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Abstract

This paper presents the first estimate to date of the anual output of Portugal's agriculture between 1500 and 1850. It adopts the well-known indirect approach, which uses a consumption function for agricultural products. Prices and wages for this come from a recently created data base. It also verifies the assumption that agricultural consumption is equal or very close to national output. The method for calculating the income variable in the function is innovative since labour supplied per worker is not constant over time as in many estimates. Instead, it is made to vary, reflecting the 'industrious revolution' which occurred in Portugal during much of the period considered. The main finding is that the country's agriculture displays a long-run upward trend, contrary to traditional stagnationist views. It was unable, however, to keep up with the even stronger concomitant growth of population. Food consumption consequently declined, sharply in the 16c. but more slowly in the 17c. It recovered during part of the 18c. but after the 1750s it slipped again and down to 1850 it lost all these welfare gains.

JEL classification: N53, O13, Q10

Keywords: agricultural output, early modern Portugal, cycles, food consumption

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'L'agriculture n'a jamais été bien fleurissante au Portugal' (Balbi 1822: vol. 1, p. 143).

Introduction

In the current state of knowledge, a quantitative approach to the long-run performance of Portuguese agriculture taken as a whole is only possible from the mid-19th century onward. Thanks to recent research mostly based on published sources, we now have at our disposal continuous time series which span the period from 1850 to the present and cover the main dimensions of this sector. Sufficient evidence has also now been assembled to make possible the estimation, at regular intervals, of the efficiency of factors of production at the aggregate, sector and factor levels.[2] For earlier times, however, there is an almost complete void in this respect, notwithstanding the considerable volume of micro-oriented scholarship on the medieval and early modern periods, often producing copious and valuable statistical results.

[2] For the period 1846-1992, see Lains (2003). The picture of the 20th century can be completed from Soares (2005).

The present paper has two aims. One is to put together, for the years from 1500 to 1850, a similar though less ambitious collection of macro time series, while naturally using different sources and methodologies. The second is to employ this information in order to establish a broad quantitative view of how the agrarian economy evolved from the end of the Middle Ages to the onset of a modern agricultural sector in the 19th century.

Pursuing these goals has several benefits. Firstly, it enables us to establish, for the first time, a unified long-run perspective of the dynamics of the entire period, thanks to a new set of consistent quantitative indicators and to the inter-temporal comparisons which they allow. Moreover, it does so over an exceptionally long period of three and a half centuries. Secondly, it delivers a macroeconomic framework into which the findings of the many micro studies which are the foundation of early modern agrarian history can be incorporated. Since this allows a higher degree of interaction between these explorations, it also considerably raises their respective analytic potential. Thirdly, it offers a number of new quantitative instruments which enable us to sharpen traditional and oftentimes unclear images of both the aggregate performance and the role of agriculture in the overall economy. Finally, it makes greater accuracy possible in assessing derived variables such as per capita food consumption, which are at the heart of current long-term macro debates, in particular those concerning the Malthusian regime. Without such a critical link, a model of long-run population size and dynamics in the pre-industrial era cannot be properly established.[3]

Much has had to be left out of the present analysis. In particular, this is not an exhaustive compilation of all the measurable aspects of the agrarian past. It does not consider subjects like land tenure and access to land, labour relations, crop acreage, or taxation and institutions, which are considered extensively in other studies. Inevitably, the focus here is on agriculture as a whole. Some attention is paid to sub-sectors and products, but the burden of our exercise is for the most part the macroeconomic picture. In addition, it suffers from the limitation of not embracing quantitative trends prior to the early 1500s, a consequence of the still fragmentary and deficient quality of the data available for this period.

To complete this overview of the early modern period, two further aspects should be taken into account. One is to consider what it was and in what proportions that Portuguese farmers produced during these years. The other is an outline of how agriculture may have evolved during these three and a half centuries given the constraints and the stimuli to which it was subjected.

Natural conditions, in particular agrologic and climatic constraints, cultural persistence and the structure of the economy determined a pattern of productive specialization in

[3] For a discussion of this problematic in the Portuguese context, see Palma and Reis (2016).

Portugal which was typical of southern Europe at the time. Output consisted mainly of grain - mostly wheat, maize, rye, millet and barley – animal products, wine, and olive oil, and was almost entirely directed towards feeding the population. Exportables and raw materials (hides, linen, wool) for domestic industry also played a role, albeit a lesser one. It is likely, as far as we know, that early in our period of study (see Table 1), the livestock subsector predominated, followed by grain, wine and olive oil in diminishing degrees of importance, a distribution which is hardly surprising. The lingering effects of the Reconquista and of the Black Death, left Portugal, at the start of the 16th century, a thinly populated country (13 to 15 inhabitants per square kilometer in 1527-32) with abundant natural resources. Labour was therefore scarce and the standard of living of this frontier economy was relatively high (Medeiros 1993; Henriques 2015).

An analogous agrarian regime has been observed for the same period in the rest of the Iberian Peninsula by Álvarez-Nogal and Prados de la Escosura (2013). They have noted, however, that during the 16th century a sustained increase in population brought on a switch to a new agrarian regime characterized by falling land-labour ratios, a retreat of pastoralism, and an expansion of more intensive crop husbandry. Lower real wages and a reduction in per capita food consumption were the consequences and, as a result, from the 1600s to the 1810s, Spain moved towards 'a lower path' of growth (Álvarez-Nogal and Prados de la Escosura 2013, 2).

Table 1 Portugal: product shares of agricultural output by value, 16th-19th centuries (percentages)

	Grain	Wine	Oil	Livestock	
1515	38	15	3	43	100
1843	53	36	17		100
1850	46	19	5	30	100

Sources: for 1515, Godinho (1968, II, 20); for 1838, Franzini (1843); for 1850, Reis (2000, 39).

Did Portuguese agriculture follow a comparable course? It seems likely that it did. Table 1 certainly reveals a long run shift in productive specialization between 1515 and 1850 which fits with this. In a period when population was growing significantly in the face of a by now fixed stock of land, as might be expected, grain, wine and oil, all of

them labour-intensive fixed products, became much more important (a shift of 56 to 69 percent of total output), and left behind land-intensive animal husbandry, which fell from 43 to 30 percent.[4] There are thus signs that Portugal may have experienced the transition from a more extensive to a more intensive agrarian regime which occurred at roughly the same time in Spain, with possibly parallel repercussions in the long run evolution of its primary sector's output.

The present study leans on the guidelines and benchmarks provided by this 'Iberian model', which it uses to analyze some major questions pertaining to Portugal's early modern agriculture. Chief among them is whether a similar long-run regime shift had the same negative consequences as were experienced over the border. The first section following this introduction shows, in terms of method and data, how the country's gross annual agricultural output at constant prices may be estimated. The second presents the main results and reveals an overall significant increase in the size of this sector. It also introduces a somewhat revised description of the customary main phases of this expansion. The third discusses the robustness of these findings, and the fourth section draws conclusions.

Method and data

Method

There are essentially two ways of quantifying the gross output of a nation's agriculture during its pre-statistical period. In the case of countries which have a strong background in quantitative history, this can be done directly by gauging the yearly output of its components at current prices and aggregating them. The real value of this estimate is then obtained by deflating this result with the help of an appropriately weighted index of agricultural prices. These procedures are feasible because sufficient reliable evidence exists for the purpose. To date, this treatment has been possible in three economies – Britain and the Netherlands and Sweden.[5]

The alternative, indirect approach, which we will follow here, has been used in countries like Italy, Spain, Sweden and Germany, where quantitative history has not yet matured enough to sustain an effort of direct measurement on such a scale (Álvarez and Prados 2007 and 2013; Edvinsson (2014) and Krantz and Schön (2012);

[4] Between 1500 and 1800, in Portugal the total land-labour ratio fell by a factor of 2.4, while in Spain it fell by a factor of 2.1. See Malanima (2009: 16).

[5] For Sweden, Edvinsson (2011) and Krantz and Schön (2012), for the Netherlands, van Zanden and van Leeuwen (2012), and for Britain, Broadberry et al. (2015). It should be noted, however, that in the last of these cases, despite the abundance of good data and the use of sophisticated estimation techniques, considerable discrepancies exist between the results obtained. See the discussion and references in Kelly and O'Grada (2013).

Pfister 2009; Malanima 2011). An indirect indicator is therefore used, namely the total domestic consumption of agricultural products, which is presumed equal to gross agricultural product. This outcome is deflated, as above, to obtain values for this variable at constant prices.

Since the second approach is well known, it is presented here only briefly. It is inspired by Wrigley (1985) and has since been significantly revised by Allen (2000) and others. It rests on three main assumptions. One is that the balance of exports and imports of agricultural produce is negligible, a condition for accepting the principle of equality between home production and consumption. Another is that food and raw material consumption can be estimated by means of a demand function for total agricultural product (Qa) given by

$$Qa = I^a P^b M^c N (1) \quad (1)$$

in which I is a proxy for real income per capita, P is the real price index of agricultural products, M is the real price index of other consumer goods and N is total population. The coefficients a, b and c are the respective income, own price, and cross elasticities of demand. In accordance with the Slutsky-Schultz relation, their sum must be zero. All the prices and wages used to calculate these variables are indicated in grams of silver, to ensure comparability. The third assumption is that markets for outputs and for factors of production function well enough to avoid serious allocative distortions. The following comments serve to establish how well these three postulates are met in the Portuguese case.

Regarding the first one, it should be noted that early modern countries usually conducted a certain amount of foreign trade, much of it in agricultural produce, and cannot therefore be termed 'closed economies'. Their exports and imports, however, were seldom large relative to GDP. Exceptionally, in Britain and the Netherlands, the difference between the consumption and production of agricultural commodities might at times account for as much as one tenth of national output. Elsewhere, this interval has been deemed to be barely significant (Allen 2000).

