting the staple root of the Christians.

Labour input as inspected thought the principal component Agricultural poverty indicates that wealth is usually concentrated to large land owners while labouring masses are poor. Poorer farmers, in addition to having low technological and capital inputs which restrain supply from labour input, may be also experiencing severe potato marketing constraints with poor terms of trade reducing potato producer prices. Publicly provided infrastructure may ease potato marketing constraints of the poor farmers, and ease terms of trade even leading in some instances to increasing producer prices received by farmers.

Potato cultivation in developing country conditions often is seen as a risky business that would require greater financial reward, especially in South Asian countries where its cultivation has made promising advances (Maldonado et al., 1998, p. 76). Infrastructures targeted particularly for potato would be a key ingredient in building of the society where potato has a greater importance through making increased inputs to potato cultivation more attractive. Public roads to production areas, communication channels, electricity availability and cold storages lower price volatility and the risk of potato merchants, thereby leading to lower marketing margins, and may give greater share for the poor producers, while also increasing affordable potato supply for the urban poor.

It is worth paying special attention to local case studies from two major potato producing countries in our sample to learn from their struggles. India and China have considerably increased their production during past decades, gaining land allocated to it also from naturally harsh cultivating environments through technological adoption.

Lal et al. (2011) surveyed potato growers, in Bihar state, in India, for perceived constraints that hinder supply increase through technological adoption. The survey results seem particularly to highlight the risk elements in potato business, including unreliable electricity availability and related to that shortage of cold storage facilities; with forced selling during gluts or harvest-period oversupply at below production costs. It seems that it is the high risk of potato farmers having to sell their potato crop at low prices that makes inputs to technology and capital unattractive, and is thus also severely restraining land input which is allocated to potato farming. In attempts to solve problems related to PC6 Better business

Bihar has according to Minten et al. (2014, p. 11) improved law and order, that has been lacking especially in rural areas.

The potato certainly has potential for changing economies of the developing countries; Zhang and Hu (2014) guides through an example how Anding county with a harsh natural environment was turned into potato capital of China. Local government worked first to ease potato supply side constraints through concentrated efforts to improve factor inputs of Table 12. Once supply easing had been effective and potato had received a recognized status, importance of the demand side increased alongside and its constraints needed also solutions. Based on experiments on technology of terrace fields, land allocation was increased on hillsides, which earlier had not held rainfall, initially by labour allocation and later by capital allocation and machinery. Demonstration of successful potato cropping by village leaders and subsidizing high quality potato seeds for poor farmers lowered the concerns and financial risk of potato cultivation compared to wheat that benefited from procurement price floor. Later, after potato cultivation had reached a nadir and started backtracking, a potato trade association was established to guarantee minimum prices also for the potato and to reduce information asymmetry. Also a local wholesale market for potatoes was opened. Such measures benefited the terms of trade of potato cultivators and ensured stability for the potato supply. The potatoes still had limited access to farther market areas which was solved through political lobbying for increased rail freight quotas. New policies were enacted that encouraged and subsidized building storage facilities for potatoes. These help to store potatoes and eventually to stabilize potato price by lowering the usual seasonal fluctuation. Local research and breeding industry for virus-free potato seedlings was started. Processing industry start was supported thus increasing demand base.

We have discovered that macroeconomic inputs of production are in central place in additive model that we pursued, explaining roughly half of the variation in the potato producer price across developing countries in our sample. The national inputs for land, labour, capital and technology are following principal components transformation also uncorrelated to each other which is mirrored by a disarray of the input use in developing countries. Particularly it seems that technology input is generally not applied in connection land, labour or capital use, even where knowledge or technology has been made available. Agricultural support prices for other food crops may lead to most suitable land for potato not cultivated with it. Available great labour force in agriculture is not put to work in favour of labour intensive potato (Horton, 1980, p. 6), since cultivating lands are largely owned by large land owners who prefer cereal production. Where profits from new technology in connection with higher capital input is expected, capital input will not be applied, or will be backtracked easily, due to risk aversion and alternative business opportunities (Lal et al., 2011). Rather technology

input usually has the form of centuries accrued knowledge and is applied, characteristically to many developing countries, in remote high altitude locations (Horton, 1987, p. 115), with low land, labour and capital inputs. To many of these same areas potato had set foot already before use of all inputs started increasing and gaining coordination in Europe. Such particular disarray characteristic to developing countries input use is suiting our model specifications and results.

