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Abstract

We construct the first time-series for Portugal's per capita GDP for 1527-1850, drawing on a new database. Starting in the early 1630s there was a highly persistent upward trend which accelerated after 1710 and peaked 40 years later. At that point, per capita income was high by European standards, though behind the most advanced Western European economies. But as the second half of the eighteenth century unfolded, a phase of economic decline was initiated. This continued into the nineteenth century, and by 1850 per capita incomes were not different from what they had been in the early 1530s.

JEL Classification: N13, O52

Keywords: Early Modern Portugal, Historical National Accounts, Standards of Living Debate, the Little Divergence, Malthusian Model.

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INTRODUCTION

Thomas and McCloskey (1981, p.102) describe Portugal, and Spain, as the "giants" of the sixteenth century, especially in comparison with Britain, the "inconsiderable little island of the sixteenth century, a mere dwarf". In turn, Bairoch (1976, p. 286) considered Portugal one of Europe's five richest countries as late as 1800, and Bairoch et al (1980) placed Lisbon as one of Europe's four most populous cities (after Naples, Paris and London). Despite this promising start, Portugal became one of Europe's poorest countries during the second half of the nineteenth century, and its convergence only started with the emergence of modern economic growth in the 1950s (Lopes 2004).

In this paper, we rely on new archival data to construct the first time-series for Portugal's per capita GDP for 1527-1850. We show that Portugal's early modern performance from 1527 was characterized by several distinctive phases. The first was a period of five decades of intensive growth which lasted from the late 1520s to the late 1570s. This was followed by decline which lasted until the 1630s. From then until the mid-eighteenth century the economy grew steadily, both in terms of incomes per capita and population, except for a 20-year interval between1690-1710. As a result, Portugal's 1750s per capita GDP was rather high by European comparison, though still firmly below that of England or the Netherlands.

Once past the 1750s, however, the sources of this expansion began to peter out. Economic performance slowed down but population grew strongly, and within half a century all of the GDP per capita and real wage gains were wiped out.[1] Thereafter income per person continued to decline, with the consequence that by the middle of the nineteenth century Portugal became one of the most backward economies of Europe, precisely as the era of modern econom-

[1] In the five decades following 1750, population grew at an annual rate of increase of 0.34 percent (Palma et al 2017) – and thus contributed significantly to the erosion of real per capita incomes.

ic growth was beginning in several other Western European countries.[2] Over the long-run, there was no per capita growth: by 1850 per capita incomes were not different from what they had been in the early 1530s.

In the spirit of Broadberry et al (2015) or van Zanden and van Leeuwen (2012), who focus on proximate rather than fundamental causes of growth, our goal in this paper is to provide a factual description of Portugal's macroeconomic history. So while we provide a detailed national accounting exercise regarding Portugal's early modern economy, we leave for future work the explanations for the fundamental causes which explain the long-term dynamics of Portugal's economy – and in particular, the reasons underlying the remarkable reversion which occurred since the mid-eighteenth century.

OUR NEW DATA

In this section we discuss the data employed in this article to construct the macroeconomic variables required by our analysis. Our aim is to obtain long-term annual series for population and occupational shares, wages, agricultural and manufacturing price indices, and land rents. These are then combined to generate a number of analytic tools such as real wages, GDP and GDP per capita. The basic procedures followed are standard in the early modern macroeconomic literature.[3]

The data we have collected originates in the four macro-regions of the country.[4] These correspond to: the North represented by Porto and its hinterland; the Centre represented by

[2] Around 1850 Portugal's real per capita GDP was below that of other countries of the European periphery such as Denmark, Norway, Sweden, Finland and Spain (Reis 2000).
[3] Fouquet and Broadberry (2015) provide an overview of these methods.
[4] In this section, we focus on the methodology employed for gathering prices, wages and rents, following as far as possible that employed in similar studies. This has been carried out in the framework of a recent major research project, "PWR- Prices, wages and rents in Portugal, 1300-1910", which supports the present work. All the basic

Coimbra and its hinterland; Lisbon and its hinterland; and the South represented by Évora and its hinterland. In Figure 1 we show a map of the country, including its six administrative provinces, its main cities and all the lesser locations mentioned in this paper.

Several concerns have guided our options regarding how these raw data should be collected and processed. One is that they should reflect market values. To this end, we try to avoid distorting influences on our figures such as administered prices or subsidies, which were common in this period. A second one is that we should avoid using too many sources. In this way we help reduce the likelihood of confusing variation in the accounting procedures. A third is to give preference to sources which would yield long and continuous series. This reduces as far as possible the use of interpolation and proxying for missing observations.[5] We achieve this by selecting organizations whose archives belong to sectors which fit the following description: local government, royal administration, hospitals, prisons, the royal university of Coimbra, charities, orphanages, and the Church, particularly monasteries and convents. Within these, we have been able to identify institutions which lasted uninterruptedly for centuries, kept well-organized accounts continuously, and imposed internal auditing procedures. They were also highly engaged in the market economy and therefore generated a considerable amount of high-frequency information.

Like the rest of early modern Europe, Portugal's system of measurement of commodities, be they liquid, solid or linear, showed considerable variation within the country. To convert these raw statistics into quantities which could be used for national estimates, we normal-

data has been released to the public at http://pwr-portugal.ics.ul.pt/?page_id=56 and also listed at the Global Price and Income History Group of UC-Davis, available at http://gpih.ucdavis.edu/Datafilelist.htm. In the online appendix to this paper, we give the full list of al primary sources consulted.

[5] We show the percentage of the variation of the principal data that is covered by our sources in Table A1 of the online Appendix. In some cases, we proxied the price of a good (e.g. beef) for a missing year by that of a close substitute (e.g. pork) by using price proportionality from a nearby year for which we had both prices.

ized them according to the metric system.[6] For example, the *almude*, a measure of liquids, contained in Lisbon 16.8 liters, in Porto 25.4 liters, in Coimbra 16.7 liters and in Évora 17.4 liters. Non-metric measures for the same commodity also proliferated: Charcoal in Lisbon, for instance, was sold in five different units.

As far as prices are concerned, we have selected those corresponding to the principal articles of consumption and production. Consumables include wheat and maize bread, meat, olive oil, wine, eggs and hens, all of which, in the literature of the early modern period, form part of the widely accepted standard consumption basket. From the production side, we take the prices of charcoal, linen cloth, soap and candles. We represent the cost of labor by means of a weighted wage consisting of both skilled and unskilled male adult workers. For the former, we use the wages of masons, taking care to exclude those of master masons. For the latter, we use the wages of helpers (*servidores*, *serventes*, *serviçais*, *trabalhadores*) which capture the value of raw labor under well identified categories which avoid distortions caused by variation in the unidentified presence of human capital in the labor stock. These wages always refer to employment in either agriculture or the building industry and to situations in which non-monetary complementary remunerations were absent.

[6] Portugal had a single monetary unit, the *real*, whose official value in silver can be found in the PWR-Portugal dataset under the heading "Monetary and Metric Conversions".

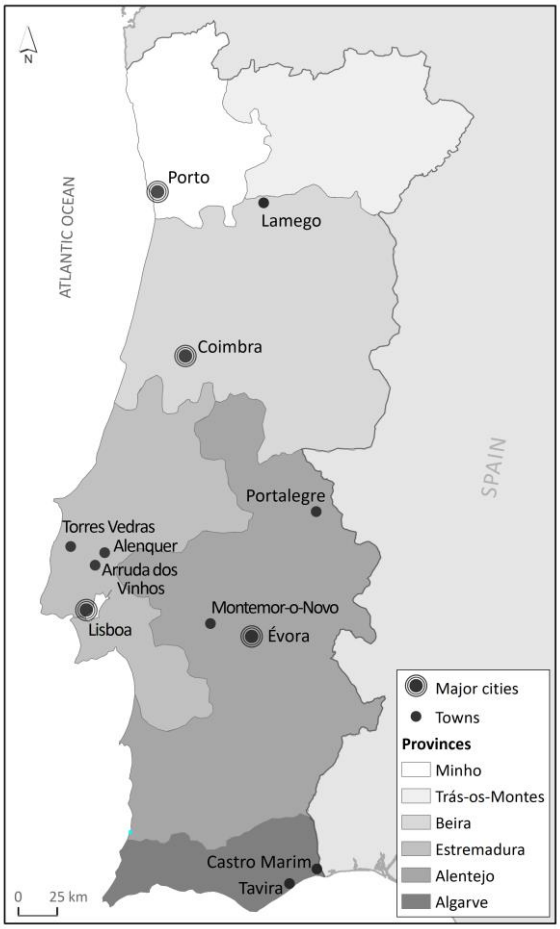

Figure 1.

MAP OF PORTUGAL

Notes: The borders correspond to the 18th century provinces, and the map indicates locations referred to in this paper.

Source: Adapted from Marques and Dias (2003)

Land rents have attracted little attention from the economic historians of this period in Portugal. In fact, rents are important for the present narrative as indicators of the value of the services produced by land and as an indicator of its relative scarcity. At this time, most land in use was not directly cultivated by its lords. Possibly a little less than half of all agricultural land was rented out on terms of commercial tenancy, with leases typically running from three to ten years (Monteiro 2005). The remainder was held under long term or perpetual em-

phyteutic contracts, whereby the lord received a fixed fee and the tenant enjoyed a de facto assignable right to the exclusive enjoyment of all the fruits of the land (Costa et al 2016; Fonseca and Reis 2011).[7] We assume that the rent of the first category of contracts provides a reliable indication of the market value of all agricultural land per hectare. Data for land rents are currently not abundant. We value them by means of an indicator based on the aggregate rent of a time-invariant set of thirty-two estates owned and regularly leased by a charitable institution in Alentejo (Santos 2003). Since this only covers the years from 1595 to 1850, we fill in the rest of the sixteenth century from other comparable sources.[8]

Palma et al. (2017) have constructed the first annual series for Portugal's population for 1527-1850, using a combination of stocks from population counts and censuses, and flows from the parish registers of several dozen parishes. Their estimation is inspired by the seminal work on England by Wrigley and Schofield (2010/1989) and Wrigley et al (1997), but offers a number of advantages. Coverage is more complete due to the uniformity and monitoring imposed by the Catholic Church, and to the availability of several national pre-modern censuses.

In order to reconstruct the occupational distribution and structural change, the first step is to estimate urban population and the main economic activities in which the population was engaged.[9] A continuous occupational structure time series is not currently available. We rely on a set of evenly spaced benchmarks linked by means of linear interpolation. We start in 1500 and continue at 50-year intervals all the way down to 1850. Our categorization does no

[7] While the first of these arrangements was employed mostly for larger units of production, the latter corresponded to small or minuscule farms.
[8] For details, see Reis (2016).
[9] This section updates the discussion in the online Appendix to Costa et al. (2015).

more than distinguish between the two most basic economic sectors – agriculture and non-agriculture – since we lack consistent information to allow for a more detailed analysis. [10]

We are unable to consider the active population separately from the rest of the population. Our quantification refers therefore to the aggregate population of families dependent on a particular economic activity, without regard to whether their individual members were employed full-time, part-time or not working at all. We should note that the historical sources we employ, in particular tax records, are also organized on a family basis, never on an individual one, and mention only the occupation of the heads of households.