Was Portugal also an exception or part of the norm? Traditionally, the view has been that the country chronically suffered from food shortages and had to import large quantities of grain in order to meet the population's nutritional requirements. According to Godinho (1955: 147), this particular deficit was 'one of the most important structural features of Portuguese economic history'.[6] This view has been recently tested using data for Portuguese foreign trade for several bench arks between 1550 and 1850 (Costa and Reis 2015). Grain imports and wine and olive oil exports, the main items, were considered for this, the conclusion being that the foreign food

[6] Author's own translation. For a recent and rare dissenting voice, which regards the 18th century only, see Serrão (2005: vol. 1, p. 172).

balance by value during this period was generally negligible and only exceeded the 3 percent mark in one benchmark, in 1850. It thus seems fair to accept that agricultural consumption is a reasonable proxy for this sector's output.

Our second supposition is that the aggregate consumption of the fruits of the land was mainly determined by two factors: the number of consumers (i.e. the population) and their purchasing power. The latter was in turn influenced by their real income, the real costs of food and non-food items, and by the respective propensities to consume them reflected in their demand elasticities. Estimating the various dimensions of this function raises several problems.

Possibly the most important of these caveats regards the calculation of nominal income, from which the real income variable is ultimately derived. Ideally, it should encompass the remuneration, during each year, of all productive factors – labour, land and capital. Unfortunately, data for them all are not always easy to come by. In the case of the first, time series for daily rates of pay are readily available for many classes of occupation. On the other hand, average days or hours of work per annum, which undoubtedly varied a good deal over time, as well as across employment categories, are not, and this introduces a significant element of uncertainty in the results. When it comes to land, time series exist too but covering all forms of land access can be problematic. In the case of income from capital, a lesser share of total income (Malanima 2011), evidence at present is practically unobtainable. Therefore, in keeping with the current practice in this literature, it is left out of our calculation.

The solution adopted for estimating nominal income is that suggested by Álvarez and Prados (2013: 9), with some modifications. It involves adding yearly total values of annual wage income and total annual land rent income in 1850, at current prices and in grams of silver. At this date, it is assumed their respective shares in national income were, respectively, 75 and 25 percent.[7] The two series are calculated from this terminal point, used as a base year, all the way back to 1500 and are combined to obtain the yearly current value estimate for total factor income.

The common practice in constructing the wage component of this exercise has been to multiply the daily wage rate (either of skilled or unskilled labour) by the working population and by a fixed number of working days in the year and assume as constant the number of hours in a working day.[8] Our approach is akin to this but more realistic in that it takes into account the simultaneous existence of different labour categories, with different rates of remuneration and labour intensities. In practice, this entails aggregating three classes of earnings: of unskilled labourers, earning the

[7] Malanima (2011: 178) uses similar proportions for Italy between the 16th and the 18th centuries. Clark (2007: 138) proposes for pre-industrial England 80 and 20 per cent.

[8] While Allen (2001) uses skilled wages, Pfister (2012) and Álvarez and Prados (2013) employ unskilled wages, and Malanima (2011), a combination of the two. The total year's work effort may comprise an average of 250 (Allen 2001, Pfister 2012), 168 (Álvarez and Prados 2013) or 165 days (Malanima 2011).

corresponding wage and working 120 days a year; of skilled urban workers, who received skilled wages and were occupied 250 days a year; and of rural non-agricultural labour (proto-industry, services), whom we presume received an intermediate wage and were active 180 days a year.[9] The shares of these categories in the overall labour force are drawn mainly from fiscal and demographic data for the different benchmarks and converted by linear interpolation into annual series.[10]

Though an improvement, this reformulation of the standard method for deriving labour income is still subject to a degree of bias. In presuming that the annual amount of days of labour per worker remained fixed for 350 years, it ignores the possible occurrence of an 'industrious revolution' such as has been claimed for many parts of the early modern Europe economy (Angeles 2008; Vries 2008). Moreover, in Portugal a long term rise in the supply of labour per worker does not seem implausible during this period, given the sustained spread of labour-intensive products like maize (Ribeiro 1986) and wine (Martins 1998), and the productive opportunities offered by imperial expansion (Costa et al. 2015). This intuition can be corroborated with some precision. It is done here by comparing the gross silver values of agricultural output estimated from, respectively, the demand and the supply sides at two distant points in time for which data exist, namely 1515 and 1850. [11]

The result is that to produce the agricultural output actually obtained in 1850 would have meant increasing the average labour effort per worker by almost 50 percent relative to 1515. Clearly a fixed labor input-based methodology would entail a substantial under-estimate of actual agricultural output in Portugal for later periods and requires a sliding adjustment in the work effort variable. In the absence of direct evidence to enable us to distribute this differential over time, we correct the bias by using an indicator of labour intensity which is reflected by the annual share of maize, the most diffused labour-intensive crop, in total grain production.[12]

Putting together an indicator of aggregate rental income is not without problems either. At this time, most of this revenue came from land, little of which was farmed directly by its lords. Possibly a little less than half of this factor of production was under a regime of commercial tenancy (Monteiro 2005). Typically, leases in this case

[9] The lengths of these three types of working years are taken from Spain's (1750) Catasto de Ensenada. See Álvarez and Prados (2013: 7).

[10] Details on the estimation of these shares and the respective sources are in section A.1.3 of the online appendix to Costa et al. (2015).

[11] The supply side benchmarks are derived from Godinho (1968) and Reis (2000). The demand side ones are estimated using the demand-for-food function described above. Details of this calculation can be found in Palma and Reis (2016).

[12] This proxy is based on data for grain production in the district of Viseu from the 16th to the 19th centuries deduced from the tithes received by the archbishopric of the city of Viseu (Oliveira 1990 and 2002). Comprehensive, quantitative knowledge about other sectors is patchier and we assume that, during these three and a half centuries, the rise of 'industriousness' was of the same order of magnitude as in this one.

ran from three to ten years and provide dependable market-based evidence on the value of the services produced by this resource. The remainder was held under long term or perpetual emphytheutic agreements, whereby the lord received a fixed fee and the tenant enjoyed an assignable right to the exclusive enjoyment of the fruits of the land (Fonseca and Reis 2011; Costa et al. 2016).[13] While the first of these arrangements was employed mostly for larger units of production, the latter corresponded to small or minuscule farms. Although the latter leases were more numerous than the former, the corresponding records are far harder to extract from the sources. We have thus assumed that the rent of the first category of contracts provides a reliable guide to the long-run market price for agricultural land as a whole. This finds justification in the fact that tenant turnover in the second, more rigid category of leases might not be infrequent, given the high mortality among tenants and their successors. Since this could lead to changes in fees at every turn, it is reasonable to suppose that emphytheutic charges were thus likely to vary over time and be therefore quite responsive to market forces, similarly to commercial ones.[14]

A second difficulty posed by the implementation of the agricultural output demand function has to do with the value of the elasticities which the model requires. In the absence of historical estimates for them, the literature has drawn inspiration from present day cases of third world economies where such parameters have been directly estimated and which have similar traits to those of early modern economies. There is a fairly wide range from which to choose and which go, for own-price elasticity, from -0.4 to -0.7, and, for income elasticity, from 0.3 to 0.6. Although we find the arguments on this matter by Álvarez and Prados (2013: 3) convincing, we have decided to employ values from Allen (2000), so that we can compare our results with his panel of estimates for agricultural output in ten European countries. We have opted consequently for the set the latter proposes, namely a=0.5, b=-0.6 and c=0.1.

In implementing this demand model, caution is also needed to make sure that the consumer price index (CPI) employed in it is suited to the context under examination. Allen's (2001 and 2009) 'respectability' basket of goods consumed by a hypothetical mid-18th century worker's household in Strasbourg is widely used by the current literature on early modern European price history. In order to adapt it to Portuguese conditions, we have altered the original list of items, as well as some of their quantities, whilst bearing in mind that the global nutritional content is not significantly altered. The Portuguese consumer basket thus defined comprises six food items – bread (made of either wheat or maize), meat, wine (instead of beer), olive oil (instead

[13] While the first of these arrangements was employed mostly for larger units of production, the latter corresponded to small or minuscule farms.