We conclude by summary recommendation for combating potato supply side constraints based on our model structure and results. Concentrated and persistent efforts to secure sustainable factor inputs availability and intelligent combined use is required. For this goal to be accomplished potato research and recommended practices would first have to reach and then also remain in cultivation fields and societies in developing countries. Allocation strategies for public and private potato advancement campaigns can be evaluated for long run durability considering whether they sufficiently address primary reasons for restricted national input use.

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Appendix Tables

Table 14: Data Summary

	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
potatoprice	94.37	163.92	272.03	320.25	416.02	933.86
Christian	0.013	2.250	12.600	36.745	77.000	98.700
PDensity	1.80	26.30	64.32	119.76	135.72	1100.00
PGrowthRate	-0.325	1.276	1.879	1.817	2.495	3.677
PerCapGDP	400	1300	2450	3070	4300	9900
ServGDP	27.00	38.77	48.85	47.76	55.95	74.60
Hdi	0.2950	0.4507	0.5235	0.5264	0.6298	0.7330
Population	0.513	5.737	15.450	97.931	41.445	1300.000
LifeExp	48.00	54.75	65.50	62.83	70.25	74.00
PopUrbanShare	11.00	26.00	37.50	39.65	54.75	66.00
UnderN	5.00	10.00	19.00	20.12	26.00	64.00
ChildM	15.00	29.75	58.50	72.22	105.00	191.00
WaterUseAg	8.70	76.92	88.90	82.07	93.85	98.00
WaterUseIn	0.200	0.875	2.400	6.790	8.025	57.600
AgricultureGDP	4.70	14.57	20.85	23.11	30.15	48.10
AgricultureExport	0.50	4.20	12.30	21.35	23.10	89.70
AgricultureImp	2.20	11.70	12.90	13.29	16.55	24.90
MaizePrice	100.4	139.4	158.0	221.7	221.7	1570.1
ExportVPerCapita	2.797	106.626	263.892	417.290	459.000	2313.726
ImportVPerCapita	47.17	163.67	451.92	589.71	850.23	1609.56
PotProdPerCap	0.105	4.284	8.530	33.731	45.362	228.765
PotProdPerAgriPop	0.115	7.344	26.273	149.352	114.561	1725.698
LandDevelopVPerAgriPop	24.30	74.25	241.67	1685.06	2094.00	14825.02
MachEquipVPerAgriPopulation	9.48	17.04	24.81	259.31	118.20	3511.90
LivestockValuePerAgriPop	78.88	206.25	422.55	955.88	791.61	14233.05
PlantationCropsVPerAgriPopulation	0.00	1.00	38.83	1351.42	325.93	24326.27
TotalAgriCapitalStockVPerAgriPopu	158.6	582.0	1062.5	4513.6	5752.7	44158.6
ArableLandShareOfLandArea	0.547	5.646	11.896	16.750	20.473	60.690
PermanentCropsShareOfArableLand	0.235	4.908	11.054	17.657	21.747	94.340
PasturesProportionToArableLand	6.569	47.115	169.058	724.967	533.405	13541.173
IrrigatedShareOfArableLand	0.408	3.006	15.301	32.230	54.635	127.299
CerealProductionPerCapita	5.526	94.330	188.284	224.915	306.199	620.186
MeatProductionPerCapita	1.379	5.099	9.517	13.973	16.429	84.444
FishProductionPerCapita	0.002	1.476	4.997	9.492	13.599	38.230

