



Article

Potato Importance for Development Focusing on Prices

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Abstract: This paper studies potato prices and consumption in the progress of economic development. Potato status tends to evolve from a luxury to a normal and, lastly, to an inferior good. In the developed world, where the potato thrived and became a food for the poor, prices of the inferior potato attract little interest due to general welfare, which further complicates discerning economic effects by computation. Contrarily, in many developing countries, due to supply constraints the potato is a relative expensive, non-staple, normal good, with little social significance. Whereas it is a common misconception that tastes in developing countries differ from advanced economies, low incomes, together with relatively high potato prices, present a real and obvious hindrance to wider potato use among the poor in the underdeveloped world. Local regressions on FAO data reveal empirical advantages favoring potato price system research in developing countries, more likely yielding predictable, statistically significant, unbiased results. Correct policies could increase potato importance in developing countries and stimulate sustainable and pro-poor growth where consumers receive affordable potatoes, while also producer incentives for greater productivity improve. Furthermore, potato-led research presents widening potential into also understanding general social structures of underdevelopment as similar factors explain both cross-border incomes and potato prices.



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1. Introduction

1.1. Aims and Contribution

For many people inhabiting the present-day developed world, the potato is a staple food item, so common that often its importance and everyday use remains unnoticed or is superficially attributed to different tastes compared to low levels of use in developing countries. This essay demonstrates with available data from recent decades that the potato tends to evolve with development from a luxury to a normal and lastly to an inferior good, unifying earlier literature on the subject. While also contributing some ideas on the discussion of input factor costs and output prices, it also introduces potato prices particularly in areas of underdevelopment as an ideal separate research environment for finding solutions that hold potential for generalization into fields that are less approachable empirically due to computational limitations.

1.2. Divide between Developed and Developing Countries

According to (Salaman 1987, Chapter xxiv, pp. 434–45), the potato started as a luxury good in Europe, its major base of dissemination. But due to success in cultivation and promoting its use amongst the poor, it became, passing quickly through the normal good status, eventually a staple inferior good in Europe. In Europe, by the 19th century, the potato arguably was the chosen food of the poor, a driving engine for economic expansion and rise of welfare in general. Also elsewhere, the potato helped nutritional needs and

supported city growth, thus inducing development by giving birth to diverse resources of human capital (Bertinelli and Zou 2008; Nunn and Qian 2011; Scott and Suarez 2012b). Rising incomes have led to a more diversified food consumption and declining potato use in richer countries, as is well known, which is understandably causing confusion in potato status related preconceptions of present-day people. Many people inhabiting the developed world consume potato as a major staple food article with an erroneous belief that lower potato use in developing countries is due to differing tastes, but the real reason for differing potato use patterns is related to prices. Historical potato status developments in western temperate countries where potato thrived have also weighed on research settings (Reader 2009; Scott 2002; Scott and Suarez 2011; Walker et al. 1999). Historically, the potato was highly important for social and economic development, particularly for the poor. Potato prices also peculiarly conform to Giffen paradox in economics textbooks, although it is doubtful whether the potato could fit into such a scenario where its rising price forces the poor to increase their potato consumption. Nevertheless, in many presently emerging economies, the potato remains a normal good, and its consumption is increasing, usually with income, as diversifying in eating habits generally occurs from local staple food articles, usually rice, wheat, or maize, towards the less common and frequently more expensive potato (Pandey and Sarkar 2005; Waid et al. 2018).

2. Literature Review

2.1. Theories for Two Main Paths in Potato Status Evolution

Separating the status of the potato between the two common alternatives, an inferior good or a normal good (even near luxury food item), and implications of these two for potato prices and development are central themes of discussion in this paper, also below in related economics history, i.e., attempts to formulate a general theory on the evolving importance of potatoes with regard to advances in national income levels. Whereas historical observations from the West in its way from poverty to economic success fueled by potato nutrition allowed no general model of historical evolution in the potato use with respect to income level, the two viewing angles may be unified basing on different potato statuses in consumption; a luxury, a normal, and an inferior good.

A principle that describes the evolving importance of potatoes and cereals, that fits into the economic history of the western temperate countries, appears in (Bennett 1936, 1941, particularly pp. 41–42 in the latter one), basing on relative prices of calorie-content of the nutrition. Poor regions depended heavily on potatoes (and other ‘cereal-potato’ foods; corn, rye, and barley), shifted to wheat as incomes rose, and, finally, with still further increases in income, shifted still further away from potatoes and cereals (including wheat), adding dependence on other foods (e.g., sugar, milk, meat, fruits, and vegetables). Based on the above Bennett’s principle, a descriptive model that connected society advancement level to its potato and wheat use was presented in Gray et al. (1954). Variability due to climate and preferences also explains cross-country differentials in the importance of potatoes and cereals in nutrition, but, according to the model, all countries that started with a ‘potato economy’ would follow roughly the same transitional path, finally reaching a developed economy where neither potatoes nor wheat are emphasized in the diet. Walker (1994) augmented the descriptive model to have total potato consumption subdivided into fresh consumption, processed foods and animal consumption, although, according to Scott (2002), its feed share appears too high since, in today’s developing countries, the potato is usually a cash crop, too expensive to be given to farm animals, unlike the history of present-day developed countries. Compared to earlier research an added contribution in the augmented model was that potato consumption would also increase in late stages of economic development because of the increase in processed food demand. Poleman and Thomas (1995) grouped the potato together with other starchy staples for international comparisons of income and dietary change. Basing on its indications, Walker et al. (1999, p. 44) presented conditions for a descriptive model which presents the approximate historical path of potato consumption behavior of modern western developed