[14] For an illustration of how this could happen with similar leases in a 16th century Spanish context, see Drelichman and Gonzalez-Agudo (2014). For a similar point about the flexibility of emphyteutic leases in 17th century Portugal, see Amorim (1997) and Neto (2012: 268).

of butter), eggs, and hens (instead of cheese) – and four non-food items – charcoal, linen cloth, soap and lamp oil. [15]

The last of the three assumptions on which our estimate of agricultural product rests has to do with the extent of the rural population's engagement in markets. As regards the early modern Period, the traditional view in European (and Portuguese) historiography has been that peasants were risk averse and tended to stay away from the imperfect and risky markets of that era. This made them inclined to self-sufficiency and, consequently, impervious, in their production and consumption decisions, to the stimulus of market forces. If this were so, attempting to model their food consumption patterns on the basis of their reactions to market signals, as we are doing here, would be contradictory and would undermine the aims of this endeavour. A growing current in economic history has argued, however, that such a belief misrepresents the situation. Peasants were not as risk averse as has been claimed and were often able to work their way round hazards, even using markets as part of their strategy for this. One important reason is that they lacked sufficient land to sustain their families and meet their obligations to pay dues and taxes in cash. They were thus compelled to enter rural markets in order to transact at least some of their farm produce and even some of their labour. [16]

Although the traditional view has enjoyed a strong influence in Portugal too (Serrão 1993: 88), the available evidence increasingly suggests a significant economic role for rural markets from 1500, if not earlier. Marques, cited by Santos (1998: 149), has claimed that already in the sixteenth century a majority of the rural population regularly worked to some extent in return for cash payments, and this continued to prevail at the end of the 18th century. Both in the most and in the least densely populated provinces at this time at least 60 percent of families were dependent for their survival to a significant extent on the sale of their members' labour (Sousa and

[15] The quantities in question correspond to a yearly consumption per adult and are the same as in Allen (2001: 421 and 2009: 36), except in the following cases in which we follow his specific alterations for southern Europe. Grain comprises both wheat and maize, in varying proportions according to their respective changing yearly shares in national output. For this sliding scale, see footnote 13. Grain is transformed into bread using the formula calculated by Allen (2001: 418-419). Pulses are not included due to lack of price information. They are replaced by the equivalent amount of grain (52 liters), which provides a similar quantity of calories. Beer (182 liters) is substituted by 68.25 liters of wine and 5.2 kg of butter, by 5.2 liters of olive oil. Five hens take the place of 5.2 kg of cheese, for which Portuguese price evidence is scant. Given the warmer and longer days characteristic of the European south, annual fuel consumption is reduced from 5 to 2 million BTUs (British Thermal Units) produced from 90 kg per (for the energy equivalent of charcoal, see http://www.extension.iastate.edu/agdm/wholefarm/pdf/c6-88.pdf). We use for other non-agricultural goods the same weights as in Allen (2001), and replace lamp oil with an equal amount (5.2 liters) of olive oil, which performed the same function. The price of soap is proxyed by that of olive oil, which was the principal raw material in the manufacture of this item.

[16] For a useful discussion of these issues and evidence on the market involvement of the French peasantry before the 19th century, see Hoffman (1996: Ch. 3). Morrison and Snyder (2000: 64) claim that in 18th century France, servants and the lower ranks of those in agriculture received half of their income in cash and that further up the social ladder this share would have been much greater. For a broader European perspective on this question, see Grafe (2015).

Alves 1997; Fonseca and Reis 2011). Revealingly, both Oliveira (1982) and Santos (1998) lay the blame for this at the door of the land scarcity which plagued more than three quarters of rural households and made it unlikely that a regime of economic self-sufficiency might have dominated the Portuguese countryside during these centuries.[17] The great abundance of price and wage data which research has recently unveiled validates the notion that, throughout the period, the majority of the population was connected to some extent with rural or urban markets.

Data

The long-term series employed here to estimate Portuguese gross agricultural product have been gathered under the auspices of the PWR-Portugal project and can be consulted at its web site.[18] The sources for both wages and prices refer entirely to Lisbon and its rural hinterland, the latter defined as the territory administered by the episcopal see of the capital city. We thus assume the validity of the principle of 'national representativeness' of the data pertaining to the country's major urban centre and surroundings, a procedure generally adopted by the early modern wages and prices literature. For a recent discussion of the kind of pitfall which this principle may create in the cases of Britain and Italy, see Malanima (2013).[19] Several reasons justify this choice here.

Portugal is a small country (89,000 square kilometres) and Lisbon is centrally located within it. Although land communications in the early modern period were poor, the capital had reasonable links by sea, river and land with many of the country's regions and their markets (Macedo 1951: 105). This would permit the circulation of commodities on a not inconsiderable scale. At least by the late 17th and 18th centuries, the integration of markets for food products was hardly insignificant (Pereira 2010). In the case of labour mobility, formal and practical restrictions were non-existent and qualitative evidence regarding internal labour movements during this period is plentiful, suggesting the existence of well-integrated markets also for this factor (Silbert 1966; Reis 2005).

In common with similar projects, our data come chiefly from the accounts of religious foundations, charitable institutions, royal palaces and municipalities. In the case of commodity prices, they refer almost always to market transactions. In the case of

[17] According to Oliveira (2000: 134), in the 17th century, this share was 80-95 percent in the province of Entre Douro e Minho, where a quarter of the Portuguese population lived. See also Maia (1991), Oliveira (2002) and Mota (2006).

[18] This project is entitled PWR-Portugal: Prices, Wages and Rents in Portugal, 1300-1910 and can be visited at http://pwr-portugal.ics.ul.pt/.

[19] For a recent discussion of the kind of pitfall which this principle may create in the cases of Britain and Italy, see Malanima (2013).

wages, they correspond to employment in either agriculture or the building industry and exclude situations in which there were non-monetary complementary remunerations. In order to standardize results, all monetary values have been converted into grams of silver and prices have been normalized by the metric system. The coverage afforded by our data compilation displays some variance, with the lowest density of observations occurring in the 16th century, especially during its first half.[20] Some linear interpolation has therefore been necessary in order to fill empty cells in the time series. In Table 2, we display the percentage of years for which there are data in each century, for the most important variables in use here. As might be expected, coverage rises over time and varies considerably across series. Since workers' daily rates of pay commonly stayed constant for much longer stretches than prices, interpolation in their case is less problematic.

Table 2 Proportion (%) of years in each century covered by the data.

	Unskilled wages	Wheat bread	Maize bread	Meat	Eggs	Hens	Wine	Olive oil	Charcoal	Linen
16th c.	54	66	n.a.	40	33	56	48	49	52	32
17th c.	40	92	84	98	100	100	83	100	98	60
18th c.	65	96	94	99	100	100	100	100	80	83
1801-1850	100	100	100	100	100	100	78	100	26	100

Sources: PWR-Portugal.

Land rents have attracted comparatively little attention in Portugal from historians of this period and no doubt for this reason attempts at quantifying them are hard to come by. In the present study, our proxy for the value of the services of land is the total rent generated every year by an invariant set of thirty two large commercial estates leased out by a charitable institution in the region of Alentejo between 1595 and 1850 (Santos 2003). We retropolate this index back from 1595 to 1565, using an analogous index for a similar set of estates owned by the hospital of Todos os Santos (All Saints) and located north of Lisbon; and, from then until 1500, employing the series for Spain published by Álvarez and Prados (2013). [21]

[20] The problem of inadequate coverage and the solutions adopted for it – inter- and extrapolation – is common in the historical construction of Early Modern price, wage and rent series. The implication is that the results obtained are more suitable for analysing the long-term picture than the short-term one. See van Zanden and van Leeuwen (2012).

[21] Between 1595 and 1850, the main Portuguese series, in grams of silver, is consistent not only with the Spanish one by Álvarez and Prados (2013), but also with several other shorter Portuguese series from

Until recently, data on the year-to-year variation of the total population of Portugal has been unavailable. The only countrywide demographic information consisted of a few household counts at irregular intervals prior to the end of the 18th century. Thereafter, the first two proper population censuses were carried out in 1801 and 1864 (Rodrigues 2008). This has serious negative implications for the present evaluation since a linear interpolation between population figures based on such far flung benchmarks is bound to smooth excessively and unrealistically the annual movements of Portugal's aggregate agricultural output. A recent annual series for the country's population during the years 1500-1850 (Palma and Reis 2015) is now available, however, and enables us to overcome this difficulty.[22] It follows the methodology pioneered by Wrigley and Schofield (1989) and combines information on national population stocks, taken from reliable benchmarks, with yearly flow statistics drawn from a sample of regionally representative parish-level demographic studies.

Trend, cycles and short term fluctuations

For a long time, the tendency of Portuguese historiography has been to regard pessimistically the performance of early modern agriculture. This consensus has been constructed on an empirical foundation consistently mainly of impressionistic and occasionally quantitative elements, but has rarely aimed at achieving findings that could be expressed numerically or comparatively. Indeed, until the 1970s, attempts at measuring total production accurately were not a part of the discipline's program. [23]The few historians who contemplated this possibility recognized that the lack of adequate sources rendered this goal unattainable. Writing in the 1960s about agrarian Portugal at the demise of the Ancien Régime, Silbert warned that 'the application of the rigorous present day methods of economic, social and geographic history [to Portugal] seems to us impossible. To change this would require a miracle' (Silbert 1966: vol. 1, p. 10). [24]

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northern parts of the country collected by Salvado (2010). Moreover, it satisfies the condition that to be accurate it should reflect the principal outputs of the sector (Clark 2002). Grain, olives and sheep are represented but wine is missing from the picture. Nevertheless, its price series tracks quite closely that of grain and our proxy can thus be deemed nationally representative from this point of view.

[22] For details of this estimation, see the on-line appendix of Palma and Reis (2015).

[23] In 1951, Macedo (1951 and 1982: 101) made a list of the time series that would be needed as a foundation for 'a clear and precise' study of the agrarian history of Portugal in the 18th century: prices, wages, rents, production areas, yields, taxes, etc. Some of these (prices and wages) were published a few years later in Godinho (1955) but even so the kind of agrarian history that Macedo had in mind did not take off.

[24] Similar concerns can be found in Oliveira (1982), Magalhães (1993), Serrão (1993) and Amorim (1997). A recent economic history of Portugal by Costa et al. (2016) reveals the persistence of these concerns as evidenced by the caution with which the authors handle in their narrative the macro-economic indicators required for the Early Modern period.

Not long after, however, in the 1970s an important change occurred as a result of the introduction into this field of the study of tithes, an exciting new tool of analysis of the agrarian past. Thanks to the influence of the French Annales School, a flow of new research based on this fiscal-ecclesiastical source spread rapidly. The result was a significant increase in the quantitative component of the study of agricultural history, as well as a drive in new directions of interpretation.[25] A more precise breakdown of the ebb and flow of agricultural activity into phases of expansion, contraction and stagnation was one important contribution of this advance. The possibility of measuring the different rates of change involved in this sub-periodization and of assessing the relative importance of different crops in its long and medium-term development was another. A third was the potential for aggregating production data into a single representative variable for the sector given the fact that, with this method, agricultural output could be linked to a due which was charged not only on all the fruits of the earth without exception, but also at a universal, easy-to-calculate uniform rate of one tenth.