Table 15: Correlations with Potato Price

	Variable	Corr.
1	Christian	0.10
2	PDensity	-0.29
3	PGrowthRate	0.08
4	PerCapGDP	-0.01
5	ServGDP	0.13
6	Hdi	-0.16
7	Population	-0.27
8	LifeExp	-0.17
9	PopUrbanShare	0.21
10	UnderN	-0.06
11	ChildM	0.17
12	WaterUseAg	0.11
13	WaterUseIn	-0.20
14	AgricultureGDP	-0.10
15	AgricultureExport	-0.22
16	AgricultureImp	0.23
17	MaizePrice	0.49
18	ExportVPerCapita	0.21
19	ImportVPerCapita	0.13
20	PotProdPerCap	-0.41
21	PotProdPerAgriPop	-0.27
22	LandDevelopVPerAgriPop	0.08
23	MachEquipVPerAgriPopulation	0.16
24	LivestockValuePerAgriPop	0.08
25	PlantationCropsVPerAgriPopulation	0.30
26	TotalAgriCapitalStockVPerAgriPopu	0.24
27	ArableLandShareOfLandArea	-0.31
28	PermanentCropsShareOfArableLand	-0.14
29	PasturesProportionToArableLand	0.10
30	IrrigatedShareOfArableLand	-0.30
31	CerealProductionPerCapita	-0.08
32	MeatProductionPerCapita	-0.09
33	FishProductionPerCapita	0.08

Table 16: Correlations of absolute value greater than 0.6

	Variables	Corr.
1	PDensity and ArableLandShareOfLandArea	0.72
2	PGrowthRate and PerCapGDP	-0.64
3	PGrowthRate and Hdi	-0.78
4	PGrowthRate and LifeExp	-0.69
5	PGrowthRate and ImportVPerCapita	-0.76
6	PerCapGDP and Hdi	0.81
7	PerCapGDP and LifeExp	0.64
8	PerCapGDP and AgricultureGDP	-0.66
9	PerCapGDP and ImportVPerCapita	0.67
10	Hdi and LifeExp	0.83
11	Hdi and ChildM	-0.71
12	Hdi and AgricultureGDP	-0.62
13	Hdi and ImportVPerCapita	0.76
14	LifeExp and ChildM	-0.83
15	LifeExp and AgricultureGDP	-0.65
16	LifeExp and ImportVPerCapita	0.61
17	PopUrbanShare and ImportVPerCapita	0.65
18	WaterUseAg and WaterUseIn	-0.79
19	MaizePrice and ExportVPerCapita	0.63
20	MaizePrice and MachEquipVPerAgriPopulation	0.76
21	PotProdPerCap and PotProdPerAgriPop	0.85
22	LivestockValuePerAgriPop and PlantationCropsVPerAgriPopulation	0.80
23	LivestockValuePerAgriPop and TotalAgriCapitalStockVPerAgriPopu	0.86
24	LivestockValuePerAgriPop and PasturesProportionToArableLand	0.94
25	LivestockValuePerAgriPop and MeatProductionPerCapita	0.74
26	PlantationCropsVPerAgriPopulation and TotalAgriCapitalStockVPerAgriPopu	0.89
27	PlantationCropsVPerAgriPopulation and PasturesProportionToArableLand	0.75
28	TotalAgriCapitalStockVPerAgriPopu and PasturesProportionToArableLand	0.76
29	TotalAgriCapitalStockVPerAgriPopu and MeatProductionPerCapita	0.61
30	PasturesProportionToArableLand and MeatProductionPerCapita	0.72