countries where the potato is now usually an inferior good. This temperate world historical potato consumption development pattern towards an advanced economy, although a past times candidate for universal applicability, works no longer in the majority of present-day developing countries; rather than being a staple, the potato is usually an expensive crop with low consumption share mainly due to constraints on the supply side (Scott 2002; Lal et al. 2011; Devaux et al. 2014). Thus, the potato groups poorly with starchy staples in such comparisons for income and dietary change. In addition, Asian countries are experiencing changes for starch demand through new uses even though incomes rise, possibly restricting Bennett's principle (Fuglie 2004). Japan, Hong Kong, and Singapore were shown as outliers already in empirical observations of Poleman and Thomas (1995, pp. 152–53). In any case, the potato differs markedly from other starchy tubers in developing countries. Per capita consumptions for cassava and sweet potato are decreasing with per capita income, while per capita consumption for potato is increasing with per capita income in cross-country comparisons (Scott 2002, p. 50; also see Figures below, in this paper). In summary, research points out two main potato statuses in present-day developing countries; first, the much more common, a non-staple normal good, and secondly, the rarer but of great historical importance, e.g., in supplying also for North European countries' world dominion during colonial times, a staple inferior good (De Ferrière le Vayer 2017; McNeill 1999).

The usual role of the potato in developing countries of present-day, however, differs from that of historical Europe described above. Nevertheless, also in Europe, the potato initially started as a luxury good, and its status more or less gradually evolved into an inferior good through the normal good status. Similarly, in many developing countries where the potato is now a non-staple normal good, having entered into the diet at a later stage of development in the form of higher priced low consumption share vegetable (Walker et al. 1999, p. 42), welfare increases may eventually turn it into an inferior good, provided that welfare spills also to the poor masses and price incentives for its cultivation improve. In that sense, all countries do follow, in a grand outline, a similar potato status trajectory from a luxury to a normal to an inferior good, but this process is often slow, stalls easily, and even periodically retreats, depending on changes in country specific conditions, as we will also explore using FAO data.

Giffen Property

In European history, potatoes were an inexpensive staple food for the poor, also often an inferior good, decreasing in consumption as incomes rose. And in economics literature, the potato goes infamously still farther by being the usual textbook example of the dreaded Giffen attributes which are forcing the poor to abandon complementing foods and increase potato consumption as its price rises. The wide circulation of Giffen property for potatoes, which become the best popularized of its price action in academic circles, received its first ingredients from Alfred Marshall's mention of bread having such attributes for the poor in the third edition of his *Principles of Economics* (Marshall [1890] 2013) and became completed as Paul Samuelson upgraded the story by choosing instead the potato and the mid-nineteenth century famine in Ireland (Samuelson 1964). This Giffen potato example is widely contested outside popular textbooks since it is unconfirmed by available data and common sense; the poor could not possibly consume more potatoes as their prices rose in famine conditions since less potatoes were available due to the blight that devastated Irish potato crops (Dwyer and Lindsay 1984). Even though potato crop casually failed, the potato was arguably the chosen food for the poor, and one of the major driving engines for the economic expansion and generally rising welfare in Europe from the 19th century onwards. Rising incomes then have led to lowering potato shares and more diversified food consumption.

Potato-dependent historical Ireland of the famine years was chiefly suspected for Giffen behavior in potatoes, but gathered evidence speaks against it, as well. Dwyer and Lindsay (1984) argued that the potato was not a Giffen good during the Irish potato famine of the

1840s, and even more generally that a closed peasant economy engaged in subsistence farming is a wrong place to look for Giffen goods, potatoes or any other, and suggested instead Singapore, a poor community that imports most of its food. Kohli (1986) responded by arguing that a closed economy also could exhibit Giffen behavior but, instead of potatoes being Giffen goods, suggested at looking at meat. Then, Davies (1994) argued that the Irish famine represented Giffen-type response on potatoes but no actual Giffen behavior as food prices were increasing generally. In a recent study, Giffen-style behavior was found in bacon pigs of the Cork market at and around Irish famine, whilst potatoes, wheat, barley, and oats displayed normal good characteristics during this period (Read 2017). At times of food insecurity, it is indeed sensible that an inferior good turns into a normal good, effectively ruining the theoretical approach which assumes constant utility.