Despite all these advantages not all that was expected of this methodology was attained. The pitfalls proved to be many. The pronounced local character of this type of research made it hard to construct, with tithes, an empirical foundation for the desired national scope of this exercise. One reason is that combining tithe-based micro indicators to reach a higher level of generality, whether regional or national, was hampered by the lack of adequate benchmarks from which to derive the weights for aggregating them. Secondly, even if nominal output values could have been generated from the merger of disparate tithe series, deflating the result always remained a problem because such studies were often not accompanied by the production of broadly based consumer price indices (CPIs), the only ones suited for this purpose. Finally, the frequent patchiness of the sources inhibited the construction of reliable, long-term, homogeneous time-series such as one needs in order to analyse agrarian history quantitatively over such long and complex stretches of time.[26]

The present effort circumvents these problems by means of a new metric as described above. Its advantage lies in its being strictly macroeconomic and grounded in a substantially broader data base. The result, in the form of an annual estimate of gross agricultural product at constant prices, is displayed in Figure 1.[27] To assist the reader in making use of it, three main features should be noted. Firstly, it is expressed in

[25] The pioneer of this diffusion was Oliveira (1979). His work has been followed, among others, by Campos (1989), Oliveira (1990 and 2002), Maia (1991), Silva (1994), Amorim (1997), Neto (1997) and Mota (2006). For a summary of tithe-based agrarian studies in Europe, see Dodds (2007).

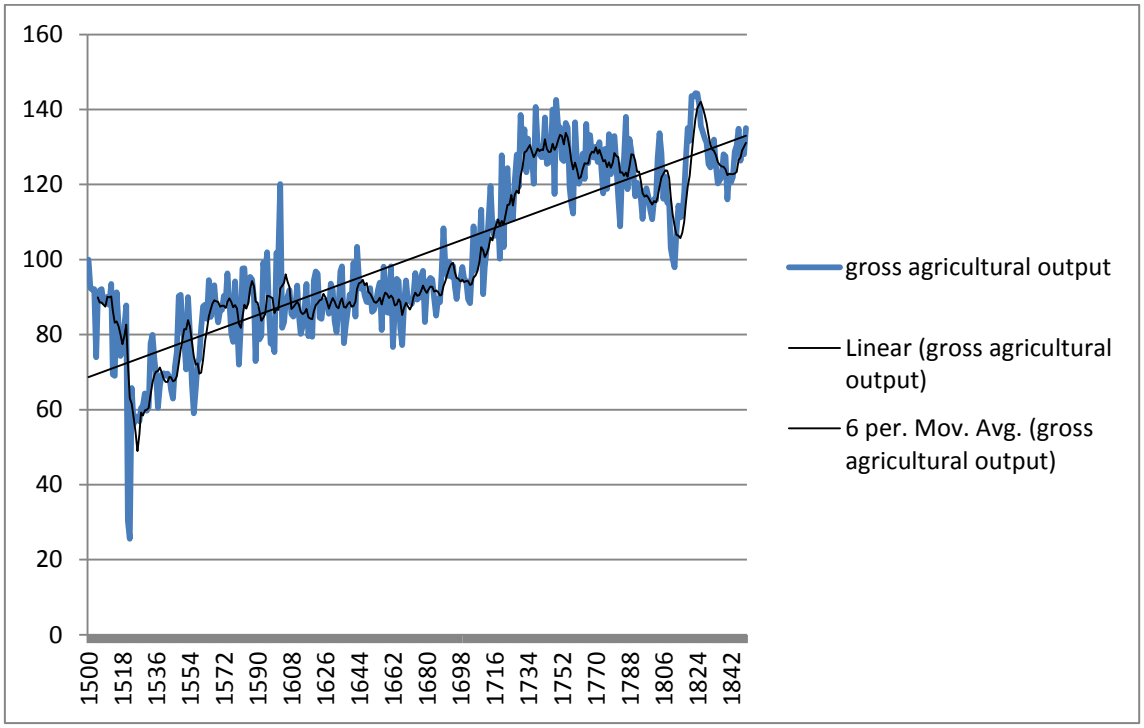
[26] This stands in contrast with Spain where Àlvarez-Nogal and Prados de la Escosura (2016) have demonstrated, for the period 1500-1800, how great is the potential for this approach in a context of an abundance of data and and of an impressively large body of researchers who have collected them.

[27] The data from which this figure is derived are represented in tabular form in the statistical appendix to this paper.

abstract numbers, a consequence of the way in which it is calculated. The implication is that, for each year, its value has no concrete significance in itself and can only serve as a relative magnitude, to be compared with that of any another year of the series. We have chosen a value of 100 for the base year of 1500, all other observations being therefore a multiple of this reference point. In the second place, one should note that it is a consistent evaluation. This means that the values presented throughout the period are the result of applying the same methodology systematically to an homogeneous data base. All observations are thus strictly comparable with each other, the same being true for the growth rate of any sub-period within the time span considered. Finally, one must remember that we are dealing here with the aggregate output of the sector, not with its per capita value, two very different concepts, which have all too often been used inter-changeably and confusingly in the literature.

The main significance of this time-series lies in its potential for solving quantitatively some of the key issues and dissipating some of the contradictions which have thrived in the analysis of Portugal's agrarian past. It allows us to deepen and clarify existing debates, but also to assist in raising hitherto unasked questions and probing new avenues of research. The development of appropriate measures of economic efficiency employing these results is an example of a possible area of innovation in the study of Portuguese agricultural history.

Figure 1 Gross agricultural product (1500=100) (1500-1850)



Sources: see text

An examination of Figure 1 brings to light its three main temporal dimensions: the long run performance over the entire early modern period; the cycles of growth, recession and stagnation into which the latter can be broken down; and the short but sharp fluctuations which are characteristic of the economies of this era. The first of these concerns the most critical question in this field: how well did the sector perform between the early fifteen hundreds and the onset of a modern industrial economy in the middle nineteenth century? The answer can now be easily given. Over the three hundred and fifty years in question, the country's agricultural effort measured in real terms roughly doubled, displaying on trend a cumulative annual growth rate of 0.20[28] percent. Although seemingly modest, it is hardly a trivial figure bearing in mind the length of the time span involved. On the other hand, as might be expected it stands in sharp contrast with the 1.01 percent achieved during the next one hundred years (Lains 2003: 254-257), a plausible contrast bearing in mind that we are comparing a pre-capitalist with a modern capitalist economy (Cabral 1976). Most important of all, however, is that it settles once and for all one of the major issues in Portugal's agrarian history, that of the persistent 'decadence' or 'stagnation' of this sector. Any claim which depicts the country's agriculture as structurally incapable of sustained long-term expansion is thus finally dispelled.

It is also evident, from Figure 6.1 that the profile of Portuguese gross agricultural output is far from a straight line. In fact, it can easily be divided into a set of coherent episodes of expansion, reversion or immobility, lasting roughly from a half to a whole century at a time. In the more structured historical narratives currently available, these phases are the backbone of the analytical effort whereby the shifting fortunes of primary production are understood as part of a process. It is therefore important to identify and re-appraise them with care. To do so, we have superimposed on the original time-series a seven-year moving average, which suggests, through a myriad of ups and downs of the output curve, the turning points at which these sub-periods may be held to have started and ended. Obviously, the phases which emerge from this procedure may seem arbitrary since their definition depends on the type of 'smoothing' we impose on the data. On the other hand, if different criteria were used, the result would hardly have differed, which thus leaves our conclusions intact.[29]

With the help of this device, we divide the three and a half centuries laid out before us into six meaningful sub-periods. Although some coincidences can be detected with the current conventional historical wisdom in such matters, some interesting differences

[28]This growth rate is measured between any pair of points representing centred averages on the linear trend line and not between the end points of the curve. If the latter were used, this would yield the much smaller rate of 0.09 per cent. An alternative, also employed in the growth literature, is to measure this rate between two sufficiently distant peaks or troughs of the curve. Given the difficulty in determining the exact turning points of our curve, we do not opt for it here.

[29] Tests were carried out with 5, 10 and 15-year moving averages and this at most altered the turning points by two years.

come to light. They may imply more than minor historiographical corrections. The 16th century illustrates this well. Generally, this has been perceived as a long and unbroken stretch of moderate growth, described by historians as an era of 'agrarian expansion' (Costa et al. 2016: 94), which for some began already in the 1450s (Santos 1998: 154-156), and from which 'crises' and setbacks tended to be absent (Gil 1965: 34). On the basis of our new estimate, however, reality appears to have been somewhat different. The long but moderate secular upswing is replaced by three distinct shorter phases, the first of which was a sharp decline of about 40 percent in gross agricultural product occurring between 1500 and the mid-1520s. This was a quite remarkable episode, which has hardly received little attention in the literature.[30] The ensuing recovery, which lasted until the late 1560s and returned agricultural output to where it had been in 1500, is the second stage. The third carries through from here for the next one hundred years as an era of oscillations around a horizontal trend line, which ended in the late 1660s. By this time, agricultural output had still not progressed in an enduring way beyond the level at which our study begins.