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10	PC11
Christian	-0.00	-0.10	0.44	0.05	-0.20	0.26	-0.18	-0.03	0.08	-0.10	-0.06
PDensity	0.02	0.19	0.18	-0.22	0.06	-0.33	-0.14	-0.03	0.06	0.48	0.15
PGrowthRate	0.27	-0.13	-0.12	-0.04	-0.01	0.06	-0.06	-0.04	-0.06	-0.04	0.24
PerCapGDP	-0.27	0.13	-0.08	-0.02	-0.08	0.09	0.04	-0.11	-0.14	0.06	0.03
ServGDP	-0.10	-0.01	0.12	-0.11	0.26	0.02	-0.41	0.02	0.37	-0.30	0.01
Hdi	-0.30	0.12	0.07	-0.02	0.03	0.01	-0.00	-0.02	-0.13	-0.05	0.06
Population	-0.04	0.16	-0.06	-0.28	-0.16	-0.29	0.07	-0.31	0.11	-0.28	-0.21
LifeExp	-0.26	0.16	0.07	-0.14	0.24	0.04	0.02	0.01	-0.04	-0.12	0.09
PopUrbanShare	-0.20	-0.08	-0.03	-0.04	-0.18	0.31	0.17	0.01	0.15	0.08	-0.09
UnderN	0.20	-0.13	0.11	0.00	0.13	-0.10	-0.16	-0.34	-0.17	-0.05	0.15
ChildM	0.24	-0.09	-0.09	0.08	-0.26	-0.01	0.03	0.02	-0.12	0.18	-0.21
WaterUseAg	0.12	0.17	-0.24	-0.00	0.42	0.02	-0.07	0.08	0.02	-0.13	-0.23
WaterUseIn	-0.17	-0.12	0.21	-0.01	-0.30	-0.17	0.04	0.18	0.02	-0.13	0.36
AgricultureGDP	0.22	-0.09	-0.06	0.21	-0.01	-0.15	0.06	0.30	-0.12	-0.09	-0.12
AgricultureExport	0.13	-0.06	0.34	0.11	-0.02	-0.00	-0.22	0.06	-0.20	-0.34	-0.00
AgricultureImp	0.04	-0.14	0.09	0.05	0.22	0.35	0.21	0.12	0.24	0.20	0.40
MaizePrice	-0.09	0.04	-0.28	0.25	-0.11	0.08	-0.47	-0.12	0.09	0.07	-0.00
ExportVPerCapita	-0.18	-0.00	-0.25	0.03	-0.37	0.03	-0.15	-0.18	-0.10	0.09	0.04
ImportVPerCapita	-0.29	-0.03	0.10	-0.01	-0.10	0.11	-0.02	0.06	0.12	-0.03	-0.23
PotProdPerCap	-0.15	0.07	0.20	0.34	0.09	-0.18	0.26	-0.13	-0.03	-0.04	-0.14
PotProdPerAgriPop	-0.16	0.03	0.24	0.34	0.08	-0.06	0.29	-0.08	-0.01	0.03	-0.14
LandDevelopVPerAgriPop	-0.18	0.10	0.05	0.15	0.17	0.05	-0.19	0.21	-0.36	0.21	-0.23
MachEquipVPerAgriPopulation	-0.18	0.08	-0.10	0.36	-0.10	-0.03	-0.30	0.09	0.13	-0.03	0.18
LivestockValuePerAgriPop	-0.16	-0.38	-0.06	-0.02	0.11	-0.18	-0.02	-0.00	-0.07	0.04	0.03
PlantationCropsVPerAgriPopulation	-0.14	-0.36	-0.00	-0.16	0.14	-0.05	-0.07	0.10	0.13	0.13	-0.17
TotalAgriCapitalStockVPerAgriPopu	-0.22	-0.30	-0.01	-0.02	0.17	-0.07	-0.14	0.14	-0.07	0.16	-0.16
ArableLandShareOfLandArea	0.04	0.14	0.30	-0.08	-0.13	-0.40	-0.15	0.16	0.17	0.27	-0.04
PermanentCropsShareOfArableLand	-0.04	0.15	0.14	-0.23	0.02	0.18	-0.13	0.12	-0.59	-0.00	0.16
PasturesProportionToArableLand	-0.12	-0.40	-0.14	-0.06	0.07	-0.17	-0.02	-0.11	-0.14	0.05	0.11
IrrigatedShareOfArableLand	-0.16	0.24	-0.10	0.15	0.22	-0.08	0.06	-0.28	-0.00	0.07	0.30
CerealProductionPerCapita	-0.06	0.16	-0.25	0.10	-0.07	-0.23	0.08	0.55	0.05	-0.20	0.21
MeatProductionPerCapita	-0.21	-0.22	-0.08	-0.11	-0.01	-0.20	0.13	-0.02	-0.15	-0.31	0.08
FishProductionPerCapita	-0.08	0.15	-0.07	-0.44	-0.08	0.14	0.06	0.20	0.02	-0.01	-0.09