The theoretical debate extends also to concern the influence of initial price levels or consumer endowments. Dougan (1982) modeled unstable, final equilibrium price to be dependent on the point where trading starts. This point, in turn, affected the modeled probability for Giffen behavior which was generalizable from a single household to concern the aggregate demand curve. Berg (1987) argued that the theoretical definition of Giffen's paradox ignoring the initial endowments of the consumer is ambiguous, whereas Nachbar (1998) criticized analysis which bases on fixed income demand as potentially invalid. Davies (1994) incorporated a calorie-modified utility function to explain Giffen behavior in decision processes compelled by a constraint on the level of subsistence, as classical writers also might have emphasized. Jensen and Miller (2008) reported experiments which uncovered Giffen behavior for rice and wheat flour in China. According to the study, inferiority and also Giffen behavior in basic foods are more likely to be seen in the purchases of those individuals who have escaped the utmost poverty of the society. Doi et al. (2009), by presenting a suitable utility function, concluded that Giffen behavior was independent of income share of the inferior good and could be found in all income classes, not only for the poor.

The Giffen effect requires that the potato should be an inferior good without near substitutes, and a great part of consumer income should go into potatoes, and at least some of it into a normal complementary good, such as meat. Then, rising potato price would increase quantity consumed, i.e., the demand curve would slope upwards, which would violate the law of demand. If the potato is so inferior that the income effect is greater than the substitution effect, potato price increase would lead the poor consumers to buy more of it and abandon meat. Despite wide use of this example in economics textbooks, no empirical research evidence exists for the Giffen behavior for the potato. In most developing countries of today, the potato is a normal good. Thus, the search for Giffen potatoes should focus on countries where it is an inferior good; but, in countries where it is an inferior good, it likely has near substitutes which neutralize the potential for Giffen property.

3. Materials and Methods

3.1. Prices, Consumption Shares, and Incomes

FAO data allows comparing how potato producer prices, consumption measured as calorie share, and income development relate to each other in present-day societies, using averages from the first two decades of the 21st century to detect directions of change for each individual country or area. For varying research settings, averaging over 10-year data periods appears promising as it sidesteps difficulties that ensue from short-run variability in prices and production quantities (Rana and Anwer 2018; Salmensuu 2021; Scott and Suarez 2011). In this research, we will study potato price, consumption, and income data for countries and areas using their decade-mean moves and cross-sectional positions.

Figure 1 relates potato price and consumption share by income classes. Countries may be classified by prevalent data clusters regarding their potato producer prices, consumption shares, and national GDP incomes. Mediocre income countries averaged the 2000s between 7.35 and 9.65 in natural logarithm of per capita GDP using inflation adjusted 2010 dollars.

Markedly, higher price usually means lower potato consumption share, and higher share lower price. In the long run, no country has both high share and high price, but, especially the poor developing countries, may have—due to limits in general purchasing power, distant producing areas, lacking infrastructure with high freight and storage costs, and weak terms of trade of the potato producers—low (producer) price with low (often predominantly urban) consumption share. Most countries in the FAO data had consumption shares varying between 0.017 and 0.055, and, in this mediocre range, the producer price appears to be generally higher in richer countries, whereas the lowest share area also reveals a similar view. The poorest countries often suffer from a wide differential wedge between producer and consumer prices, which leads to low potato producer prices together with low consumption share.

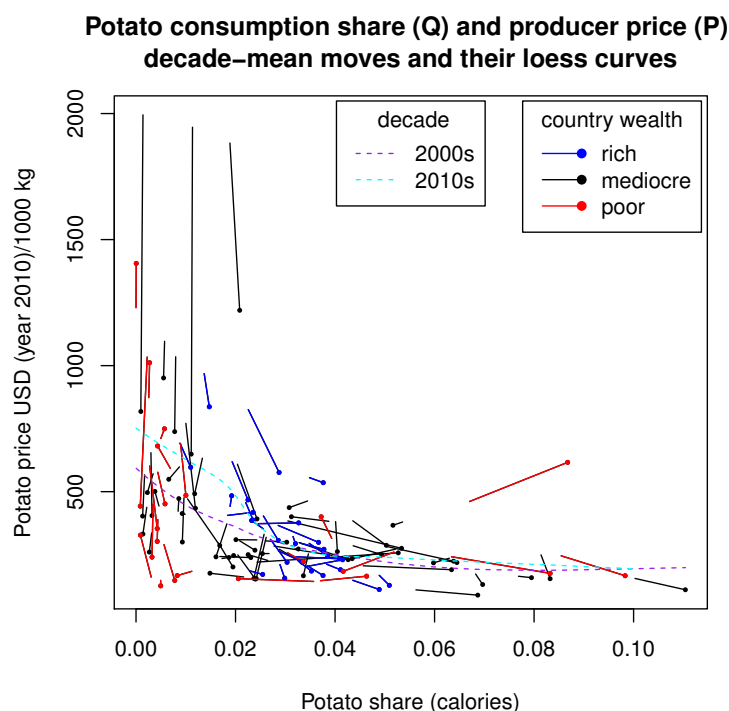


Figure 1. Potato consumption against price. Each country is represented by a half open line segment (pin), endpoints representing data values. The closed end (pinhead) of each connecting line is average for 2000–2009. The open end (without pinhead) is average for 2010–2019. The segments (pins) are colored here by three classes of GDP per capita.