Turning to the 17th century, the standard narrative has long perceived this as a classic age of economic torpor after the good fortune which allegedly stamped the fifteen hundreds. As regards agriculture, several recent analyses based on micro-evidence from tithe records have concurred that gross agricultural product in 1700 probably still had not exceeded the level attained in 1600 (Oliveira 1990: 55; Neto 2012: 266 and Costa et al. 2016: 177). Yet, they are also unanimous in asserting that by the last two or three decades of this century the sector's productive rhythm may have been rising again.[31] Divergence exists mainly regarding when protracted stagnation began. Was it in 1600 or 1620?[32]

The information in Figure 1 confirms most of this assessment but with some adjustment. On the one hand, it corroborates two cherished notions: that the 'crisis' (as periods without growth have often been designated by Portuguese historians) lasted approximately for a century; and that it came to an end sometime in the 1670s or 1680s. On the other, it shows that this long absence of growth started much earlier

[30] One factor which helps account for this downswing is the frequency of bad harvests: one in every decade of this period. The most dramatic of these was the harvest failure of 1521-22 caused by a severe drought, which afflicted Spain, Portugal and Morocco. Agricultural output fell by a third of the average of the previous decade (Godinho 1963-1965: vol. 2, p. 278). For a compilation of 'calamities' during the Early Modern period, see the specific section in PWR-Portugal entitled 'Chronology of calamities'.

[31] While in an earlier work Serrão (1993) declared it impossible to pronounce on the national agricultural trend of the 17th century, he has more recently stated (2005: 47-53) that, at least from the 1670s on, it is clear that output was on the increase.

[32] In the case of studies which use similar evidence but with a regional focus, patterns diverge somewhat from these national perspectives. In the Entre-Douro-e-Minho province, Capela (1987) found that local agricultural output was taking off already from 1650. In Beira Litoral, there was a similarly precocious economic recovery, according to Amorim (1997), and the same may have happened in Algarve (Magalhães 2008).

– either in the 1570s or the 1580s – some thirty to fifty years sooner than has been thought.

In the early modern era, the 18th century is undoubtedly the sub-period that has enjoyed the least consensus concerning the performance of agriculture. It is also the epoch which has probably been the most thoroughly scrutinized and which has attracted the largest amount of research. Disagreement has arisen mainly over two issues. One of them is whether growth was sustained over the whole century, or was concentrated entirely in the first half of it, with the second witnessing stagnation or even a reversal. The former view has been espoused by Costa et al. (2016: 210) with some caution, by Marques (1973: vol. 1, p. 519), Serrão (2005: 148-9 and 2009: 48), Oliveira (2007: 256) and Lains (2009: 3 and 48). The latter has been defended by Justino (1988: 28-30), Pedreira (1994: 386) and Monteiro (1998: 317)[33], mainly on the grounds that the decades after 1750 witnessed a pronounced decline in the grain sub-sector.[34]

The second problem regards the net variation in output that may have occurred over the course of the entire century as a whole. For those who have defended the existence of a continuously rising agricultural cycle, the answer to this, obviously, has to be a secular increase. From the opposing point of view, of those who endorse a downswing after mid-century, a net expansion over these hundred years is not a foregone conclusion. The outcome depends on whether the slow-down in the last fifty years annulled the gains of the preceding half-century. Only one author, Pedreira (1994: 389), has so far attempted to quantify this outcome and described this century as a time of 'stagnation'.

Our new estimate also helps to clarify these doubts too. A glance at Figure 1 reveals a very marked contrast between the two halves of this century, with an unmistakable downturn in the early 1750s. Moreover, it shows that growth did not start abruptly circa 1700 but constituted, as noted above, part of a longer trend coming from the 1660s. This accelerated around the turn of the century and ended in the 1750s at an historic peak almost 50 percent above the figure for 1500. At an annual compound rate of 0.72 percent (measured from 1665 to 1754), this was the longest continuous sweep of agricultural growth in Portugal's early modern period and the best result, in terms of levels, ever achieved prior to 1825.

Figure 1 helps illuminate a further aspect of 18th century agricultural history. It shows that the output decline following the early 1750s was significant enough to justified

[33] This point is corroborated by Monteiro (2003) on the basis of the real income of fifty families of the high nobility between 1750 and 1820. A similar decline has been detected by Ribeiro (2012) lower down the social scale, for the provincial nobility of the region of Coimbra.

[34] Regionally-based studies are present once again in the debate, this time on the side of the retreat of agricultural output after 1750. See Silbert (1978), Magalhães (2008) and Santos (2003).

may have been sufficient to justify the pessimism of enlightened contemporary opinion, but not sufficient to cancel earlier advances. Although by the next trough, around 1811, gross agricultural product had suffered an overall decline of 40 percent relative to its mid 18th century peak, it was still 20 percent above the previous 17th century low, around 1665. As Serrão (2009) has suggested, it is as if, during the seventeen hundreds, an epochal change had occurred in the nature of Portuguese agriculture, and permanently raised its productive capability to an entirely new plane.

The last of the six stages into which Portuguese early modern agrarian history can be divided runs from the trough in 1811 until 1850. In contrast with the sub-periods which made up the preceding three hundred odd years, it is probably the least known and understood. The chief virtue of our gross agricultural product estimate is that it thus allows us to fill an empty space a void in the overall trend of agricultural performance between the demise of the Ancien Regime and the middle of the 19th century. For a period generally held to have been economically adverse owing to the regression in manufacturing and trade and to the prevailing climate of social and political turmoil, the achievement of an annual growth rate of 0.7 percent – an overall increase of 30 percent – may come as a surprise. This presents us with the puzzle of what could have caused such a re-awakening of primary production, bringing it back to the historic peak of the 1750s. Possible explanations are: the Liberal implementation of a partial land reform in the 1830s; a shift hypothetical flight of capital and enterprise from the less promising performance of the trade and industry sectors; and the establishment during the 1810s of a protectionist regime for beleaguered grain producers (Ferreira 1995). The respective impacts of these factors remain, however, to be tested.

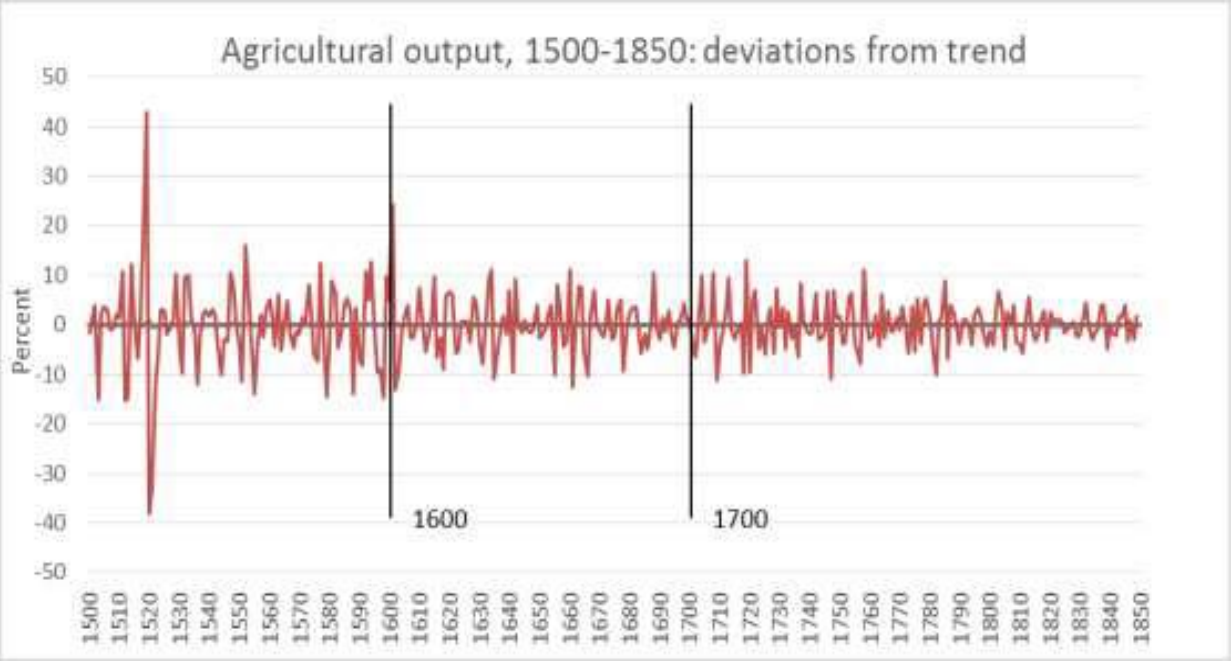
A salient feature of pre-industrial economies over the centuries has been a succession of short but quite significant oscillations in agricultural production have been a salient feature of pre-industrial economies. This alternation of 'good' and 'bad' harvest years have been a major attraction for agrarian historians and are amply documented in their writings. Portugal, in this respect, is no outlier. Indeed, the record of these fluctuations and of their proximate causes constitutes a substantial part of its early modern economic historiography. In these analyses, however, agricultural prices, and not the output variations themselves, have played the leading role in the study of the problematic of short-term output variations. [35]

The third major contribution of the newly estimated index of gross agricultural output is the possibility of deriving a better indicator from it for making cross-temporal comparisons of this sector's variability. This is done here by taking annual deviations from the long-term trend of gross agricultural product and dividing them by the

[35] For examples, see, amongst many others, Godinho (1955), Oliveira (2002) and Santos (2003).

respective trend values in those years.[36] Relative to the conventional price-based approach, the advantage of this is, first of all, that it is based on a direct indicator, rather than a proxy, as has happened up until now. The second is that, while our indicator reflects the reaction of the entire sector to shocks, in most studies this is not the case. Usually, only one price or a small handful of disaggregated prices have been employed, and in the latter case these may well follow contradictory paths and be difficult to reconcile. A third is that in price based-evaluations a given year is compared with the preceding one or with the mean of a number of preceding years, a standard of comparison which has quite a different meaning implications from those from that provided by a trend.