Table 1 displays the best available figures for Portugal's urban population, defined as the total number of inhabitants of agglomerations of more than 5,000 residents. We employ one source only, Bairoch (1988) – but we make an adjustment to it.[11] Bairoch included in his estimate all urban centers designated as such by his sources, irrespective of size, and simply added them up to obtain "urban population". We exclude from the category of "urban" all towns having less than 5,000 inhabitants. At the same time, we have recovered the residents of all the towns that Bairoch dropped from his count every time they were not mentioned in his sources for a particular benchmark, though they are known to have continued to exist over this period. When this happens, we assume that it was due to an error or omission, and not to a contraction of the population in question to a figure below our stipulated minimum. We have therefore interpolated the "missing" inhabitants at the level observed in the count of the previous benchmark, as long as this was not less than 5,000 inhabitants.

[10] Evidently, the rural and urban non-agricultural components both encompass manufacturing, transport, trade and administrative activities wherever carried out, but because of lack of information, we are unable to consider these distinctions.

[11] For different reasons, Álvarez-Nogal and Prados de la Escosura (2007) employ data for Spain which also departs from Bairoch's. Our correction is smaller than theirs, however.

	(1)	(2)	(3)	(4)	(5)
	total	urban	rural non-agricultural	agricultural	total non-agricultural
1500	1	0.155	0.169	0.676	0.324
1550	1.275	0.193	0.205*	0.877	0.398
1600	1.837	0.242	0.318*	1.277	0.560
1650	2.148	0.267	0.512*	1.369	0.779
1700	2.349	0.293	0.672**	1.384	0.965
1750	2.475	0.429	0.721***	1.325	1.150
1800	2.936	0.476	0.848****	1.612	1.324
1850	3.455	0.607	0.537****	2.311	1.144

Table 1

PORTUGAL'S POPULATION: TOTAL AND BY SECTOR (MILLIONS).

Sources: for col. 1, 1500 from Rodrigues (2008, p.176), and other dates from Palma et al. (2017); col. 2 from Bairoch (1988) revised; * is a linear interpolation based on Álvarez-Nogal and Prados dela Escosura (2007); ** is from Montemor-o-Novo, Portalegre, Castro Marim and Tavira-Cacela's archival data; *** inferred from Sá (2005); **** are from Reis (2005).

Columns 3, 4 and 5 of Table 1 show rural non-agricultural, agricultural and total non-agricultural population. To arrive at these figures, we begin with the observation that only a small part of the agricultural labor force in Europe lived in urban units with a population of more than 5,000 and thus represented a very small proportion of the total urban population (Allen 2000, Van Zanden 2005). Allen and van Zanden have assumed therefore, as a reasonable simplification, that in practice this agricultural segment can be represented as equal to zero.[12] We follow the same assumption here.

[12] More recently, Álvarez Nogal and Prados de la Escosura (2007) claimed that, in the case of Spain's urban network, there was a significant presence of "agro-towns". This would invalidate this assumption and has led to a much more complicated treatment of the data, so as to separate the "urban agricultural" component. In the case of Portugal, we have chosen to ignore this problem since the only region - Alentejo - where agro-towns were pre-

The next task is to arrive at the share of the non-urban population that was engaged in agriculture and was *ipso facto* the "agricultural population" of the country. For 1500, we use the assumption that the occupational structure in Europe, up to the early-sixteenth century, was roughly homogeneous and that agriculture occupied about 80 percent of the rural population (Wrigley 1985, Allen 2000). The remaining 20 percent corresponded to the rural non-agricultural population.[13] At the end of our period, we have reliable data from Sá (2005) for 1750, and from Reis (2005) for 1800 and 1850.

We have also constructed a 1700 benchmark, which is based on tax rolls compiled around this date, and held at present in their respective municipal archives.[14] They contain detailed, reliable information on occupations of heads of families. They pertain to rural townships (i.e. with less than 5,000 inhabitants) and their respective hinterlands. Two of them (Montemor-o-Novo and Portalegre) are in Alentejo. This was a lightly populated, predominantly rural province in the south, with some "agro-towns", and as such was not particularly representative of the country as a whole. The other two cases come from the province of Algarve (Castro Marim and Tavira-Cacela), a coastal region further south, with a higher density of population, many small holders and a complete absence of "agro-towns". Altogether, it would have been much more like the rest of the country north of Lisbon. [15] Despite the differences between these two regions, in 1700 their respective shares of non-urban population en-

sent represented a small proportion of the national population. We therefore accept that the urban population as defined was non-agricultural population.

[13] These proportions are confirmed by the available evidence for late-medieval Portugal. According to Godinho (1968-72), in Alenquer, a provincial center, at the end of the fifteenth century those engaged in agriculture represented 74 percent of the entire population. In the case of Torres Vedras, a small town and its hinterland, in 1381, the "non-agricultural population" came to 33 percent of the whole (Rodrigues 1995). Further back, in 1369, in Arruda dos Vinhos, near Lisbon, 86 percent of all households were of farmers, the non-agricultural population representing therefore 14 percent (Marques 1980, p. 126-31).

[14] For a discussion of these tax rolls, see Reis (2017).

[15] The chief town in the county of Montemor-o-Novo had a population of about 3,500 out of a total of 7,300 for both the town and its hinterland (Fonseca 1986). In Castro Marim, these figures were 632 and 1,928, while in Tavira-Cacela they were 1,848 and 2,660. Their agricultural populations were 64 and 67 percent respectively (we include 74 fishermen in Tavira, an important fishing port, and treat "agriculture" here as the "primary sector"). In Portalegre, a town of about 7,500 inhabitants (1480 households), had a rural hinterland of about 5,000, where 78 percent of the population was engaged in agriculture. In the town itself, between 20 and 30 percent of the labor force was also agricultural. In all these cases we have treated the usually fairly substantial category of individuals with a "non-identified occupation" as belonging to the category of those living off agriculture.

gaged in agriculture were very similar. They were within a narrow band from 64 to 67 percent. Pending fresh evidence from additional sources, we have opted for the mean value of 65.5 percent. The remaining benchmarks – 1550, 1600 and 1650 – are derived by means of a log-linear interpolation as used by Álvarez-Nogal and Prados de la Escosura (2007) for Spain for the same years.[16]

In Table 2, we present the absolute values of Table 1 converted into shares of total population. The advantage lies in allowing us to perceive, at a glance, the shifts in the socio-economic population categories and thus grasp structural change over time more readily. It suggests, for instance, that the imperial expansion of the sixteenth century did not a have significant impact on the economic weight of agriculture (col.3; Costa et al. 2015; Palma 2016) though, in contrast, it did so during a good part of the eighteenth century's colonial expansion in Brazil. It also brings to light the fact that the higher productivity of secondary and tertiary sectors (col. 4) gained ground for two and a half centuries from 1500 to 1750, but slowed their contribution to economic modernization after that date. It reveals the apparently steady ruralization of manufacturing activity during the two first centuries considered here and its re-urbanization in the course of the following 150 years (col.5).

[16] This interpolation is a better solution than those used by Wrigley and Allen who were obliged to cover, in this manner, two and a half centuries (1550 to 1800) instead of one and a half, as here (1550 to 1700).

	(1)	(2)	(3)	(4) = (1) + (2)	(5) = (1) / (4)
	Urban	Rural non agricultural	Agricultural	Total non-agricultural	Urban/ total non-agricultural
1500	0.155	0.169	0.676	0.324	0.479
1550	0.151	0.161	0.688	0.312	0.485
1600	0.132	0.173	0.695	0.305	0.432
1650	0.124	0.239	0.637	0.363	0.343
1700	0.125	0.286	0.589	0.411	0.304
1750	0.173	0.291	0.535	0.465	0.373
1800	0.162	0.289	0.549	0.451	0.359
1850	0.176	0.155	0.669	0.331	0.531

Table 2

PORTUGAL: POPULATION SHARES OF TOTAL BY OCCUPATION

Notes: urban corresponds to population >5,000

Sources: same as for Table 1

PORTUGAL'S GDP PER CAPITA, 1527-1850

The early modern economic history literature has embraced the real wage as a valuable measure for international and inter-temporal assessments of living standards (Allen 2003, Pfister et al 2012). On the other hand, a real wage trend suggesting long run stagnation does not necessarily mean that this will be the case for per capita income. In the well-studied English case, for instance, real day wages conform to such a picture of stagnation during the entire early modern period (Allen 2001, Clark 2007, 2010), yet this is not confirmed by output-side GDP estimates, which show substantial intensive growth (Broadberry et al. 2015). When real wages are annual, rather than daily, they confirm the per capita GDP picture (Humphries and Weisdorf 2017).

This points towards a recognition that GDP per capita should be preferred as a measure of overall well-being. In the literature, two ways have been employed for estimating this metric in the case of premodern economies. One is supply-side based and requires abundant production data. It has been employed in the cases of England/GB and the Netherlands (Broadberry et al 2015; Van Zanden and Van Leuween 2012). In countries like Portugal, however, where output data are scarce, one has to rely on demand-based methods as has been done in the cases of Spain, Italy, Sweden and Germany (Álvarez-Nogal and Prados de la Escosura 2013, Malanima 2011, Schön and Krantz 2012, Pfister 2011).[17] The latter consists of two stages. First, it has been generally assumed, unrealistically, that all workers were employed the same number of days per year in each year considered. Álvarez-Nogal and Prados de la Escosura (2013) improve on this first step by considering that agricultural output was derived from not only labor but also land. In the present instance, we go further by using supply-side evidence in order to also adjust the labor supply, thus correcting the demand-side estimates for agricultural output.

The second stage is to gauge the size of the non-agricultural sector. This is done either by assuming a constant inter-sectoral productivity gap, which is the baseline option we take here; or by extrapolating the coefficients of a regression using urbanization as a covariate for data pertaining to a later period (Malanima 2011); or through the construction of sectorial current-price indexes (Álvarez-Nogal and Prados de la Escosura (2013). We show the results under all three approaches. We begin by presenting different series which build towards our baseline real per capita GDP. We show all the main results along the way, with additional data and results being described in the online Appendix. We start by displaying our weighted real day wage based on occupational shares. We then transform it into a better measure of annual

[17] Numerous studies have confirmed that direct output and demand-based reconstructions of income tend to be consistent (Álvarez-Nogal et al 2016; Broadberry et al 2015a, pp. 120-124, Broadberry et al 2015b, p. 65; Edvinsson 2016).

earnings from income with an adjustment to the number of days worked. This is then used in the construction of agricultural GDP. Finally, we show overall GDP.