Table 17: Principal Components 1-11 with Loadings of Original Variables

	PC12	PC13	PC14	PC15	PC16	PC17	PC18	PC19	PC20	PC21	PC22	PC23
Christian	0.20	-0.08	0.08	0.09	-0.08	0.00	-0.18	0.21	-0.06	-0.35	0.06	0.23
PDensity	0.28	0.03	0.00	-0.11	0.09	0.04	-0.06	-0.06	0.21	-0.40	0.11	0.22
PGrowthRate	0.13	0.11	-0.05	-0.33	0.33	0.17	0.07	0.30	-0.19	-0.05	-0.43	-0.15
PerCapGDP	-0.12	0.26	-0.35	0.05	-0.02	-0.26	0.12	0.14	-0.19	-0.42	-0.11	-0.20
ServGDP	-0.12	0.02	0.38	-0.17	-0.06	0.17	0.04	0.07	0.15	-0.10	-0.05	-0.28
Hdi	0.05	0.12	-0.02	-0.05	-0.09	-0.03	-0.32	0.11	-0.02	-0.07	0.04	-0.22
Population	-0.04	0.04	-0.25	0.30	-0.05	0.50	0.14	0.24	0.10	0.03	0.06	0.08
LifeExp	0.03	0.01	-0.10	0.01	0.04	-0.13	-0.20	-0.06	0.18	0.33	-0.19	0.40
PopUrbanShare	0.29	0.26	0.15	0.34	0.33	0.03	-0.09	0.09	-0.01	0.10	0.09	-0.13
UnderN	0.11	-0.51	-0.12	0.37	-0.09	-0.16	-0.14	-0.00	-0.23	0.04	-0.08	-0.13
ChildM	-0.03	0.14	0.14	-0.01	-0.57	-0.10	0.14	0.10	0.32	-0.02	-0.19	-0.03
WaterUseAg	0.17	0.08	-0.04	0.15	0.06	-0.18	0.22	-0.08	-0.11	-0.10	0.02	0.04
WaterUseIn	-0.29	-0.05	0.10	0.10	-0.05	0.04	0.12	-0.18	-0.24	-0.02	-0.02	0.01
AgricultureGDP	0.31	0.16	-0.02	0.07	-0.07	0.43	-0.31	-0.28	-0.23	-0.09	0.04	-0.03
AgricultureExport	0.08	0.30	-0.48	-0.21	-0.04	-0.08	-0.05	0.03	0.20	0.15	0.08	0.00
AgricultureImp	0.04	-0.07	-0.37	0.05	-0.15	0.30	0.27	-0.03	0.17	0.04	0.10	-0.01
MaizePrice	0.26	-0.10	-0.10	-0.02	0.01	0.04	0.16	-0.07	-0.04	0.09	-0.06	0.14
ExportVPerCapita	0.02	-0.16	-0.03	-0.30	0.12	0.16	-0.10	-0.00	0.05	0.14	0.06	0.14
ImportVPerCapita	0.06	-0.04	-0.08	-0.08	-0.09	0.02	0.05	-0.43	-0.07	0.04	-0.39	0.06
PotProdPerCap	0.13	-0.08	0.10	-0.37	0.02	-0.04	0.25	0.15	-0.23	0.12	0.41	0.01
PotProdPerAgriPop	0.23	-0.23	0.07	0.04	0.04	0.08	0.07	0.21	0.23	0.00	-0.46	-0.10
LandDevelopVPerAgriPop	-0.35	-0.22	-0.12	0.04	0.17	0.33	-0.03	-0.01	0.09	-0.13	0.02	-0.17
MachEquipVPerAgriPopulation	0.15	0.04	-0.03	0.24	-0.13	-0.06	0.17	0.05	0.06	0.03	0.18	-0.14
LivestockValuePerAgriPop	0.12	0.15	-0.01	0.11	0.03	-0.09	-0.16	0.00	0.22	0.08	0.05	-0.16
PlantationCropsVPerAgriPopulation	0.01	0.05	-0.07	-0.07	-0.21	0.01	0.08	0.28	-0.39	0.04	-0.06	0.31
TotalAgriCapitalStockVPerAgriPopu	-0.06	0.01	-0.09	0.03	-0.06	0.09	-0.01	0.16	-0.11	0.01	0.00	0.06
ArableLandShareOfLandArea	0.07	0.13	-0.10	0.10	0.13	-0.10	0.17	-0.04	-0.14	0.33	-0.18	-0.26
PermanentCropsShareOfArableLand	0.19	0.10	0.34	0.14	-0.07	0.14	0.35	0.09	-0.06	0.18	0.00	0.10
PasturesProportionToArableLand	0.04	0.01	0.08	-0.02	0.03	-0.04	-0.02	0.05	0.19	0.12	0.11	-0.13
IrrigatedShareOfArableLand	0.04	0.26	0.11	-0.05	-0.39	0.20	-0.22	-0.04	-0.21	0.04	-0.15	-0.02
CerealProductionPerCapita	0.04	-0.19	-0.02	0.07	-0.00	-0.11	-0.12	0.39	0.08	-0.06	-0.09	0.17
MeatProductionPerCapita	0.24	-0.07	0.00	-0.07	0.04	-0.01	0.32	-0.31	0.11	-0.35	-0.07	0.02
FishProductionPerCapita	0.33	-0.34	-0.14	-0.24	-0.28	-0.02	-0.08	0.02	-0.07	0.09	0.13	-0.39