Figure 2 Agricultural output (yearly deviations from trend) (1500-1850)



Source: See text.

Figure 2 displays the deviations of annual agricultural output from trend measured in percentage points.[37] It allows us to observe the frequency and intensity of these episodes and brings to light the archetypal unevenness in the early modern performance of this sector. If we assume a drop in output of more than 10 percent as the threshold for 'bad' agricultural years, the total of such occurrences for the whole of the early modern period comes to a total of twenty-one such events. This suggests

[36] A Hodrick-Prescott filter for annual data is used for the purpose of calculating the trend values. obtaining the values for constructing this indicator of deviations.

[37] A similar exercise has been carried out for England before the Industrial Revolution by Kelly and O'Grada (2013). Unfortunately, owing to differences in the methodology used to estimate gross agricultural product, their results cannot be compared with those presented here for Portugal.

that serious food scarcity was taking place on average once every seventeen years, that is, more than once in a generation. It also corroborates the traditional view that this was an epoch in which exposure to hunger and its trail of misfortunes was not uncommon. On the other hand, a less obvious fact and one that is hardly remarked upon by the literature is the decline over time of the incidence of bad years, which these data reveal. In the course of the fifteen hundreds, fourteen episodes may be classified as 'lean', or worse: 1504, 1513-4, 1521-3, 1532, 1537, 1545, 1552, 1556, 1580, 1589 and 1597. It was also the century in which the only truly catastrophic shock of this kind – a fall in output of more than 30 percent – took place, in 1521 and again 1522. In contrast, during the 17th century bouts of serious hunger were endured only five times – 1603, 1636, 1656, 1662 and 1667 – and in the next century, Portugal was visited three times only by this scourge: in 1710, 1748 and 1783. During the first half of the 19th century, there was not a single agricultural year which was calamitous by this standard.

One may speculate as to whether it was the colder and wetter climate of the 1500s which determined this 'hunger cycle', and then the climatic improvement, from about the 1630s, which later had the opposite effect on harvests (Palma and Reis 2015). One may also suppose that it was the secular change in the product mix, towards greater diversification, which rendered agriculture less susceptible to adverse natural conditions and flattened the peaks and troughs of agriculture's productive profile. The rising integration of regional and local markets and the gradual reduction of institutional barriers detected by Serrão (2009) for the 17th and 18th centuries may also have lessened the oscillations of agricultural prices and reduced agricultural the amplitude and frequency of deviations. Or it could be a combination of all three. The evidence available at present does not allow us to pursue a more rigorous analysis of this question. both and possibly other factors as well. Whichever it is, the main point to be made here is, once again, that shifting from other tools of analysis to output estimates has two important advantages. It enlarges the information pool at our disposal, thus providing a richer and clearer picture of the past. And it takes us further into our exploration of the past by raising new questions and problems and creating additional demand for new data and for the methodology to produce them.

Are the results consistent?

The importance of the issues raised by the construction, for the first time, of a pre-1850 measure of gross agricultural production is sufficient to justify questions regarding the methodology and sources used for this purpose. Some of them have been pondered already in the methods and data section above, and hopefully dispelled. Others, concerning the historical consistence of the results, have not and

need now to be discussed. In this section, we try to verify the credibility of our findings by examining them in the light of the broader picture of European agriculture, as well as by checking their plausibility in terms of relevant domestic indicators.

The first step is to establish that our long-term profile of Portuguese agriculture does not point to an unusual growth rate. Allen (2000) provides a convenient standard of comparison in the form of a sample of nine West European countries for which gross agricultural output at constant prices has been calculated for the period 1500-1800. Table 3 displays the percentage increase of their respective agricultural outputs over these three centuries, as well as for Portugal. These data are calculated as the variation between the benchmark values at the extreme points of the distribution, rather than along the trend line, for reasons of comparability with the standard we have adopted here. The conclusion is that Portugal is hardly out of line with the rest since it belonged to the majority of nations which managed to achieve a relatively modest secular agricultural growth rate in this period. The former contrasts with England and the Netherlands, which reached the exceptional rates of increase of, respectively, 95 and 147 percent in the same interval. [38]

Table 3 Agricultural output increase, 1500-1800

	Increase (%)
Italy	22
Spain	31
France	33
Portugal	**33**
Austria	43
Germany	53
Belgium	60
Poland	95
Netherlands	119
England	147

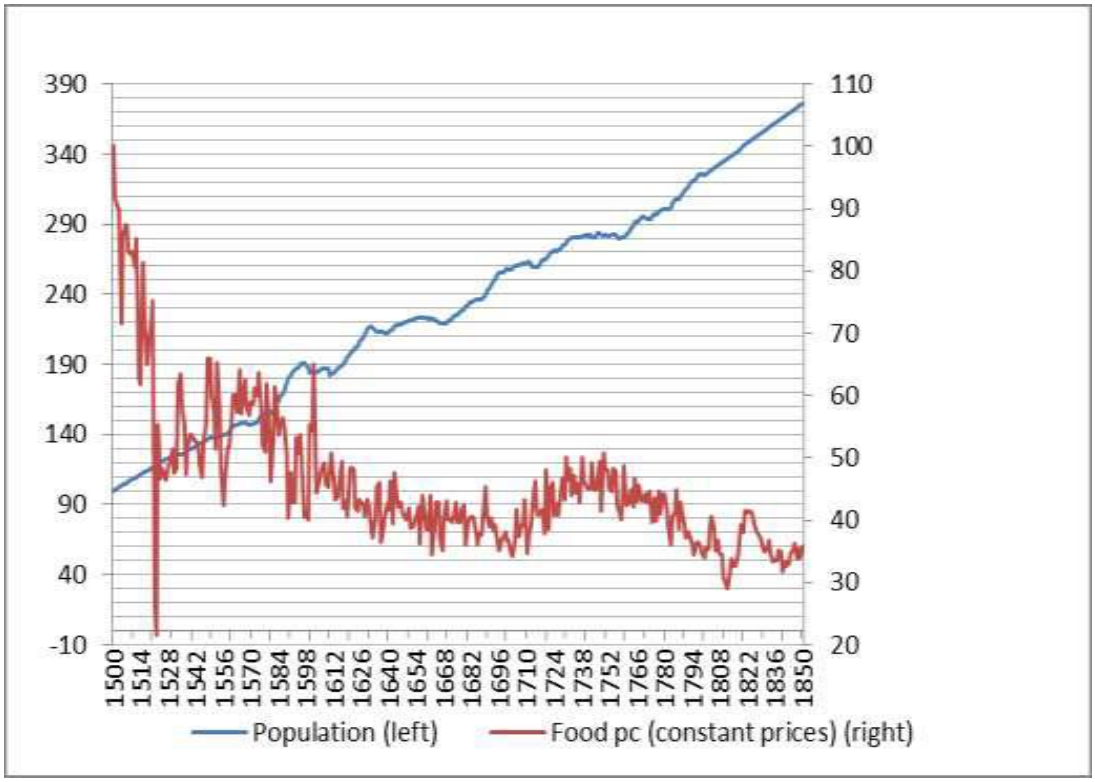
Source: Allen (2000: 17) and text.

Although we may not have erred as regards the rate of change, a second concern here is whether we may not have over- or under-valued the actual level of output instead. The current dearth of country estimates of agricultural output at current prices for this period makes it difficult to reach comparative conclusions regarding levels, as opposed

[38] We are unable here to compare agricultural output levels at different points in time because Allen's (2000) methodology for estimating this variable differs in important respects from ours. In our case, we Ours assumes a variable annual number of days each worker worked per year, in contrast with his preference for assuming a fixed labour input per capita. This biases would bias upwardly the Portuguese figures for levels.

to rates of change. An indirect way of approaching this problem is from a Malthusian point of view. In an era such as this one, of scarce food supplies, each national agricultural system had to deliver a minimum per capita nutritional requirement in order to sustain its population. Anything less than this 'subsistence' food consumption over a significant stretch of time would have implied an untenable demographic situation, as preventive or positive checks would sooner or later have kicked in. Observed population movement can thus be a way of determining whether our calculation of agricultural output is realistic, not by direct comparison with other national outputs but by analyzing whether historical demographic dynamics corresponded to estimated food availability.

Figure 3 Per capita food supply and population in Portugal (1500 = 100) (1500-1850)



Sources: for population, see Palma and Reis 2015; for food supply, see text. Notes: food supply is assumed as equal to agricultural output.

Figure 3 graphs food supply per capita (drawn from our estimate of agricultural output) in early modern Portugal and reveals a significant fall in this variable between 1500 and 1850. A long-term decline was not uncommon in Europe at that time, as

Allen (2000: 18) has pointed out: 'on most of the continent, [agricultural] output […] failed to keep pace with population growth', particularly during the 16th century.[39] Indeed, all nine countries in his sample experienced decreases in food consumption in the range of 10 to 33 percent during these three centuries. In Portugal, however, the drop was considerably greater – 60 percent – yet this happened at a time when population was rising impressively, and by 1800 had reached a level almost three times higher than in 1500. The joint performance of these two variables over such a long time span seems like a flagrant contradiction of the workings of the Malthusian model. To solve this puzzle we consider two possibilities. One is that we have underestimated the food supply and therefore the diet consumed per capita, which may have been after all a lot closer to 'subsistence'. This would explain the absence of any significant demographic reversion. Alternatively, our calculations might be correct and yet so at such a high level initially, that even at the lowest subsequent levels of decline it never moved below 'subsistence'.