To obtain real wages for Portugal, we use data for four regions of the country. We use data for Porto and its hinterland to represent the North (Minho plus Trás-os-Montes in Figure 1), Coimbra and its hinterland to represent the Centre (Beira in Figure 1), Lisbon and its hinterland (Estremadura in Figure 1) and Évora and its hinterland to represent the South (Alentejo plus Algarve in Figure 1).

We convert nominal wages by employing the procedure originally outlined by Allen (2001). We use a CPI defined by the silver price of a basket with a composition of goods assumed to represent the consumption needs of a pre-modern 'respectable' working class family. We make some adaptations to this formula, as required by differences in preferences and geography, whilst taking care that the caloric and protein standards are not significantly altered.[18] The most important is that dictated by the remarkable shift in bread consumption from wheat to maize (i.e. American corn, *zea mays*) flour which occurred during the period of this study. This is taken into account by altering the annual grain content of the CPI in accordance with the information on production shares based on tithes (Oliveira 1990, 2002).[19] Other changes to the original basket are the replacement of beer by wine, butter by olive oil, and cheese by hens (Table 3).

[18] Reis (2016) shows that this basket has a similar caloric and protein content as the Strasbourg basket. In the case of fuel consumption, the reduction from 5 to 2 million BTUs per basket is due to the significant difference in average temperatures, from 15.15º C in Portugal, compared with 10.25 º C in Strasbourg or 8.5 º C in England.
[19] This procedure mitigates some of the traditional problems with PPPs (Deaton and Heston 2010, p. 12; Allen 2017). We have made this change for the Porto, Coimbra and Lisbon hinterlands, but not Évora, which represents Alentejo and Algarve, where maize bread was not consumed.

	Quantity per person per year (Strasbourg)	Quantity per person per year (Portugal)	Spending share (Portugal, percent)
Bread	182 kilos	182 kilos	30.4
Beans/peas	52 liter	Substituted by 52 liters of wheat	6.0
Meat	26 kilos	26 kilos	13.9
Butter	5.2 kilos	Substituted by 5.2 liters of olive oil	4.3
Cheese	5.2 kilos	Substituted by 5 hens	3.6
Eggs	52 units	52 units	1.3
Beer	182 liters	Substituted by 68.25 liters of wine	20.6
Soap	2.6 kilos	2.6 kilos	1.8
Linen	5 meters	5 meters	5.3
Candles	2.6 kilos	2.6 kilos	3.1
Lamp oil	2.6 liters	2.6 liters	4.7
Fuel	5.0 millions of BTU	Substituted by 2.0 millions of BTU	5.0
Total			100

Table 3

RESPECTABILITY BASKETS

Source: for the Strasbourg basket, Allen (2001, p. 421). For the Portugal basket, see text.

Although we do not have as much data for other parts of the country as we do for Lisbon – and we lack region-specific occupational data altogether – we do have enough data such that for most periods variation is annual for the four regions. As Figure 2 shows, prices move closely together in the four regions, which we interpret as evidence for market integration. It is

hence not surprising that wages also exhibit similar trends though the labor market seems less integrated than the commodity market (Figure 3).

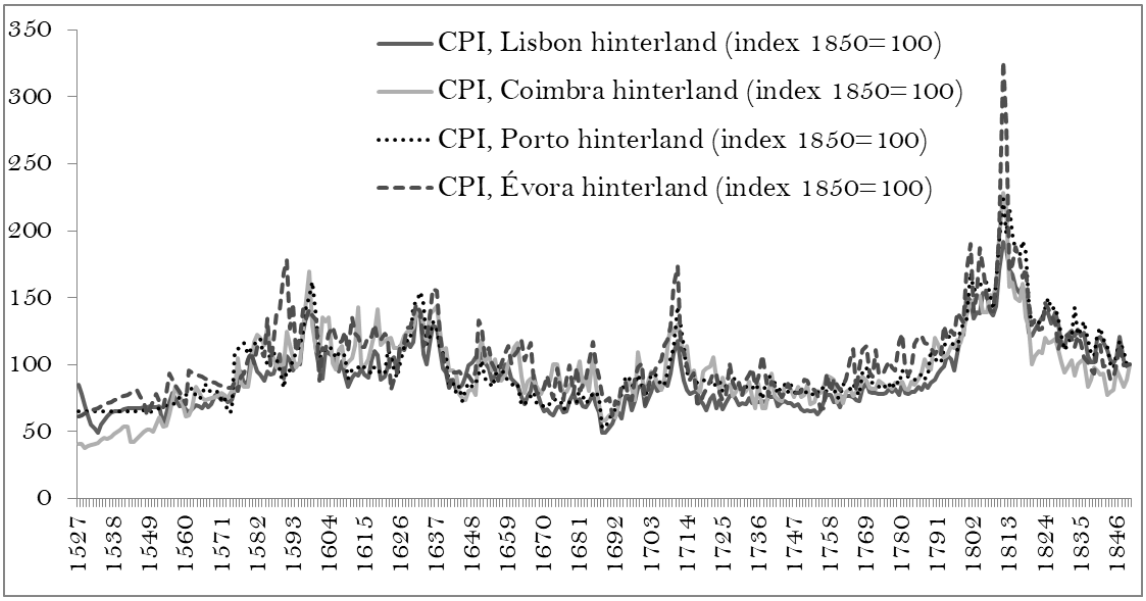

Figure 2

CPI FOR PORTUGAL'S FOUR REGIONS, 1527-1850

Sources: see text.

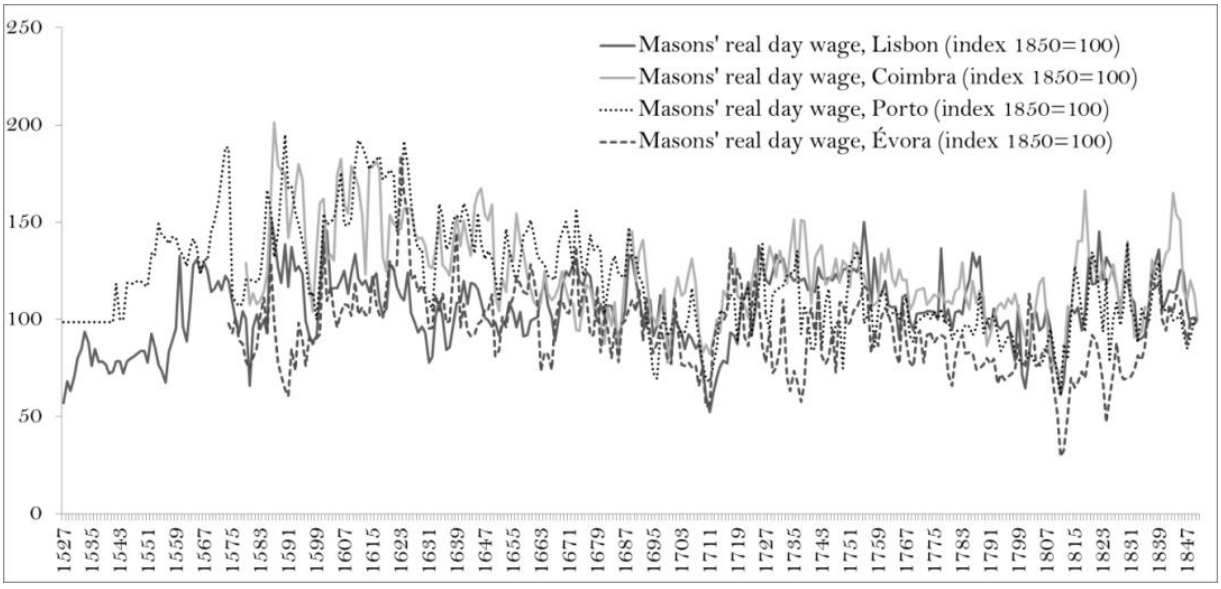

Figure 3

SKILLED WAGES FOR PORTUGAL'S FOUR REGIONS, 1527-1850

Source: see text.

In Figure 4 we present our baseline national real day wage index.[20] This is a weighted average of the wages of the four regions of the country, where the weights are given by their respective population shares.[21] Each wage is in turn constructed by weighting the real incomes of unskilled, skilled, and mid-skilled workers according to their occupational shares at each given moment, by interpolating the values of Table 2. It shows that day wage growth was vigorous throughout the sixteenth century and was followed by decline during the seventeenth century. Over the very long-term, however, it had an approximately stable trend.

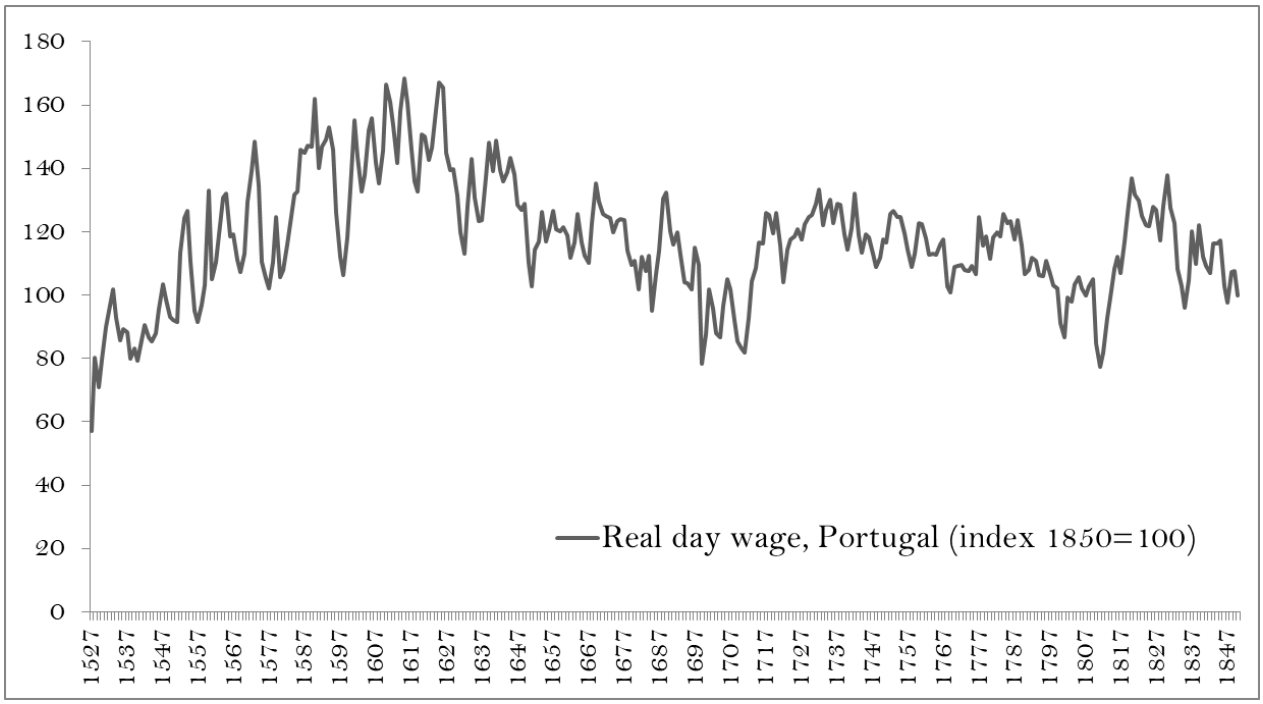

Figure 4

A NATIONAL REAL DAY WAGE INDEX FOR PORTUGAL, 1527-1850

Sources: see text.