Table 18: Principal Components 12-23 with Loadings of Original Variables

	PC24	PC25	PC26	PC27	PC28	PC29	PC30	PC31	PC32	PC33
Christian	-0.28	0.15	-0.17	0.04	0.12	0.11	0.37	0.03	0.13	0.00
PDensity	0.20	-0.03	0.21	-0.09	-0.07	0.03	-0.09	0.10	-0.01	0.00
PGrowthRate	0.05	-0.09	0.12	-0.19	-0.02	0.28	0.22	-0.09	0.01	0.00
PerCapGDP	0.17	-0.14	-0.00	0.37	0.23	-0.11	0.02	0.13	0.10	-0.00
ServGDP	0.26	-0.07	-0.04	0.09	0.18	-0.19	-0.07	0.04	0.05	-0.00
Hdi	-0.31	-0.45	-0.11	-0.55	-0.04	-0.13	-0.17	-0.05	-0.01	0.00
Population	-0.06	-0.05	0.10	-0.06	0.05	0.10	0.05	0.04	-0.00	0.00
LifeExp	0.29	-0.30	-0.22	0.11	0.04	0.25	0.25	-0.06	0.14	0.00
PopUrbanShare	0.40	0.23	-0.07	-0.21	-0.00	0.04	-0.17	0.02	0.09	0.00
UnderN	0.29	0.00	0.07	-0.15	0.16	-0.12	-0.07	-0.07	0.06	-0.00
ChildM	0.28	-0.09	-0.14	-0.26	0.12	0.09	0.10	0.02	0.08	0.00
WaterUseAg	-0.05	0.08	-0.03	-0.31	-0.16	-0.19	0.38	0.38	0.05	0.01
WaterUseIn	0.19	-0.06	-0.04	-0.16	-0.22	0.13	0.11	0.48	-0.14	0.00
AgricultureGDP	0.13	-0.29	-0.05	0.22	0.09	-0.09	0.02	0.06	0.12	-0.00
AgricultureExport	0.15	0.26	0.07	-0.06	-0.16	-0.09	-0.20	0.10	-0.02	0.00
AgricultureImp	-0.05	-0.07	-0.09	-0.11	0.19	-0.17	0.05	0.03	0.05	0.00
MaizePrice	-0.13	-0.08	-0.26	0.01	0.16	0.28	-0.35	0.29	-0.17	0.00
ExportVPerCapita	0.14	0.06	-0.08	-0.05	-0.03	-0.59	0.31	0.03	0.02	0.00
ImportVPerCapita	-0.09	0.08	0.55	-0.18	0.25	0.02	0.00	-0.03	0.15	-0.00
PotProdPerCap	0.17	-0.06	0.07	-0.11	0.31	0.14	0.07	0.02	0.04	0.00
PotProdPerAgriPop	-0.03	-0.06	-0.01	0.20	-0.31	-0.17	-0.08	0.22	-0.12	-0.00
LandDevelopVPerAgriPop	0.10	0.19	-0.13	-0.12	-0.00	0.21	0.06	-0.05	0.09	0.28
MachEquipVPerAgriPopulation	0.05	-0.16	0.29	0.07	-0.36	0.10	0.24	-0.37	0.09	0.06
LivestockValuePerAgriPop	-0.08	0.05	0.12	0.06	0.30	0.04	0.30	0.08	-0.56	0.28
PlantationCropsVPerAgriPopulation	0.07	-0.04	-0.03	-0.00	-0.22	-0.14	-0.17	-0.11	0.02	0.46
TotalAgriCapitalStockVPerAgriPopu	0.05	0.05	-0.00	-0.02	-0.05	0.02	0.05	-0.07	-0.14	-0.79
ArableLandShareOfLandArea	-0.17	0.07	-0.33	0.01	0.14	-0.13	0.12	-0.13	0.14	-0.00
PermanentCropsShareOfArableLand	-0.09	-0.03	0.15	0.11	0.11	-0.14	-0.07	0.01	-0.06	-0.00
PasturesProportionToArableLand	-0.22	0.03	0.08	0.11	-0.04	0.11	-0.04	0.32	0.67	0.00
IrrigatedShareOfArableLand	-0.02	0.49	-0.09	0.01	-0.04	0.07	0.05	-0.02	0.02	-0.00
CerealProductionPerCapita	-0.02	0.22	0.09	-0.08	0.29	-0.08	-0.12	0.01	0.08	0.00
MeatProductionPerCapita	0.01	0.14	-0.37	-0.08	-0.05	0.01	-0.06	-0.36	0.01	-0.00
FishProductionPerCapita	0.05	0.09	-0.01	0.14	-0.17	0.20	0.08	0.10	-0.07	-0.00