We consider two food baskets at current prices and valued at current prices in grams of silver, which are accepted as standards of 'subsistence' for the Eary Modern period. One is the 'barebones' diet proposed by Allen et al. (2012: 873) and inspired by the survival efforts of poorly paid labour during this period.[40] The other is Federico and Malanima's (2004: 445) 'minimal subsistence basket for Italy'.[41] Both correspond to the needs of an adult and are converted here using Portuguese prices so as to be comparable with Portuguese per capita food consumption estimates. We cannot use here our earlier quantification of national agricultural consumption (see Figure 6.3) since it is in constant, not at nominal silver prices. We obviate this problem by employing a short cut estimation method proposed by Malanima (2011: 179). This yields an acceptable current price estimate for this variable. It involves multiplying total labour income[42] by a factor of 1.4 to obtain the total income of all production factors.[43] Since it is presumed that only a third of the population is economically active (Álvarez and Prados 2007: 326), we multiply this figure by a factor of 0.33 and again by one of 0.6. The latter takes into account Malanima's additional assumption that food consumption is equal to 60 percent of the value of total income.

Figure 4 allows us to compare the cost, at Portuguese current prices, of two distinct patterns of 'subsistence' food consumption with the value, also at current prices, of the food that, at different points in time, was actually available to the Portuguese

[39] More up-to-date figures for Italy and Spain corroborate this finding. See, respectively, Federico and Malanima (2004) and Álvarez and Prados (2013).

[40] It comprises 165 kilos of maize (wheat), 20 kilos of beans/peas (wheat), 5 kilos of meat and 3 kilos of butter (olive oil) for a year. Items in brackets are the replacements in Portugal for those in the original Northern European list.

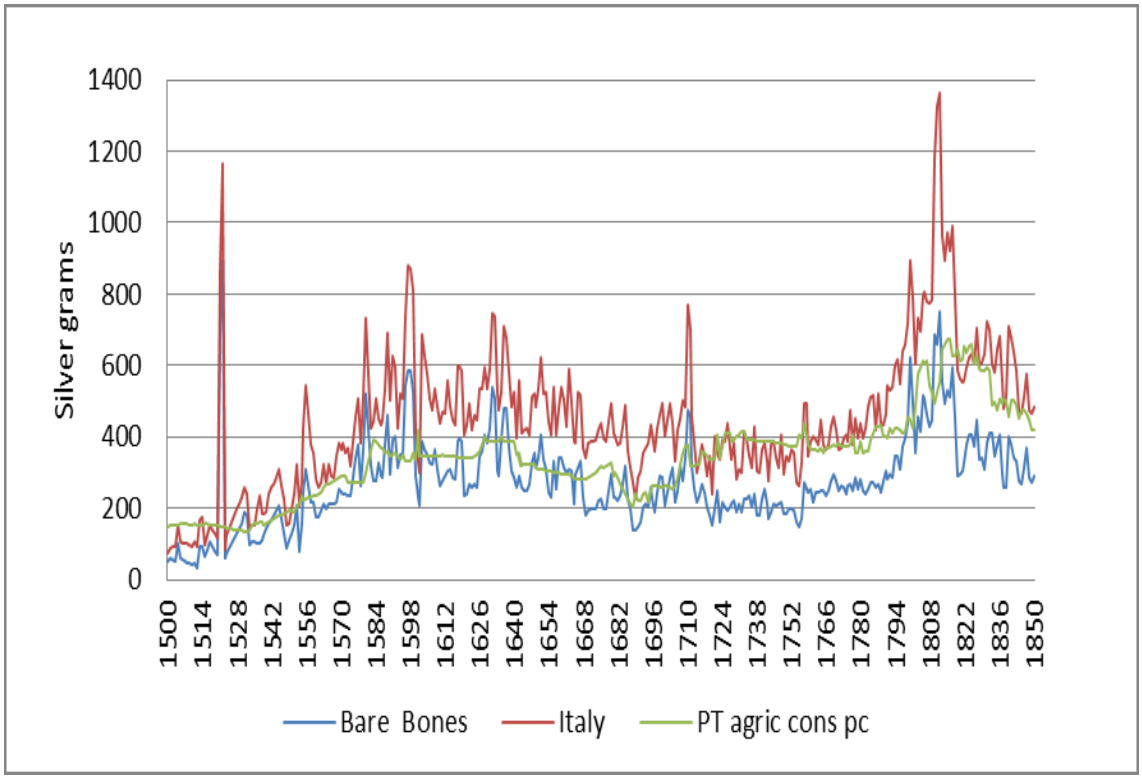
[41] It includes 50 kilos of wheat, 170 kilos of other cereals (we use maize), 10 kilos of meat, 3 kilos of olive oil and 80 litres of wine. Firewood is in the original but for the sake of uniformity is ignored here.

[42] The total income from labour in grams of silver is obtained as described above in p.7.

[43] Malanima (2011: 178) considers that labour income equals 70 per cent of total income.

population. We conclude that Portugal's agriculture consistently provided a level of consumption which was close to accepted subsistence requirements and thus made it possible for the population to withstand Malthusian pressures and keep on expanding. We may thus conclude that our findings are not an underestimate of gross agricultural output.

Figure 4 Subsistence baskets (Italy and 'barebones') and Portuguese per capita food consumption, market prices



Sources: Italian basket - Federico and Malanima 2004: 445); 'barebones' basket - Allen et al. 2012: 873; Portuguese basket - see text.

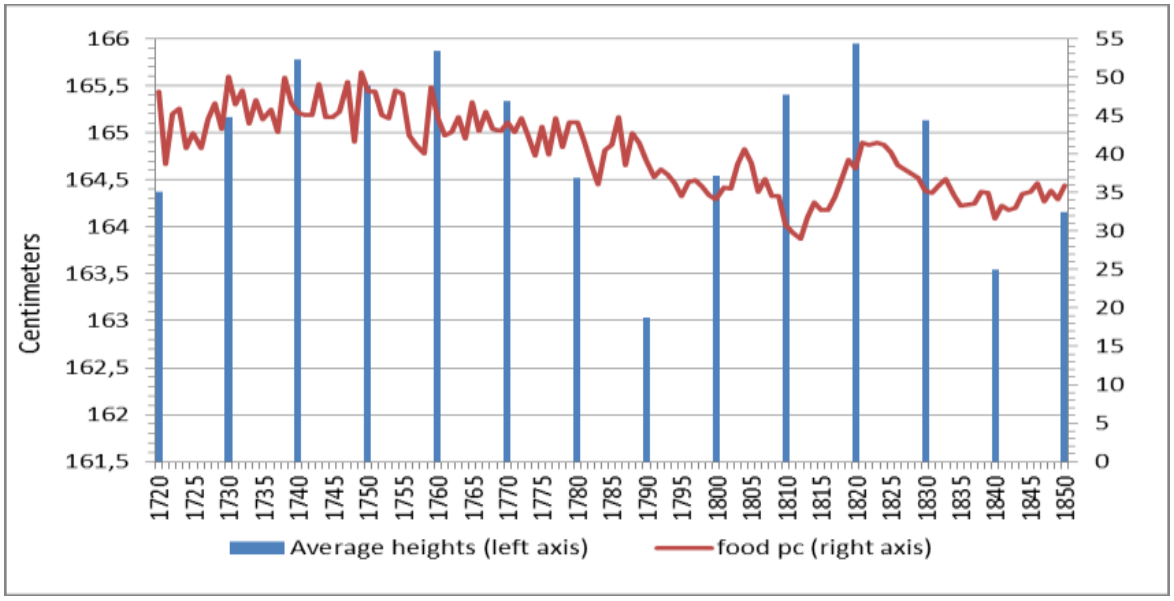
Percapita food intake offers us a second opportunity for corroborating our initial output findings, this time using evidence from the field of anthropometric history.[44] A recent study regarding the evolution of the height of Portuguese males between 1720 and 1980 has shown that the standard of living and the level of human capital of this population were, in the long run, the principal determinants of stature (Stolz et al. 2013). The first of these was measured by these authors using the real wage level, but in the present instance we employ average real food consumption instead. This choice

[44] The link between food consumption and heights has been explored in the same way for Italy by Federico and Malanima (2004).

is, in fact, an even better solution since we use a variable which has a more direct impact on corporal growth than wages, only part of which are spent on the nutrients which promote physical development. On the other hand, it has the disadvantage for us of only covering the years between 1720 and 1850.

Even so, setting these two variables side by side, as in Figure 5, provides encouraging support for our estimates of the agricultural trend during the last century and a half of the period under observation. In the forty years from 1720 to 1760, steadily rising food supplies per person were matched in Portugal by the upward evolution in the height of the military recruits born in those decades. During the 1760s to 1790s, this co-movement was reversed, after which the two variables entered together another upward swing until the 1820s. The last period for which we have data, from 1820 to 1850, witnessed another decline in both food consumption and stature.

Figure 5 Average heights and food supply per capita (1720-1850).



Note: stature measurement taken 20 years after per capita food consumption observed. Sources: for average heights (Stolz et al. 2013); for food supply (see Figure 3.).

The preceding approaches to the consistency problem have considered only the long-term behaviour of our estimated variable. Looking at its short-term fluctuations can may also help us assess the reliability of this indicator. The method, in this case, is to compare qualitative records of agricultural disturbance – pestilence, bad weather, earthquakes, war and civil commotions – with episodes of severe harvest failure such as were identified in Figure 6.2 above. The source for these accounts is an annual 'compilation of calamities' located presented in the PWR-Portugal site. It is based on a

variety of contemporary descriptions and chronicles, as well as historical studies, covering the period from 1309 to 1909.[45] The expectation is that 'bad agricultural years' should coincide or at least be follow closely to years in which 'calamities' occurred. The former are identified here as those in which gross agricultural product fell by more than 10 percent relative to trend. As we saw earlier, the total number of these incidents amounts to 22, which were unevenly spread out over three and a half centuries.