In order to reflect change over time in the true number of days worked per year we apply a supply-side adjustment to the preceding estimate. There is evidence that this indicator of

[20] The separate evolution of the long-term real day wages for unskilled and skilled (masons) workers are shown in Figures A2 and A3 of the Appendix. The skilled premium is approximately constant over time.

[21] The source is Palma et al (2017). We assume population shares were constant at the 1574 level during 1527-1573. Furthermore, we only have reliable wage data for Porto's hinterland from 1541 onwards, for Coimbra's hinterland from 1579 onwards and for Évora's hinterland from 1574 onwards. For the periods from 1527 until these dates, we use our data for Lisbon's hinterland as a proxy.

labor intensity rose significantly over this period in Portugal, as it did elsewhere in Europe.[22] In Portugal, this was a response to a more labor-intensive agricultural system required by the spread of highly-productive maize and wine (Ribeiro 1986), and to the economic opportunities offered by the empire (Costa et al. 2015). As a consequence, the growth of per capita income was higher than suggested by real wages calculated under the assumption of a fixed supply of labor per worker.

We calculate the real annual earnings per worker from day wages, where the number of days worked varies both across time and by worker type. For any given year and region the weighted wage is given by

$$annual\ earnings\ per\ worker\ in\ region\ j = \sum_{i=1}^{3} a_i w_{ij}\, l_i$$

where $\sum_i a = 1$ are the weights corresponding to the occupational shares as given in Table 2, w_{ij} the day wage corresponding to each worker class in region j, and l_i the number of days worked by each class, where i = skilled, unskilled, and mid-skilled for that year.

Our procedure comprises two parts. The first produces estimates of average yearly labor input per worker at the beginning and at the end of the period under observation. These benchmarks must be constructed independently from each other, yet be consistent in their manner of construction. Once we have established the size of the differential between them, the second task is to split the additional long term labor effort into yearly variation over the period. Instead of interpolating linearly[23] we use, as a plausible determinant of yearly increments, the share of maize in grain production based on the tithes received between the sixteenth and

[22] A nearby example is Spain, where between 1750 and 1850 the number of working days per year and per worker rose by 43 per cent. See Álvarez-Nogal and Prados de la Escosura (2013, p.7); in Italy, they increased 80 percent between the fifteenth century and 1850 (Federico and Malanima 2004).
[23] Figure A4 in the Appendix shows that the quantitative results do not change very much if linear interpolation is used as an alternative.

the nineteenth centuries by the bishopric of Viseu, a major grain producing region (Oliveira 1990, 2002).[24]

For our baseline, we use a number of sources. Yearly skilled urban labor input is drawn from Brandão (1552), a definitive account of the city of Lisbon in the mid-fifteen hundreds. In general, this yearly work load was 270 days, an unsurprising finding since it is equal to the days of the year minus Sundays and sanctified days.[25] Similar data regarding unskilled workers in agriculture are unobtainable and this obliges us to use an indirect approach. This involves constructing a supply-side estimate of the output of this sector, which we then divide by the current daily wage, to establish the total number of days of labor required for producing it. With this in hand, we infer the average yearly labor input per worker, by simply dividing this global labor effort by the number of workers engaged in agriculture.

To implement this method, we turn to two independent and creditable supply-side estimates of agricultural output. One is the sum of the gross valuations of the country's four main agricultural sectors *circa* 1515 – grain, wine, livestock products and olive oil – at current prices and converted into grams of silver, as proposed by Godinho (1968-72). We transform this aggregate as outlined above, using population and occupational shares from Tables 1 and 2, and also figures for silver prices and wages from the PWR data-base. Hence, we can recover the number of days worked: we obtain a result of 124 days per worker per year.

[24] The first reliable observation corresponds to just over 20 percent in 1701. We assume a level of 0.1 percent in 1600, and interpolate linearly until 1701. The resulting values closely match a few partial observations available for the seventeenth century. For instance, under our procedure we assume about 13 percent for 1665, while the true value was around 15 percent (Oliveira 1990).

[25] Note this is a more conservative choice (in the sense of generating less growth) than if we had chosen 250 days for skilled workers, as commonly done (e.g. Álvarez-Nogal and Prados de la Escosura 2013, Allen 2000).

While informative, this method is not exempt from doubt, because Godinho does not reference the sources used.[26] A second method refers to 1530-1532 and adopts the same four-sector model of agriculture, and the same labor force, price and wage data. It has a regional rather than a national dimension – 60,000 acres in the northern hinterland of Coimbra (it is an area around Lamego shown in Figure 1) and a population of 36,000 – but represents well the nation's agricultural productive structure (Reis 2016). The statistics for its agricultural volumes were calculated by Fernandes ([1532] 2012) using direct evidence from tithes.[27] Our calculation of labor input per agricultural worker in this instance is 119 days per worker per year.

Given that these two methods produce similar outcomes, but the second is more reliable, we settle for a choice of 120 days, which is the same as in Spain during the same period and for the same type of workers (Álvarez-Nogal and Prados de la Escosura 2013, p. 7). We complete this initial benchmark by assuming, for lack of additional evidence, that rural non-agricultural workers were employed an intermediate 195 days a year.

Obtaining similar indicators for our second benchmark of 1850 is considerably easier since by this date economic statistics had become far more abundant, accessible and reliable. For skilled urban labor, we draw on government surveys covering the most significant regions of the period: Entre-Douro-e-Minho, Beira and Estremadura. They show that by this time the average had ascended to 293 days a year, a small increment of 8.5 per cent relative to our starting point, and attributable to the decline in holy days after the 1750s (Coelho 1861; Silva 1861;

[26] Detailed information on the source used by Godinho, the leading Portuguese economic historian of the post-war era, is not mentioned by him in keeping with the French historiographic practice of 60 years ago. But it is clear that the data arise in connection with a royal plan, around 1515, to divert funds from the king's tithe income to pay new officials in the military orders. This would have required updated knowledge of the size of this revenue and therefore of agricultural income too. Regarding this reform, see Viterbo (1983). On the mechanics of tithe collection and distribution in the late fifteenth century, see Henriques (2015).

[27] Rui Fernandes, a rich merchant and tax contractor of the city of Lamego, was appointed to produce this survey of a circular area, with an 11 kilometer radius, centered on Lamego.

Colaço 1862; Oliveira 1867).[28] Meanwhile, the unskilled agricultural labor force had an annual input of 202 days per worker. This has been measured by replicating, with minor alterations, the methodology employed for the baseline construction, with its same four sub-sectors, namely grain, wine, livestock and olive oil.[29] It represents a rise of 67 per cent relative to the baseline.[30] As above, we complete this benchmark by assuming again for rural non-agricultural workers an intermediate 247 days a year.

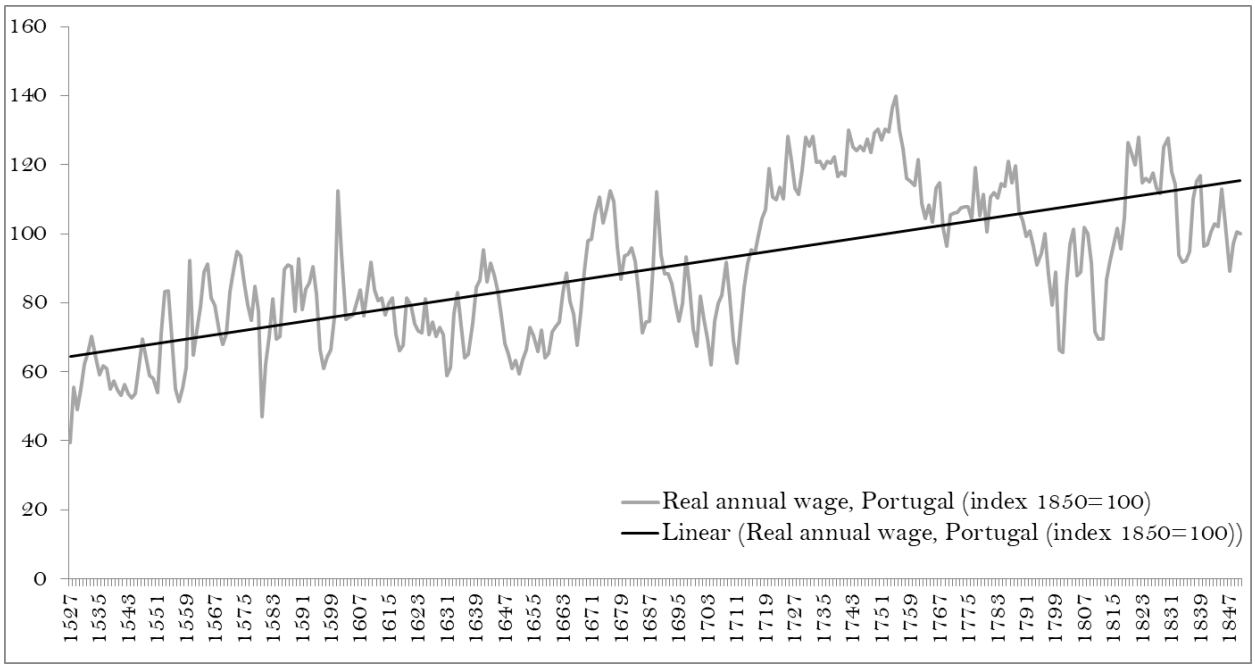

Figure 5

REAL ANNUAL EARNINGS PER WORKER WITH VARYING LABOR SUPPLY

Sources: see text.

[28] With regards to the urban economy, the empire had the strongest impact from the mid-seventeenth century onwards (Costa et al. 2015). Our database also includes annual wages, which confirm this overall pattern of rising earnings from labor. Nonetheless, annual salaries generally correspond to white-collar professions of higher levels of human capital, like doctors and lawyers. We hence need to be cautious in comparing their evolution to that of the salaries of the occupations paid daily, because a divergence could be due, for instance, to higher returns to human capital. At the same time, the skill premium between white-collar and unskilled workers slightly declined during 1620-1764 (Reis 2016), which provides support for the idea that annual earnings did rise for all workers.

[29] The supply-side measure of agricultural output in 1850 is derived from a new generation of government statistics and is discussed in Reis (2000). At this time, new agricultural items such as potatoes, maize and rice were present and are included in in the category "grain".

[30] Rebello da Silva (1868), a distinguished contemporary agronomist, reckoned that 200 days was all that the agricultural year could offer laborers in terms of employment.