3.2. Research Questions

We will next inspect using recent decade averaged FAO data from 2000s to 2010s the two views for potato status evolution; an inferior good following a predominantly historical pattern for temperate western countries as opposed to a normal good for a majority of present-day developing countries in subtropics and tropics. We are interested in analyzing how they match to each other in the data and how they fit into a unifying view. Particularly, by using comparative statics results (Chiang 1984, pp. 215–17 derives the normal good case), we will separate dP/dY and dQ/dY by their signs, i.e., whether these shifts are positive or negative sloping, and then consider cross-sectional local regressions on this endpoint data of decade-average moves for hints how likely statistical modeling can succeed in distinguishing empirical effects.

3.3. Comparative Statics: Inferior and Normal Good Potato Statuses

Mathematics below can demonstrate the intuition how development affects consumption and prices depending on two general potato statutes, either an inferior or a normal good. Following Chiang (1984, pp. 215–17) suppose a market where potato quantity demanded equals supplied quantity in equilibrium, so that $Q_d = Q_s$. Quantity supplied

is a (supply) function S of price P ; thus, $Q_s = S(P)$. Naturally, supply is increasing with price, i.e., $dS/dP > 0$. Quantity demanded is given by a demand function D of price P and income Y ; thus, $Q_d = D(P, Y)$. Demand is decreasing in price (no Giffen behavior here), i.e., $\partial D/\partial P < 0$, while the potato status commands the direction of $\partial D/\partial Y$. For the inferior good status of the potato, we have $\partial D/\partial Y < 0$, whereas, for the normal good status, on the contrary, it is true that $\partial D/\partial Y > 0$. The equilibrium price \bar{P} is a function of the only exogenous variable Y ; thus, $\bar{P} = \bar{P}(Y)$. In addition, in the equilibrium, we have the corresponding equilibrium quantity $\bar{Q} = Q_d = Q_s = S(\bar{P})$.

Applying implicit function theorem gives $\frac{d\bar{P}}{dY} = -\frac{\partial D/\partial Y}{\partial D/\partial \bar{P} - dS/d\bar{P}} > 0$, where the last inequality holds using above assumptions for a normal good status, whereas, for an inferior good status of the potato, contrarily $\frac{d\bar{P}}{dY} < 0$. By the chain rule and recalling that $\frac{dS}{d\bar{P}} > 0$ and that $\frac{d\bar{P}}{dY}$ was just solved to depend on the two statuses, we also receive the corresponding result that concerns the equilibrium quantity: $\frac{d\bar{Q}}{dY} = \frac{dS}{d\bar{P}} \frac{d\bar{P}}{dY} > 0$ for a normal good, and $\frac{d\bar{Q}}{dY} < 0$ for an inferior good.

Thus, by the above mathematics, for the normal good status of the potato, increases in its price and quantity associate with income growth; for inferior good status on the contrary, its price and quantity decreases associate with income growth. We will use these results in quantifying how FAO-areas by their cross-sectional positions match to their last decade-average move direction from the 2000s to 2010s. Compared to rich countries, poorer countries are more stable in inferior or normal good trajectories and have larger variability in potato prices and consumption levels. Such characteristics aid in distinguishing effects in quantitative research.

4. Results and Discussion

Whereas in richer countries where affordable potato nutrition is abundantly available, and the diversification in consumption habits made the potato an inferior good, statistics demonstrate that, in modern-day developing countries, the diversification is due to income rise also, but its general direction is opposite, towards the relatively expensive and little used potato. Thus, in developing countries, higher potato consumption shares follow as incomes rise.

Figure 2 presents how prices and growing incomes relate to each other by their recent decade-average moves, whereas Figure 3 represents income against consumption share that approximates consumed quantity. A normal good by its definition receives increasing demand with income, $dD/dY > 0$, whereas the opposite is true ($dD/dY < 0$) for an inferior good. Chiang (1984, pp. 215–17) demonstrates for the normal good condition that, holding everything else constant, increasing income also leads to increases both in price, $dP/dY > 0$, and in quantity, $dQ/dY > 0$. For the inferior good condition, $dD/dY < 0$, increasing income then trivially leads to decreases both in price, $dP/dY < 0$, and in quantity, $dQ/dY < 0$. Positive or negative slopes of these moves (drawn as pins, similarly as in Figure 1), thus, convey normal or inferior good status, respectively, in Figures 2 and 3. In all the three Figures alike, we notice that as incomes rise both potato price and share are increasing particularly for countries of lower GDP. This phenomenon indicates the potato’s usual normal good status in developing countries. Figure 2 also illustrates that potato consumption share tends usually to be mediocre in richest countries, with few low consumption share classified countries in the high-range of GDP. Cross-sectionally, low share countries have usually higher producer prices with an increase in prices and shares until the mid-range of GDP. Particularly, we notice that, for the poorest countries, cross-sectional movement directions in potato status depicted by the local regressions are generally aligned with the individual country movements, whereas the situation is more blurred for more developed countries. Thus, whereas less developed countries more clearly follow their expected status that

relates to their position with respect to the coordinate axes, richer countries are more prone to behave irregularly and move opposite to cross-sectional position related patterns in inferior or normal good statuses. This phenomenon understandably causes modeling problems unless developed and developing countries are differentiated.