Table 19: Principal Components 24-33 with Loadings of Original Variables

Table 20: Potato Price Regression

Endogenous: Potato Price, Exogenous: Principal Components 1-33 (scores)

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	320.2537	28.2723	11.33	0.0000
PC1	-0.5528	9.6239	-0.06	0.9561
PC2	-25.9870	14.1847	-1.83	0.1167
PC3	-41.4537	17.2277	-2.41	0.0528
PC4	0.7936	17.9441	0.04	0.9662
PC5	-5.5964	18.2377	-0.31	0.7693
PC6	60.1525	19.2502	3.12	0.0205
PC7	-52.6166	21.4576	-2.45	0.0496
PC8	21.9842	25.8857	0.85	0.4283
PC9	42.4904	26.1968	1.62	0.1559
PC10	40.2143	29.2026	1.38	0.2177
PC11	-42.8770	30.8159	-1.39	0.2135
PC12	-4.8437	33.7914	-0.14	0.8907
PC13	-45.7765	37.9209	-1.21	0.2728
PC14	-13.7135	39.8707	-0.34	0.7426
PC15	23.2125	45.7227	0.51	0.6298
PC16	-20.0510	49.4407	-0.41	0.6991
PC17	-18.7920	52.3947	-0.36	0.7321
PC18	74.9485	57.7774	1.30	0.2422
PC19	17.7866	65.6212	0.27	0.7954
PC20	21.7562	66.8692	0.33	0.7560
PC21	-61.3729	80.4527	-0.76	0.4745
PC22	-32.1204	82.8845	-0.39	0.7117
PC23	67.4176	87.5310	0.77	0.4704
PC24	-68.3067	105.6667	-0.65	0.5419
PC25	-39.6219	114.1853	-0.35	0.7404
PC26	-161.2532	140.9593	-1.14	0.2962
PC27	-200.6002	167.6838	-1.20	0.2767
PC28	82.5374	194.7487	0.42	0.6865
PC29	8.1762	260.0152	0.03	0.9759
PC30	-142.6911	281.8090	-0.51	0.6307
PC31	75.4837	338.2796	0.22	0.8308
PC32	-603.3365	404.2473	-1.49	0.1862
PC33	1472.3646	19641.7689	0.07	0.9427

Residual standard error: 178.8 on 6 degrees of freedom
Multiple R-squared: 0.8789, Adjusted R-squared: 0.2128
F-statistic: 1.319 on 33 and 6 DF, p-value: 0.3921