Using the resulting number of days worked for each worker type, we can calculate national annual wages. Figure 5 shows the result, where we can see that that the trend was clearly positive. There are three factors which explain why real annual earnings per worker grow, while the day wage of both skilled and unskilled workers are stagnant. First, structural change means that over time a higher proportion of unskilled workers move to better paid mid-skilled and skilled wages. As noted in Table 2, the nonagricultural sector labor force increased from a trough of 30.5 percent in 1600 to a peak of 46.5 percent in the mid-eighteenth century. But this effect is by itself small, and is already reflected in the evolution of our weighted day wage over time (Figure 4), as compared with the underlying trends of its inputs, the skilled and unskilled wages.

Second, not only is there an increasing share of skilled workers, but these workers are also working more days per year. Third, all workers also work more days as time went by. Over time (until 1750), not only did a higher share of workers get higher wages, but within worker types, they also worked more days in the year, a dynamic effect which compounded the higher day wage effects. The combination of these level effects over time leads to the temporary growth spurt visible in Figure 5, lasting from the late 1520s to the early 1750s.

Welfare ratios for Lisbon (calculated using the respectability basket and assuming a family of 3.15, as detailed in Allen 2001) illustrate how variable working days matter in explaining the growth of annual consumption as opposed to day wages. (We show these for Lisbon rather than Portugal in order to be more directly comparable to Allen's other cities.) Figure 6 show welfare ratios for Lisbon for both skilled and unskilled workers under different assumptions about working time: either fixed (but variable by class), or, variable by class but increasing over time. In the absence of proper PPPs for the past, they also illustrate the fact that Lisbon's workers were faring relatively well by international standards; in the mid-

eighteenth century, only cities such as Antwerp, Amsterdam, and London (Allen 2000, p. 428) had higher consumption patterns than Lisbon.

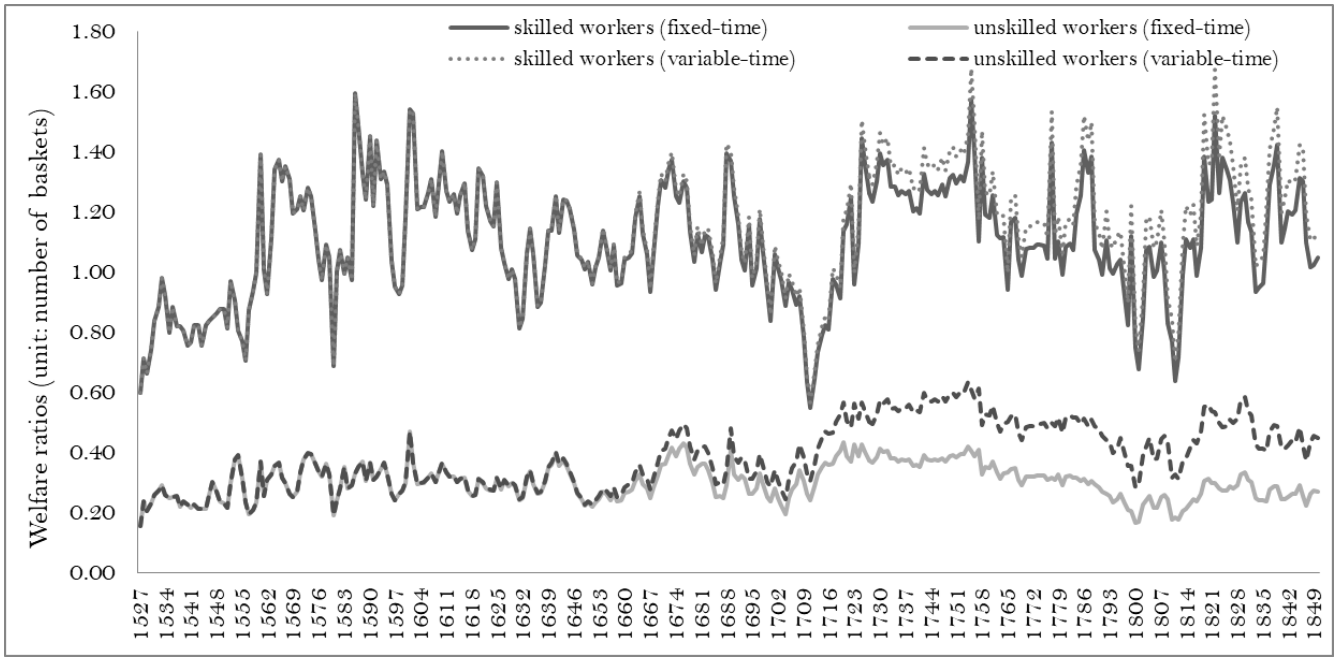

Figure 6

WELFARE RATIOS FOR LISBON (RESPECTABILITY BASKET)

Sources: see text.

Portugal's agricultural product over this period has been estimated by Reis (2016), using Lisbon wages and the methodology set by an earlier version of the present paper. The first part of the exercise uses a demand-for-food function to obtain gross agricultural output, taken to be equal to food consumption (Wrigley 1985, Allen 2001).[31] For any given year, the agricultural product (Q_a) is given by the expression,

$$Q_a = P^{\alpha} I^{\beta} M^{\chi} N$$

in which P is the real price of agricultural products, I is real income per capita, M is the real price of other consumer goods and N is total population. The coefficients α, β and χ are, respectively, the own price, income and cross elasticities of demand. This function takes into ac-

[31] The online Appendix (Table A2) shows the very small size of the differential between food imports and exports and compares it to agricultural output. See also Costa and Reis (2017).

count the impact on food consumption of fluctuations in real income, food prices and non-food prices, as well as their respective elasticities.

A fairly wide range of choices exists with regard to the selection of demand and income elasticities. In the absence of anything better, the literature has resorted to emulating the present day elasticities of less developed economies with traits presumed similar to those of early modern economies. The possibilities range from -0.4 to –0.7, for own-price elasticity, and from 0.3 to 0.6 for income elasticity. We have found the arguments advanced by Álvarez-Nogal and Prados de la Escosura (2013) convincing and have therefore opted here for the set they propose in which α = -0.4, β =0.3 and χ =0.1.

The principal difficulty with this model is how to quantify the real income variable. The best solution to date is that proposed by Álvarez-Nogal and Prados de la Escosura (2013, p. 9), who employ a weighted index of wages (0.75) and land rents (0.25).[32] Including land rents slightly increases the volatility of the income series, but does not change the result significantly. We build an overall income index which we then deflate using our CPI. Figure 7 shows the result.[33] It shows stagnation until the 1630s, growth until the 1750s, decline until the 1820s and stagnation thereafter.

[32] The result is very similar to summing yearly the actual current-price wages and rents as in Álvarez-Nogal and Prados de la Escosura (2013).
[33] Figure A6 in the appendix compares this result with that using the day wage as the only source of income.

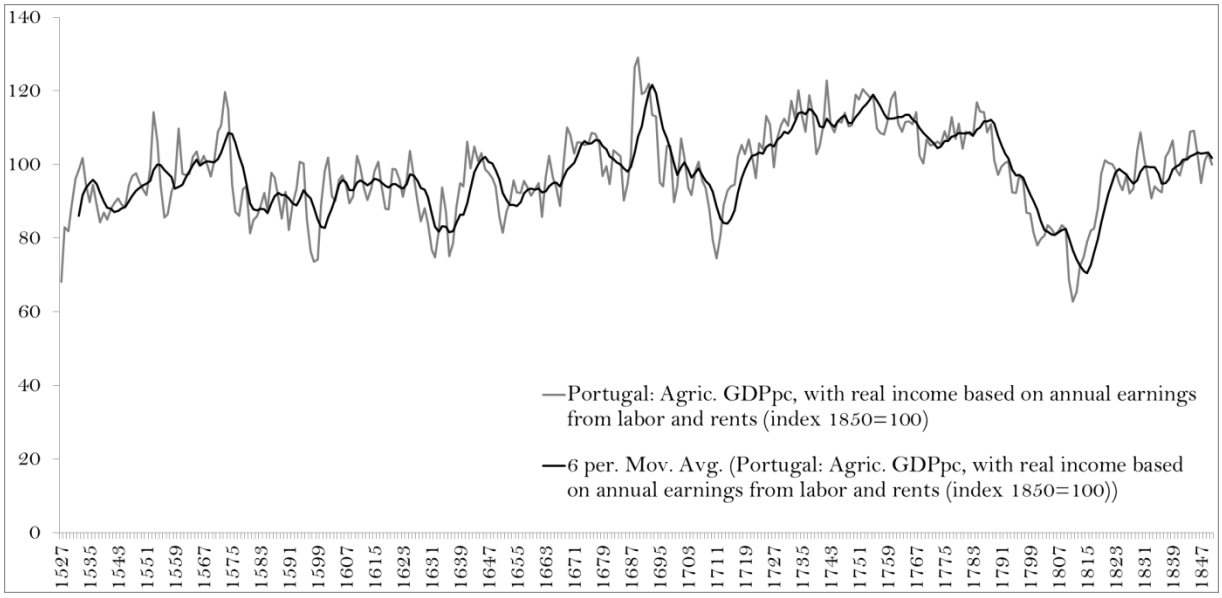

Figure 7

AGRICULTURAL REAL GDP PER CAPITA

Sources: see text.

The second major step in estimating GDP is the quantification of the non-agricultural part of the economy. Both Malanima (2011) and Álvarez-Nogal and Prados de la Escosura (2013) have postulated a significantly stable relation between the urban share of the population and the size of the secondary and tertiary sectors together. The former has extrapolated this link all the way back to 1300 using the coefficients of a linear regression covering the years 1861-1936. In it, non-agricultural output was the dependent variable and urbanization served as the covariate. In turn, Álvarez-Nogal and Prados de la Escosura used change over time in the country's "adjusted" urbanization rate to proxy for the variation in the size of the nonagricultural economy, and then backed up current-price values for both the agricultural and non-agricultural sectors by using, respectively, the agricultural CPI, and an index which consists of an average of the industrial CPI, the global CPI, and the nominal wage (Álvarez-Nogal and Prados de la Escosura 2013, p. 14-16).