The conclusion is that pronounced momentary downturns in our output estimate were indeed associated with years in which Portugal was visited by misfortune, as observed by contemporaries. They were can usually be linked to 'food shortages', 'famines' or 'disastrous crops'. On the other hand, we must not ignore the fact that not all the years in which such disasters were reported were attended by severely insufficient harvests. There are several reasons why this match might not always have occurred. One of them concerns years when, owing to lack of data, we had to interpolate interpolations had to be made in order to fill gross agricultural products the gaps in our series. This could lead to a 'smoothing' effect in the time-series and could make what was in effect a bad year 'disappear' from the statistical curve. Another is that adverse circumstances in a particular year might harm a certain crop but not necessarily all of them simultaneously. Since our main indicator is constructed from several weighted averages, this could lead to an 'ironing out' of signs of a sudden drop in production. It is interesting to note that almost two thirds of these 'bad years' were related to sharp rises in both wheat and wine prices. If one of these crops alone had been stricken e.g. by weather or quakes, it would have taken a much more severe shock in the other one for this event to show up in the aggregate output statistics. Finally, we have to consider that statistical smoothing of the output curve may have also taken place as a result of efforts by the crown or municipal authorities to combat shortages, in particular when this involved measures to restore decimated food supplies, either by importing grain or by stimulation of its overland trade.[46]

Conclusion

This paper provides for the first time a much-needed consistent metric for Portugal's real gross agricultural output during the early modern period. It uses a standard indirect method based on a consumption function for agricultural products and a rich recently mined data base for its construction.

[45] See PWR-Portugal, under 'Chronology_of Calamities (earthquakes, famines, food crises, hunger, pandemics, pestilences, plagues, starvations, wars, …)'.

[46] There is a good deal of anecdotal evidence in this respect but it has yet to be used systematically in order to allow an encompassing analysis of this problem.

Our year-by-year estimation allows us to clarify a number of important issues. Overall, Portugal's pre-industrial agriculture did not stagnate during the period considered, contrary to what has often been thought. Indeed, it attained a reasonable rate of expansion, similar to that of many other European countries. In fact, it succeeded in sustaining a fast-growing population using a fixed supply of land thanks to a process which involved significant shifts in the structure of production, in the intensity of land use and in increased labour effort. This agrarian regime transition occurred in the course of a succession of stages in which growth alternated with stagnation or even reversion, and which we are now able to define with greater precision than before. This did not prevent, however, a permanent fall in the level of food consumption compared to that enjoyed by its population at the onset of our period of study. This agrarian regime transition occurred in the course of a succession of stages in which growth alternated with stagnation or even reversion, and which we are now able to define with greater precision than before.

The principal aim of the present study is has been to draw a profile of the most important sector of the economy of Portugal during the early modern period using quantitative tools. The objective here is simply to facilitate future research in the field of Portuguese agrarian history by laying the groundwork for this. It does not attempt to reach a deeper and more focused kind of analysis than this. The objective here is simply to lay the groundwork for and facilitate future research in the field of Portuguese agrarian history.

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Statistical Appendix

Table A.1 Annual data for gross agricultural output and food per capita, 1500-1850 (constant prices) (1500=100)

(1)	(2)		(1)	(2)		(1)	(2)		(1)	(2)	
1500	100	100	1600	102	55	1700	95	37	1800	111	34
1501	92	92	1601	101	54	1701	94	37	1801	116	36
1502	92	90	1602	120	65	1702	89	35	1802	116	35
1503	92	90	1603	82	44	1703	88	34	1803	127	39
1504	74	72	1604	83	45	1704	96	37	1804	134	41
1505	89	86	1605	88	47	1705	109	42	1805	128	39
1506	92	87	1606	90	48	1706	97	37	1806	116	35
1507	92	87	1607	92	49	1707	102	39	1807	122	37
1508	89	83	1608	85	46	1708	103	39	1808	115	35
1509	89	83	1609	85	45	1709	113	43	1809	115	35
1510	90	83	1610	87	48	1710	91	35	1810	103	31
1511	88	81	1611	93	51	1711	98	37	1811	100	30
1512	94	85	1612	85	47	1712	103	39	1812	98	29
1513	69	63	1613	80	43	1713	111	43	1813	108	32
1514	69	62	1614	82	44	1714	120	46	1814	114	34
1515	91	81	1615	87	46	1715	109	42	1815	111	33

1516	82	73	1616	93	49	1716	106	41	1816	112	33
1517	74	65	1617	80	42	1717	108	41	1817	118	34
1518	78	68	1618	83	43	1718	110	42	1818	126	37
1519	82	71	1619	79	41	1719	100	38	1819	135	39
1520	88	75	1620	94	48	1720	128	48	1820	132	38
1521	30	26	1621	97	49	1721	103	39	1821	144	41
1522	26	22	1622	96	48	1722	122	45	1822	143	41
1523	66	55	1623	85	42	1723	124	46	1823	144	41
1524	56	47	1624	84	41	1724	111	41	1824	144	41
1525	58	48	1625	89	43	1725	116	43	1825	141	40
1526	58	47	1626	89	43	1726	111	41	1826	136	39
1527	57	47	1627	89	43	1727	121	44	1827	134	38
1528	60	49	1628	86	41	1728	128	47	1828	132	37
1529	61	49	1629	94	43	1729	119	43	1829	131	37
1530	64	52	1630	92	42	1730	139	50	1830	125	35
1531	60	48	1631	84	38	1731	130	46	1831	125	35
1532	61	48	1632	81	37	1732	135	48	1832	129	36
1533	78	62	1633	87	41	1733	123	44	1833	132	37
1534	80	64	1634	97	45	1734	132	47	1834	125	35
1535	73	58	1635	98	46	1735	125	44	1835	120	33
1536	69	55	1636	78	37	1736	128	46	1836	121	33
1537	60	47	1637	83	39	1737	120	43	1837	122	34
1538	66	52	1638	86	41	1738	141	50	1838	128	35
1539	69	54	1639	91	43	1739	131	47	1839	128	35
1540	70	54	1640	89	42	1740	128	45	1840	116	32
1541	69	53	1641	99	46	1741	127	45	1841	122	33

1542	70	53	1642	85	39	1742	127	45	1842	121	33
1543	69	52	1643	103	48	1743	138	49	1843	122	33
1544	65	49	1644	95	43	1744	125	45	1844	129	35
1545	63	47	1645	92	42	1745	126	45	1845	130	35
1546	71	53	1646	93	43	1746	129	45	1846	135	36
1547	75	55	1647	90	41	1747	140	49	1847	126	34
1548	90	66	1648	89	40	1748	117	42	1848	132	35
1549	91	66	1649	89	40	1749	143	51	1849	128	34
1550	83	60	1650	92	42	1750	136	48	1850	135	36
1551	79	57	1651	86	39	1751	135	48			
1552	71	51	1652	87	39	1752	127	45			
1553	90	65	1653	89	40	1753	126	45			
1554	80	58	1654	92	41	1754	136	48			
1555	67	48	1655	94	42	1755	135	48			
1556	59	42	1656	81	36	1756	119	42			
1557	65	47	1657	98	44	1757	115	41			
1558	73	52	1658	94	42	1758	112	40			
1559	73	52	1659	86	38	1759	137	49			
1560	82	56	1660	86	39	1760	126	45			
1561	88	60	1661	98	44	1761	120	42			
1562	88	60	1662	77	34	1762	122	43			
1563	84	57	1663	87	39	1763	128	45			
1564	95	64	1664	95	43	1764	121	42			
1565	85	57	1665	94	43	1765	136	47			
1566	90	61	1666	82	37	1766	126	43			
1567	93	62	1667	77	35	1767	133	46			

1568	87	59	1668	88	40	1768	127	43
1569	83	57	1669	94	43	1769	127	43
1570	86	59	1670	89	40	1770	130	44
1571	87	59	1671	89	40	1771	126	43
1572	90	61	1672	88	40	1772	131	45
1573	89	60	1673	90	40	1773	125	42
1574	96	64	1674	96	43	1774	118	40
1575	89	58	1675	89	40	1775	129	44
1576	80	52	1676	90	40	1776	119	40
1577	78	51	1677	95	42	1777	133	45
1578	94	62	1678	97	42	1778	123	41
1579	84	54	1679	83	36	1779	133	44
1580	72	46	1680	92	40	1780	133	44
1581	83	53	1681	94	40	1781	125	42
1582	98	61	1682	95	41	1782	116	39
1583	98	60	1683	95	40	1783	109	36
1584	88	54	1684	90	38	1784	124	41
1585	92	55	1685	85	36	1785	127	41
1586	95	56	1686	90	38	1786	138	45
1587	95	55	1687	89	38	1787	119	39
1588	90	51	1688	96	40	1788	132	43
1589	73	40	1689	108	45	1789	129	41
1590	87	48	1690	98	41	1790	123	39
1591	79	43	1691	96	39	1791	117	37
1592	80	43	1692	99	40	1792	120	38
1593	99	53	1693	95	38	1793	119	37

1594	96	51	1694	98	39	1794	116	36
1595	102	54	1695	93	36	1795	111	34
1596	86	45	1696	90	35	1796	117	36
1597	78	41	1697	94	37	1797	119	37
1598	78	41	1698	95	37	1798	117	36
1599	75	40	1699	98	38	1799	113	35

Sources: see texto

Notes: (1) gross agricultural output; (2) food per capita.

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