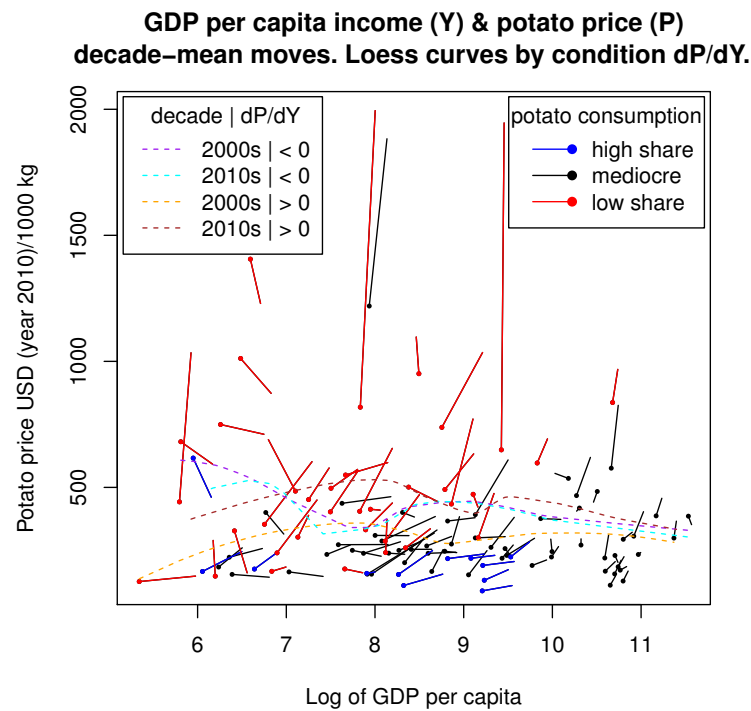


Figure 2. Logarithm of GDP per capita against potato producer price. Richer countries have less separable potato price behavior with respect to income, and weaker predictability as cross-sectional positions followed by local regression curves weakly if at all agree with potato statuses in individual country moves. For the poorest countries, the slopes (dP/dY) of the latest decade-mean moves are a better match to the signs of the slopes of cross-country local regression curves of the 2000s and 2010s. The slopes optimally rise for a normal good and descend for an inferior good status of the potato, aiding cross-sectional modeling.

Producer price data for potatoes is relatively scarce in FAO statistics, and we will double the number of areas studied by ignoring its absence. As potato consumption share relates to potato price, as we saw in Figure 1, it is possible and also more interesting to continue the study including this other half of potato related observations, although they are missing actual price data. Thus, the remainder of this study discusses potato consumption share against GDP per capita. Figure 3 relates that, especially for less developed areas, potato consumption share tends to increase with rise in GDP per capita, whereas, for richer areas, increasing GDP often leads also to lowering of potato consumption share. It also seems that a turning point exists where increased development can make the potato an inferior good but—counteracting this inferior good trend—refined uses which appeal to wealthier people will emerge with development; noticeably, richest areas do not have very low shares. With similarity to our earlier observation in Figure 2, we notice here also that, for developing countries, the signs of the drawn slopes in individual FAO-area data are consistent by the condition dQ/dY cross-sectionally in local regressions. On the contrary, for the richest countries, the local regression curves are rising where they use endpoint data consisting of descending decade-mean moves and descending where they use data consisting of rising move endpoints.