Both approaches have disadvantages, the principal one being that focusing on urban production alone entails ignoring the contribution of proto-industry to non-agricultural production. Another is that they overlook the more than likely rise in productive efficiency which arose in parts of the economy during the preindustrial era. To surmount these, we resort to the procedure proposed by Pfister et al (2012) for Germany by assuming a constant ratio between the share of agriculture in total output and its share of employment. In other words, we maintain that the inter-sectoral productivity gap (p) between agriculture and total output is time-invariant over the period considered. The expression for GDP at any given year t is then,

$$GDP_t = Q_{a,t}/(p \times \frac{L_{a,t}}{L_t})$$

in which $Q_{a,t}$ is agricultural output and $L_{a,t}$ and L_t are agricultural and total labor respectively, all of them at time t, and p is the constant productivity gap. Since we possess estimates of agricultural output (Reis 2016) and of major sectoral shares (discussed next), all that is needed to derive GDP is to determine this gap at a point in time for which this is possible and then extrapolate back. We use an estimate for Portugal of p from the mid-nineteenth century (1850)[34] which is of a credible order of magnitude. It is lower than those for Italy (Malanima 2011) and Germany (Pfister 2011) and similar to the value derived for Spain (Álvarez-Nogal and Prados de la Escosura 2007).[35] The expression for obtaining the value of p is,

$$p_{1850} = \frac{Q_{a,1850}/Q_{na,1850}}{L_{a,1850}/L_{na,1850}}$$

where $Q_{a,1850}$ is agricultural output, $Q_{na,1850}$ is non-agricultural output and $L_{a,1850}$ and $L_{na,1850}$ are, respectively, the total labor of these two sectors, in the year 1850. The value we adopt for Portugal is 0.7, the unweighted mean of those obtained from data found, respectively, in Lains (2003) and Reis (2000). The result using this constant inter-productivity gap (IPG)

[34] Notice that this year is prior to the onset of major structural changes in Portugal; see Lains (2003).
[35] For Spain, the value is 0.66, and for Italy and Germany it is 0.81, plausibly suggesting a higher level of economic development in the last two countries.

method is our baseline result for real per capita GDP, as shown in Figure 8, and in the continuous black line of Figure 9. The growth patterns are similar to those of the agricultural sector: stagnation until the 1630s, growth until the 1750s (interrupted by a brief decline of just over a decade during approximately 1695-1705), then persistent decline until the 1820s followed by stagnation thereafter, until the end of our period.

There are two alternatives which can be used to estimate a time-varying inter-sectorial productivity gap. The first is that of Malanima (2011), which relies on a regression of the size of the nonagricultural product on a constant and, as a covariate, the urbanization ratio.[36] We show the result with this method in Figure 9. The second is the method of Álvarez-Nogal and Prados de la Escosura (2013, pp. 14-16), which uses change over time in Portugal's urbanization rate to proxy for the variation in the size of the nonagricultural economy, and then backs up current-price values for both the agricultural and nonagricultural sectors. This is done by using, respectively, the agricultural CPI, and an index which consists of an average of the industrial CPI, the global CPI, and the nominal wage.[37] This method is also shown in Figure 9. As this figure suggests, the different methods lead to similar results, which suggests that our baseline results in Figure 8 are robust.

INTERNATIONAL COMPARISONS

The notion of persistent Early Modern stagnation is related to that of the structural inability of these economies to generate technical and organizational change on an appreciable scale. In order that some growth should happen at the intensive margin, three conditions needed to be met. One is that innovation would occur and influence sizable sectors of the economy.

[36] Our regression covers the 1848-1923 period, with Leite (2005) for the urbanization ratio, and the size of the nonagricultural sector inferred from the current-price value of services and industry over total GDP, taken from Lains (2003).
[37] For the current-price value of agriculture in 1850, we used Reis (2000).

Another is that it would have to translate into palpable productivity gains. The third is that this impetus would have to be sustained over a relevant time span. Recent research on pre-industrial Britain and Holland demonstrates that they possessed these attributes and thus contradict the view of Malthusian historians such as Clark (2007). The relative dynamism of Portugal's performance over long periods of time, shown in Figure 8 suggests that it may have been yet another country which did not fit the condition of economic torpor depicted by the standard literature. Nonetheless, from a very long perspective it stands true that Portugal's per capita real income was no higher in 1850 than it had been in the early 1530s.

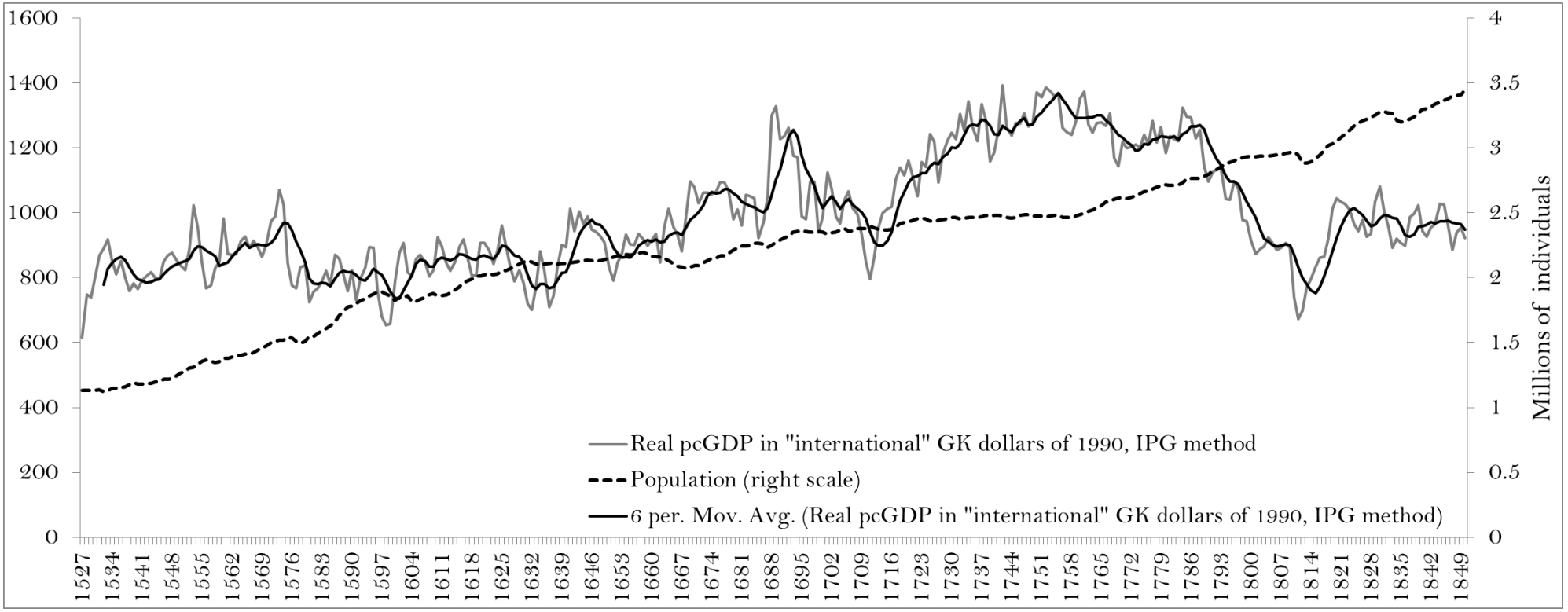

Figure 8.

PORTUGAL'S GDP PER CAPITA (IN "INTERNATIONAL" GK DOLLARS OF 1990, LEFT SCALE) AND POPULATION (RIGHT SCALE), 1527-1850

Sources: for real pcGDP, see text; for population: see text and Palma et al. (2017)

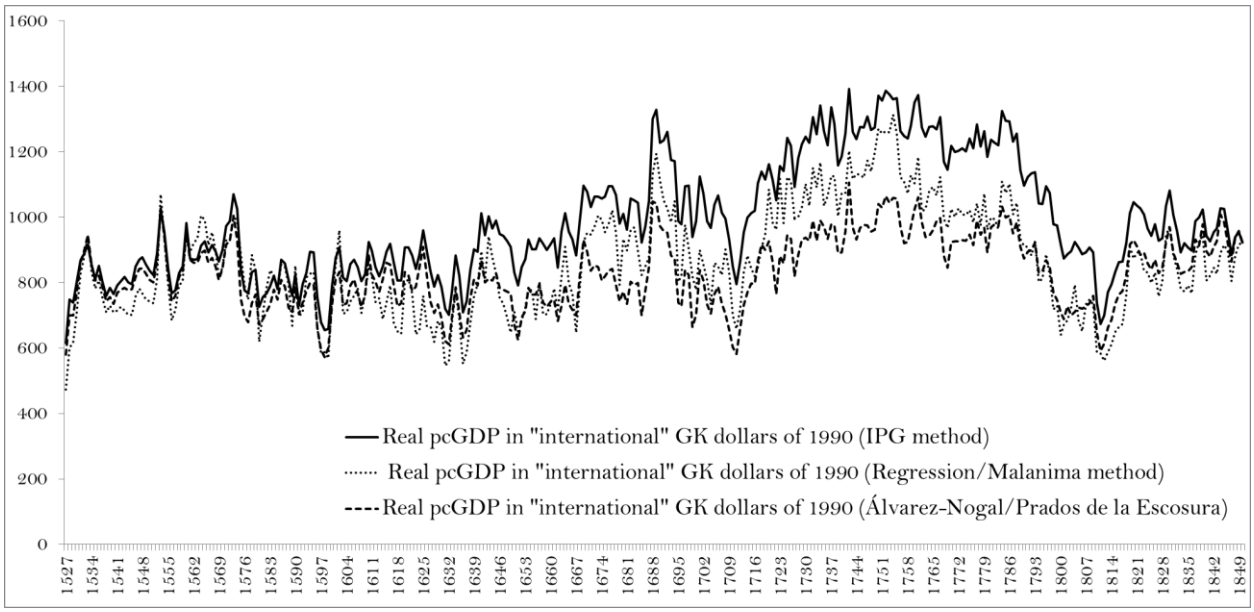

Figure 9

PER CAPITA REAL GDP USING ALTERNATIVE METHODS TO CALCULATE THE INTER-SECTORIAL PRODUCTIVITY GAP.

Sources: see text.

As we document in Figure 8, the sixteenth century did not witness any overall progress. But from the early 1630s a completely different picture is visible. Three forces were mainly responsible for changing the Portuguese economy and instilling it with a clear impulse to grow. One was the spread from around sixteen hundred of a new irrigated, highly productive crop – Indian or American maize - which displaced traditional foodstuffs and established entirely new production and consumption patterns (Ribeiro 1986). Another was the development, from the late-seventeenth century, of a highly commercialized and competitive Port wine sector which established a remarkable export sector focused on the flourishing British market (Martins 1990). The third was the establishment throughout the whole of the early modern period of an overseas empire, which linked the mother country, through a complex web of sea lanes and mercantilist ties, to a multiplicity of profitable settlements and trading posts (Costa et al. 2015). It is remarkable that the timing of the 1710-1750 boom coincides with that of the influx of Brazilian gold (Costa et al 2013). All of these were gradual developments which in-

voked a capacity for technical and organizational change, as well as for major investment in human, physical and financial capital. All of them had significant long-run macroeconomic implications.[38]

Portugal's economy is held to have been comparatively backward during the early modern period (Allen 2005, van Zanden 2009). By contrast, we have shown that the Portuguese economy experienced 120 years of per capita growth between 1630 and 1755: 0.44 percent a year.[39] Portugal's growth rate hence compares favorably with that of Holland, of 0.41 percent per year during 1500-1650 (van Zanden and van Leeuwen 2012), and that for England/Britain, of 0.30 percent for 1600-1750 (Broadberry et al 2015), their respective golden ages of early modern growth. The important difference is that in the 1750s Portugal entered a remarkable period of decline.

In order to have a comparative view of Portugal's long-run performance, we now shift the discussion from volume-based measures to a comparison of income levels. In Table 4 we show the results using the well-known Maddison method.[40] This shows that Portugal's favorable circumstances by the mid-eighteenth century, which were largely the result of remarkable growth in the previous half century (but also dated back to the early seventeen hundreds) were not to last. In the very long run, the economy conformed to the predictions of the Malthusian model. Despite variation in response to shocks, income reverted back to what could be interpreted as a long-term "subsistence" level. Nonetheless, while the forces of convergence to such a steady state did include endogenous fertility and mortality responses in the spirit of Malthus, it is equally possible that negative effects of a political economy or institutional nature were also present.

[38] For an up-to-date overview of this period's economic history, see Costa et al (2016).
[39] This annualized growth rate was calculated using the familiar compound growth formula.
[40] Maddison gives 923 GK international 1990 dollars for both 1820 and 1850. Our data show these two are inconsistent. We pick the least remote value, 1850, as the preferred one.

	England/GB	Holland	Germany	France	North and Central Italy	Spain	Sweden	Portugal (Maddison 2003)	Portugal (this study)
1500	1068	1454	1146	935	1553	846	-	606	-
1550	1058	1798	-	-	-	-	995 (year: 1560)	-	836
1600	1082	2662	806	901	1363	892	761	740	790
1650	925	2691	948	-	1398	687	966	-	830
1700	1513	2105	939	992	1476	814	1340	819	987
1750	1695	2355	1050	-	1533	783	973	-	1371
1800	2097	2609	986	1045	1363	916	857	923 (year: 1820)	916
1850	2330	2355	1428	1597	1481	1079	1076	923	923

Table 4

OUTPUT PER CAPITA IN EUROPE IN "INTERNATIONAL" GK DOLLARS OF 1990.

Note: Data for Portugal shown extrapolating backwards from the 1850 benchmark in Maddison (2003, p. 66).

Sources: For France until 1800, levels are taken from Ridolfi (2016, p. 197). For the others, the following sources: for England/GB, Broadberry et al (2015); for Holland, van Zanden and van Leuween (2012); for Germany, Pfister (2011); for France in 1850, Álvarez-Nogal and Prados de la Escosura (2013, p. 23); for North and Central Italy, Malanima (2011); for Spain, Álvarez-Nogal and Prados de la Escosura (2013); for Sweden, Schön and Krantz (2012).

CONCLUSION

The effort to understand the historical origins of modern economic growth necessarily involves paying attention to early first movers. Understanding what went wrong is a crucial part of the effort to make sense of what went right in Northwestern Europe. Knowing how prices, rents, income and population evolved in the countries that lagged behind by the nineteenth century is a critical piece of the puzzle, as it provides a source of variation in the data which allows us to compare them with modernizing economies. The behavior of such major macroeconomic variables during the early modern period was already well known for England, Holland, Germany, Sweden, Italy, and Spain.[41] In this study we have considered the case of Portugal, which has so far been absent from the literature.

Was Bairoch (1976, p. 286) right when he considered Portugal one of Europe's five richest countries as late as 1800? We can now conclude that it is true that during much of the early modern period Portugal was comparatively prosperous. While a loss of dynamism is already noticeable from the second half of the eighteenth century, as late as 1750 income levels in Portugal were high by Western European standard though clearly behind those in Britain, Holland, and North/Central Italy. At least between c. 1630 and 1755, Portugal was not Malthusian, in the sense that per capita income did not have a tendency to converge towards a stagnation steady-state, and real income per person increased about 75%, despite the growth in population. Much growth was of an extensive nature, but Malthusian forces were not sufficient to cancel Smithian intensive growth opportunities.

At the same time, while the timing of convergence or divergence depends on the country of reference, Portugal's income level was below those of the most advanced countries for all

[41] See, for England, Allen (2001), and Broadberry et al (2015); for Holland, van Zanden and van Leeuwen (2012); for Germany, Pfister (2011), and Pfister et al (2012); for Sweden, Edvinsson (2013a, b) and Schön and Krantz (2012); for Italy, Malanima (2011, 2013); and for Spain, Álvarez-Nogal and Prados de la Escosura (2007, 2013).

of the early modern period, as shown in our Table 4. Nonetheless, there were periods of convergence such as the first half of the seventeenth or of the eighteenth centuries. Compared with England/GB, an unmistakable divergence in the income differentials happened in the course of the early modern period, but it dates from no earlier than the second half of the eighteenth century.[42]

After the mid-eighteenth century Portugal entered a period of persistent decline which had as proximate causes the increase in population combined with the exhaustion of the previously available engines of economic growth without their substitution by new sources. Whether there was also an institutional element in this decline and how it may be related to the previous resource boom remains unclear at the moment. What is certain is that the growth which had taken place until then was accompanied by limited structural change.

We have offered an account of the main proximate factors in the growth and decline of Portugal's economy from the early sixteenth to the mid-nineteenth century. This has enabled us to add Portugal to the pool of existing evidence on GDP, as well as factor and commodity prices and allows us to round off the usual picture for early modern Europe with the inclusion of a non-core economy. We have concluded that although Portugal enjoyed comparatively high incomes well into the early modern period, its structural modernization was comparatively slow. As the engines of growth ran out of steam after c.1750, a reversal took place which, within a century, would leave Portugal as one of the poorest countries in Europe.

[42] For a similar finding but using real wages, see Malanima (2013).

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Online appendix to

FROM CONVERGENCE TO DIVERGENCE:

PORTUGUESE ECONOMIC GROWTH, 1527-1850

The data for this paper is available online at:

https://sites.google.com/site/npgpalma/publications

I - Percentage of the yearly variation of the principal data covered by our sources

	Unskilled wages	Skilled wages	Wheat	Maize	Meat	Eggs	Chickens	Wine	Olive oil	Coal	Linen
1527-1600	80	85	92	n.a.	62	50	68	85	74	72	76
17th c.	87	91	100	99	100	100	100	100	100	100	99
18th c.	94	98	100	100	100	100	100	100	100	100	96
1801-1850	100	100	100	100	100	100	100	100	100	100	83

Table A1. Data coverage for the main variables underlying the construction of our series (percentage covered by at least one of our four regions). Sources: PWR project.

II – Primary data sources employed in this article

All the primary sources consulted in gathering the data for this article are given, by region, in the references section below. Figure A1 is an example of how a typical page of the many account books we consulted for primary data looks like:

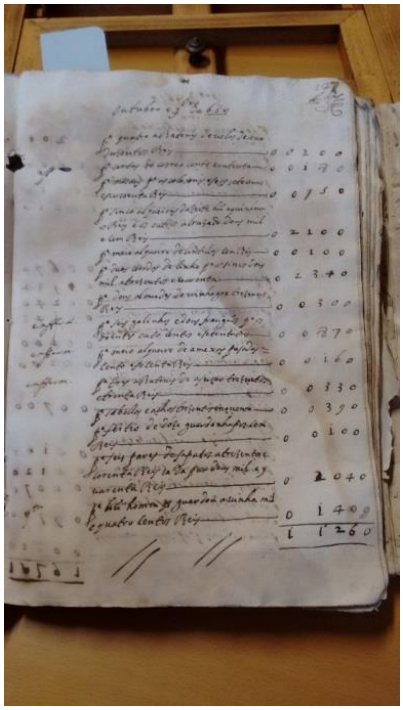

Figure A1. A typical example from an expenses book page containing wages and prices.

III – Additional figures

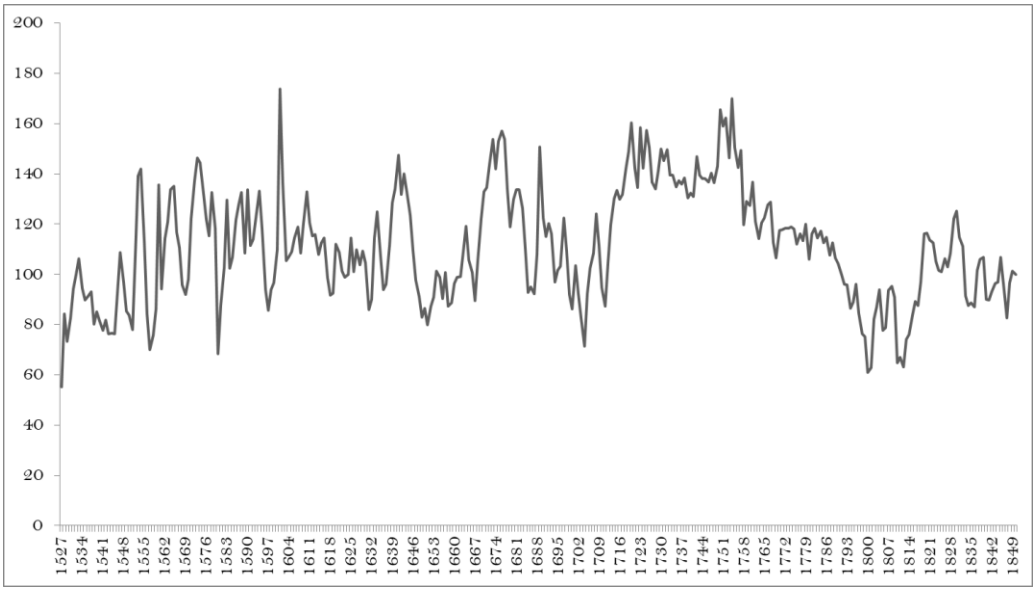

Figure A2. Lisbon real day wages for unskilled workers (index, 1850=100). Sources: see text.

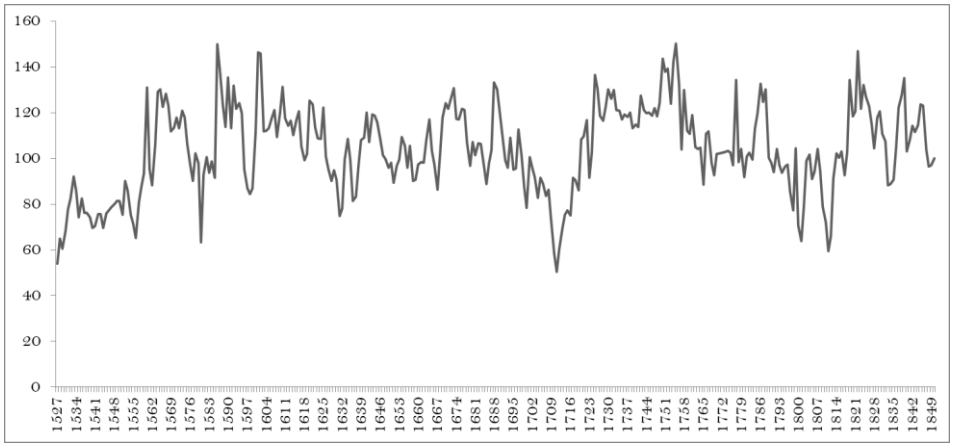

Figure A3. Lisbon real day wages for skilled workers (index, 1850=100). Sources: see text.