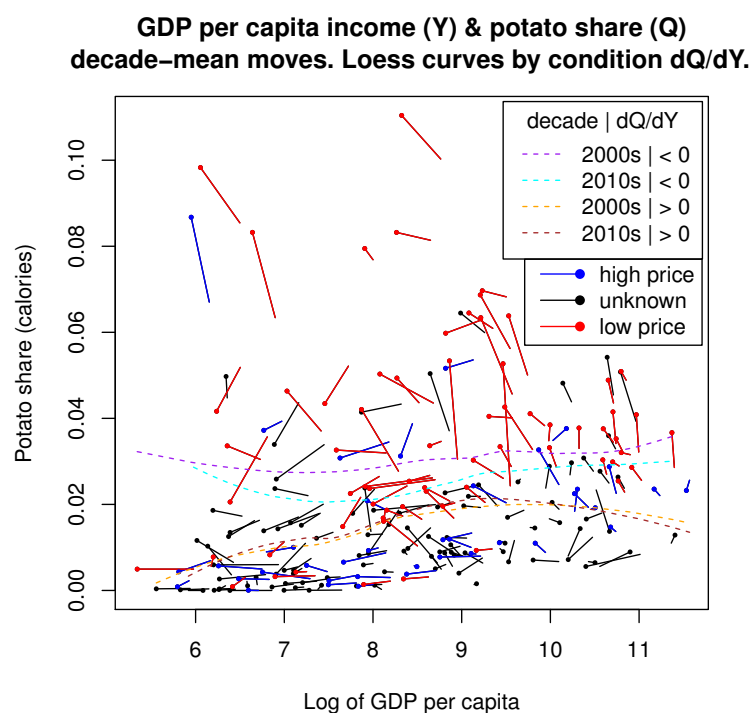


Figure 3. Potato share against GDP per capita. Half of the FAO-areas with unknown producer price data. The limit of 350 USD/1000 kg, using inflation adjusted 2010 dollars, classified known potato prices into high or low for this representation. Developing countries are consistent to their individual country condition dQ/dY in cross-sectional local regression slopes, whereas rich countries cross-sectionally behaved contrarily to their individual country conditions with loess curve rising for descending decade-mean move endpoint data, and vice versa.

Figure 3 also presents that, in many poorer areas, potato consumption share slowly trends upwards together with development. We should also observe that half of the areas, a notable minority of low income developing countries, as well, fit into inferior good potato status by decreasing share of potato consumption with increasing welfare. Particularly, in the richest countries, the potato is often viewed as an inferior staple that faces per capita consumption decline with rising incomes as consumers diversify their nutritional habits. The variance in consumption shares is high for poor countries and low for rich countries, which is unsurprising as poor countries that have either a normal good potato with a low consumption share or an inferior good potato with a high consumption share converge in their potato status paths with development. Simplifying, we seem to have areas, where potato is inferior and areas where it is still a normal good. Refined end-uses may make its path change—from an inferior good status back to a normal good status—at later development phase of the society, while areas where the potato is a low share luxury or normal good may gain share rapidly with success in cultivation and turn potato into an inferior good. In the European history, the potato followed such a route. In addition, in Asia, the potato was a luxury good, e.g., in Pakistan and Bangladesh, still in the 1970s and 1980s (Bouis and Scott 1996).

4.1. General Stages in Evolution of Potato Importance

As half of the FAO-areas in Figure 3 represent inferior good characteristics by their $dQ/dY < 0$ condition, while the other half follow normal good characteristics where decade-mean moves conform to $dQ/dY > 0$, we discuss shortly inferior and normal good potato statuses' relation to development.

Considering the evolution of potato importance as stages, the first stage belongs to luxury good status; potato consumption and production are low, and consumer price is particularly high. In Figure 3, these characteristics are particularly identifiable from

lower income countries with low potato consumption share. High priced potato belongs mainly to the diet of the wealthier people (Salmensuu 2021; Scott 2002; Thiele et al. 2010). However, high potential unit profits in the supply chain of luxury good potato likely lead to engineering of increased supply which progresses the potato to its normal good phase. Or even farther, since even though the potato was luxurious initially after its arrival to Europe also (Salaman 1987, Chapter xxiv, pp. 434–45), it claimed—after initial scepticism—its place as a significant staple food item and an engine of economic growth, which transformed it into an inferior good.

The second of the stages belongs to the normal good status, which supply constraints (Kaur et al. 2020; Salmensuu 2021) make an enduring, stable stage in present-day developing countries as the potato is increasingly used as a vegetable crop with economic development; in these countries advances in economic development are accompanied by increases in potato use, although prices also rise with increasing demand as the potato becomes affordable to many (Chiang 1984; Salmensuu 2021, and Figures of this research). As the poor people gain in income, they start using the potato. Still, Scott (2002, p. 51) suggests that per capita consumption in many developing countries may never reach that of Europe. Many developing countries need persistent efforts in research based policy for the potato to become a staple food article, price risk is a noted constraint to its expansion (Guenthner 2010; Pandit and Chandran 2011; Salmensuu 2020). Progressing into a staple food article in the case of the potato has often been accompanied by general positive wealth, welfare and health effects in population. These effects were first quantitatively established in Nunn and Qian (2011) and expanded to study common effect from the potato and milk in Cook (2014), since milk with its high vitamin A and calcium content provides complementarity to potato nutrition. A subsistence farmer only needs daily intake of 5 potatoes complemented with a quart of milk to remain healthy. We also notice from relative country-level aggregate statistics of the latter study that Chinese have weak lactase persistence which makes the potato, with its milk complement, nutritionally more valuable to Europeans. Although the Chinese during colonial times in large rejected introductory attempts of many European values and customs, including Christianity, democracy, and potato cultivation, their recent science based policy has been able to notice and correct some of the errors, at least the one concerning the potato (Su and Wang 2019). Potato cultivation enjoys high suitability in some parts of China, where its benefits are now experienced and it is slowly heading to become a staple food article. In some more remote production areas, the potato is already a local staple, which is usual for developing countries, also more generally (Khanal et al. 2019; Scott and Suarez 2012a). In Figure 3, the normal good status for the potato is found particularly in less wealthy countries where increasing income still increases potato share; reaching the staple status often means advancing wealth and inclusive welfare, but then also lowering consumption share eventually entails as the potato has transformed into an inferior good.

The third stage is the inferior good. This common potato status in rich countries has led also to two misconceptions in the building of theories related to evolving potato importance. Firstly, the potato is the dreaded Giffen good of many economics textbooks, although no evidence is encountered of such potato behavior. Secondly, some studies make no differentiation between developed and developing countries, although both empirical modeling and historical circumstances would mandate it. The poor ate potatoes as a basis of their diet in temperate western countries as these countries transitioned into the developed world, whereas, in the contemporary developing world, the potato is food for more affluent people as supply constraints hinder its cultivation incentives.

Where the potato is a major staple, it is bound to become an inferior good also. With more income, poor consumers are diversifying their consumption habits, away from the potato. Europe, that accounted for 4/5 of worldwide potato area and production half a century ago, now accounts for 1/3 of area and 1/2 of production (Nayar 2014). In this inferior good group, the potato is currently a cheap staple, usually with declining per capita consumption and large spatially clustered production. This tendency applies to

modern developed countries that have evolved in their history from a potato economy as approximated by the Walker et al. (1999) descriptive model but also to some countries that lag in development and experience persistent farmer poverty despite high potato use, such as Peru (Antazena et al. 2005; Mayer and Glave 1999; Rose et al. 2009). Losses experienced by peasant producers narrate that Peru, the origin of the crop, is also on its way towards spatially clustered commercial production. For the developing countries, such production and consumption characteristics are rare, perhaps best approximated in the Andes and a few former Soviet states. As another example of such high share countries, Belarus tracks the aforementioned historical descriptive model (income growth reducing potato consumption) which needs that potatoes can be seasonally grown over large areas and that they can be a staple food crop. Their relative weak development even in the midst of potato plenty still favorably compares to countries that have lacked potato blessing and experienced similar political turbulence.

With enough income growth, an inferior food item is bound to lose its share in consumption until it is no longer a staple food article. The latest decade-average moves in Figures 2 and 3 have positive slopes in many of the richest countries, however, thus unexpectedly demonstrating normal good characteristics in potato use. Such renewed interest for the potato in rich areas due to new uses does follow Walker (1994) description. Ensuing lowest variance in consumption shares for potato markets in richer areas also makes distinguishing their determinants harder compared to poorer areas where also expectedness in trends how potato status associates with development presents a better structure for computation, including areas where potato is already an inferior good.

4.2. Long Run Averaging, Factor Prices, and Development Research

Above, we concentrated on studying associations of potato prices and consumption using decade averages, which appeared in poorest areas to favor empirical research. The same may be, in all likelihood, said on the other parts of the potato price system, extended to factor prices, as the mathematics below convey.

Consider familiar supply and demand identities from economic theory:

$$Q_s = S(P, F_p),$$

where Q_s is quantity supplied, which is determined by a supply function S of price P and input factor prices F_p ;

$$Q_d = D(P, Y, R_p),$$

where Q_d is quantity demanded, which is determined by a demand function D of price P , income Y , and substitute (and complement) pricing R_p .

In equilibrium, quantity supplied equals demanded quantity, i.e.,

$$Q_s = Q_d = Q.$$

Assuming that Q and P are endogenously determined, the exogenous variables, Y , R_p , and F_p , determine their equilibrium levels;

$$Q = f_0(F_p, Y, R_p),$$

$$P = g_0(F_p, Y, R_p).$$

In macroeconomic scale (production and income are nation-level), we can also present the latter function g_0 of price using instead Equation (1)

$$P = g_1(F_{use}, Y, R_p), \quad (1)$$

since F_p , i.e., factor prices of inputs (land, labor, capital, technology), are likely inversely related to their utilization F_{use} . Furthermore, as relative prices of substitutes, R_p , correlate with the importance of the potato in a society, what is presented above agrees with the data dimension reduction results for developing countries (Salmensuu 2021) where, in addition, market infrastructures affect to both demand and supply sides. Such infrastructures targeted specifically for the potato are a key ingredient to greater potato importance, greater effectiveness in the use of its factors of production, and increased supply of potatoes to urban centers, while increasing the profit share of the farmers.

Another point of view particularly highlights the effects of potato supply side constraints to factor input use. Classical period economists usually assumed prices to depend on the cost of production, i.e., the supply side. In the long run, the supply was perfectly elastic. Its intuition may be followed by setting competitive markets with zero profits in Equation (2), so that income is equal to costs—alternatively, assuming inputs receive all payments, the same Equation is an accounting relationship independent on technical or allocative efficiency of the produce (Dias Avila and Evenson 2010). Thus, using above notation, let F_{use} and F_p denote vectors which take input use and price values such that $F_{use}^T = (x_1, x_2, x_3, x_4)$ and $F_p^T = (p_1, p_2, p_3, p_4)$, where the superscript T denotes a transpose. In equilibrium, then:

$$PQ = F_p^T F_{use}. \quad (2)$$

However, typical, also more generally, to agricultural commodities, prices and quantities are usually in a cobweb cycle where farmer decisions are also sensitive to changes in relative prices to other produce, with losses and profits to farmers alternating. Thus, in practice, long run averaging is needed for Equation (2) to agree with empirical reality. Whereas, in the short-run, potato production costs and incomes diverge as potato price fluctuation hinders competitive market entry and exiting without losses, long run hypotheses for factor input cost calculations in various levels may be based on local production costs determining output prices for non-traded commodities (Pandit and Chandran 2011; Pawelzik and Möller 2014; Salmensuu 2021).

Equation (2) may be further reduced, noting F_{use} complementarity for constrained supply and an inverse relation between factor prices and utilization, while P and Q are endogenously determining each other, by specifying a function g where potato output price is explained by the use of factors inputs F_{use} or even simply their prices; $P = g(F_p)$. In practice, whether to choose either output levels or prices, and similarly factor input levels or their prices, for empirical estimation depends on availability of data and methodologies. Many sources, including FAO data, provide country-level estimates more often on quantity or consumption share and relatively scarcely on price information for several commodities including potatoes. In addition, methodologies which base on input and production output levels are the mainstream, e.g., popular Malmquist index (Rana and Anwer 2018, applied to potato productivity) non-parametrically differentiates measured productivity into technical and efficiency changes. Its cost-based version benefits also from factor prices (Maniadakis and Thanassoulis 2004). Although more rarely used, prices also can play a prominent role due to the duality between production factors and their prices, which is useful for productivity growth accounting (Hsieh 2002; Jorgenson and Griliches 1967). Prices are easier to observe than quantities that pass through the markets particularly in developing country conditions. Acquiring reliable local estimates which quantify potato trade or production levels or corresponding factor inputs, such as totals in farmland used, working man-hours, investments, or technological inputs for crop production, is likely a challenging task, compared to simply observing the prices that, in competitive markets, relay similar information, while integrating also such supplies in the economy that pass unnoticed from officials. In general, developing countries would benefit from simple measuring approaches instead of estimates based on trade and production levels that pass through the official channels and cumbersome regulations.

Concerning what was noted on the duality between prices and production, and its applications in the total economy, as well as single individual industries, the study of the potato price system appears important to help us understand the wider economy and its development. Characteristics particular to the potato scene in developing countries served as a structure so that the dimension reduction exploration results in Salmensuu (2021) could validate general economic theory presented above for Equation (1). Despite its special focus, similar reasoning should apply to multiple other markets and produce due to the generality of the above theory, including fields of study that are less approachable empirically. It is likely that the potato could show the way forward in research that concerns cross-country income differentials. How macroeconomic factor inputs explain cross-country

income differentials compares very closely to their association with cross-country potato producer price differentials. In established reviews of development accounting, capital input accounts for 20 percent and human capital input accounts for more than 10 percent of cross-country income differences, whereas unknown efficiency or total factor productivity has 50–70% share (Caselli 2005; Hsieh and Klenow 2010). Using dimension reduction to construct the factors, (Salmensuu 2021) found similar explanatory shares for these two factors (20 and 12 percent, respectively), whereas also similarly close to 50% of the variation in cross-border potato prices remained unknown. In addition, factors corresponding to labor and land inputs also provided explanation for potato prices, 7 and 12 percent, respectively. Efficiency undoubtedly plays a major role in potato scene, as well. Where factor prices or their rents are high, output costs and prices are also high, and outputs low. Inputs are either idle or inefficiently used without complementarity benefits.

As potato prices and consumption are a key to inclusive growth, and also relate structurally to general income growth in developing countries, the study of the potato price system presents potential for opening insights on such social structures of underdevelopment that are less approachable empirically directly.

5. Conclusions

This work demonstrated through running local regressions and discussing recent research on potato importance for development that we clearly more likely encounter statistically significant, unbiased, correct coefficients and conclusions on the potato price system using data from poor countries compared to the developed world where welfare and highly integrated markets complicate calculations. Particularly, we noticed a difference in stability how inferior and normal good statuses are affected by development. The potato becoming a staple food article has usually led to it passing from the normal good status into an inferior good, particularly as increasing use of potatoes in history often has been accompanied with notable economic growth and inclusive welfare, China being a recent example of the potato induced growth potential (Su and Wang 2019; Wang 2015). With such an established effect on country wealth, it is expected that the study of potato price system can also open insights on cross-country income distribution as the basic factors of production have similar explanatory shares on the two—potato producer prices, as well as income differentials.

We also unified the two views on potato's evolving importance, demonstrating the potato's tendency to evolve with development from a luxury to a normal and lastly to an inferior good. The consumption share behavior of the potato as a society develops may be an indication whether it is an inferior, a normal, or still a luxury good in a developing country, thus affecting its income elasticity of demand as consumption share approximates demand where supply constraints prevail. The potato can be classified through income change affected demand change into luxury, normal, and inferior good statuses. The luxury good stage is usually an initial, unstable situation; high unit profits entice engineering supply usually very soon. The normal good status is the most usual status for the potato in present-day developing countries; this status is also relatively stable due to common and persistent supply constraints. The other stable status for the potato is an inferior good, which is rare for present-day developing countries but it was historically predominant in the development of the temperate western world.

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