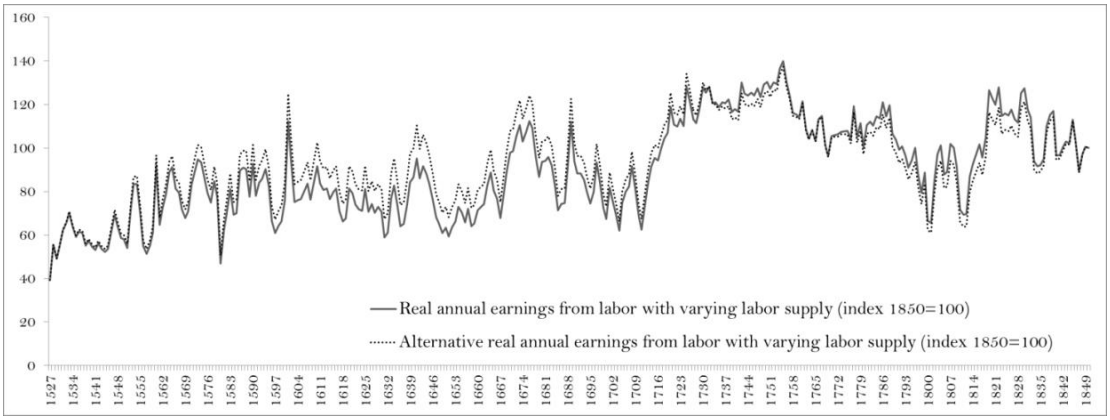

Figure A4. Lisbon's annual earnings per worker under alternative assumptions for days worked. The solid line shows our baseline real annual earnings compared with those with interpolated working days since the beginning of the sample.

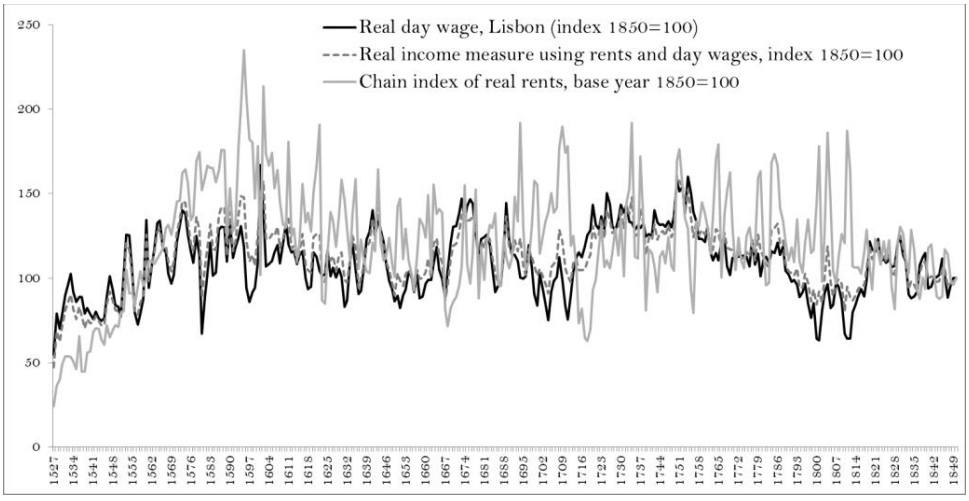

Figure A5. Land rents and real income (Lisbon's hinterland only) including and excluding land rents.

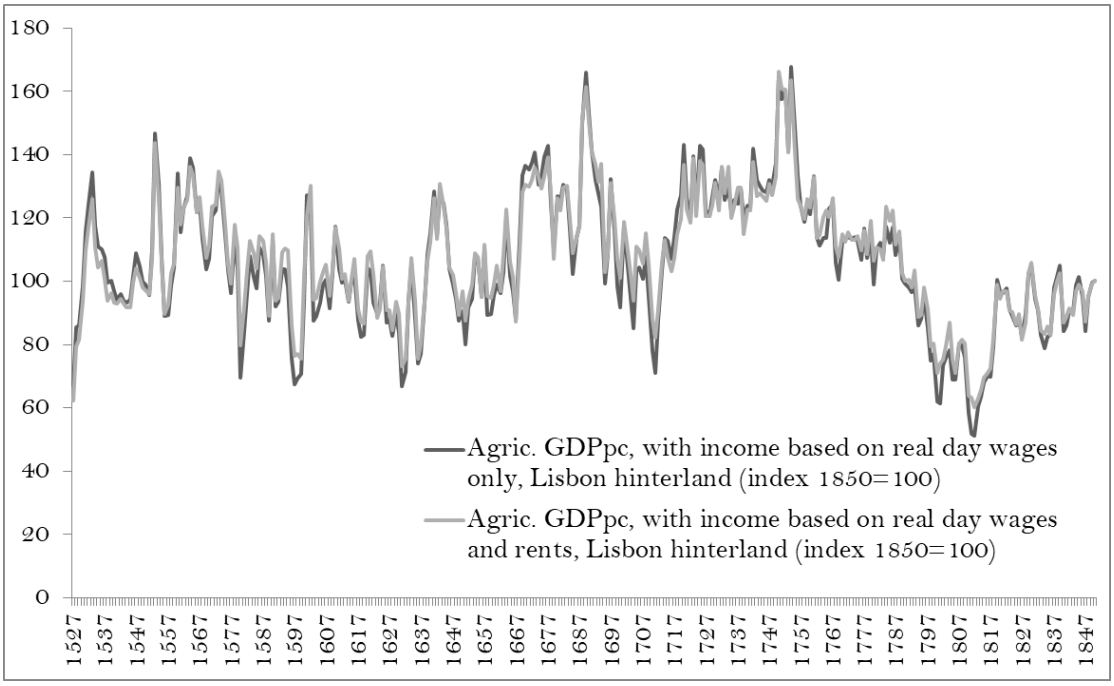

Figure A6. Agricultural GDP per capita based on Lisbon's day wages, with and without land rents.

IV – Portugal's external food balance

Table A2 shows the results of quantifying the external food balance. The Appendix to Costa and Reis (2017) gives the information on sources and how these figures were arrived at. For each benchmark, the export or import of the three main items of the food trade, in their respective current values in grams of silver (cols.1, 2 and 3) iare expressed and then summed up to obtain the overall food deficit or surplus in silver too (col.4).

Since we do not possess any quantification of national agricultural consumption at current prices, a short cut estimation method proposed by Malanima (2011, p. 179) is used instead. This procedure starts by multiplying the total wage bill in grams of silver by 1.4 which gives us the estimated income of all production factors (land, labor and capital). This is multiplied by a coefficient of 0.6, to arrive at a figure, also in silver, representing the total expenditure on food by the recipients of national income, i.e. the population (col.5). We can then determine the magnitude of the food surplus/deficit relative to food consumption (col 6 of table A2) and the

value of the ratio **r** (col. 7 of table A2) which can be used to adjust correctly food consumption when trying to estimate agricultural output.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Wine exports	Olive oil exports	Grain imports	Food surplus/deficit	Agricultural consumption	Surplus/deficit /agricultural consumption (percent)	Food production/ consumption ratio **r**
1550	-	0.7	17.4	-16.7	916.1	-1.82	0.982
1600	0.02	14.2	24.5	-10.3	1965	-0.005	0.995
1650	0.9	18.5	14.3	5.1	1961	0.003	1.003
1700	11.9	27.2	14.4	24.7	1858	1.3	1.013
1750	14.9	15.6*	23.0	7.5	2311	0.3	1.003
1800	128.5	8.3	151.6	-14.8	3360	-0.4	0.996
1850	117.2	4.3	6.95	114.6	3742	3.1	1.031

Table A2. Portugal's external food balance. Cols 1-5 in millions of grams of silver. * interpolated value based on average of quantities for 1700 and 1800 valued at 1750 prices. Source: Costa and Reis (2017)

Online appendix references

Primary sources

We have collected both prices and wages from account (receipts and expenditures) books of the institutions listed below. Almost all were purchasers both of commodities and labor services. Some of them were also sellers of certain commodities produced by them. The account books of these institutions always display: the date of the transaction, the gross and unit value of the commodity, the unit of measurement employed, the quality of the product (for example, coarse or fine paper, mutton, pork or beef) and particular features of the transaction.

In order to proxy missing values we sometimes used a similar product or labor type (e.g. tallow candles for wax candles, or carpenters for masons, both being skilled workers) by adjusting its price using a price ratio with the original product at a nearby year. Furthermore, to complete our Linen series for Lisbon during 1766-1829, we relied on Madureira (1997), listed in the secondary sources section.

Lisbon and its hinterland

Casa da Congregação do Oratório (BPA) Casa da Saúde, Lº 1º Receita e Despesa (AMLx)

Casa dos Contos: Archive of the Court of Auditors

Convent of Nossa Senhora da Luz: National Archive

Convent of Santa Marta de Jesus: National Archive

Convent of Santo Alberto: National Archive

Convent of São Domingos de Lisboa: National Archive

Convent of Carmo, Expenses of the Sacristy: National Archive

Hospital of S. José: National Archive

Hospital of All Saints: National Archive

Holy House of Mercy of Almada: ASCM Almada

Holy House of Mercy of Lisbon: Archive of the Holy House of Mercy of Lisbon

Holy House of Mercy of Lisbon, Shelter: Archive of the Holy House of Mercy of Lisbon

Holy House of Mercy of Lisbon, Foundlings: Archive of the Holy House of Mercy of Lisbon

Monastery of Chelas: National Archive

Monastery of S. Dinis de Odivelas: National Archive

Convent of Santo António da Convalescença: National Archive

Fabric of the See of Lisboa: National Archive

Seminary of Santa Catarina: National Archive

Administration of the Royal Household, Kitchens: National Archive

Porto and its hinterland

For Porto, we rely on Godinho (1955) as a secondary source plus the following primary sources:

Casa Pia Orphanage (administration): Porto District Archive

The See of Porto (revenues and expenditure): Porto District Archive

Colégio dos Órfãos, Daily Expenditure: Porto Municipal Archive

Porto Holy House of Mercy, Jailhouse Expenditure: Archive of the Santa Casa da Misericórdia do Porto.

Porto Holy House of Mercy, General Hospital: Archive of the Santa Casa da Misericórdia do Porto.

Porto Holy House of Mercy, Interments: Archive of the Santa Casa da Misericórdia do Porto.

Porto Holy House of Mercy, Hospice for the Homeless: Archive of the Santa Casa da Misericórdia do Porto

Porto Holy House of Mercy, D. Lopo Hospital: Archive of the Santa Casa da Misericórdia do Porto

Porto Holy House of Mercy, Foundling Home: Archive of the Santa Casa da Misericórdia do Porto

Municipality of Porto, Palace of the Municipality: Porto Municipal Archive Municipal Abattoir, Porto Municipality: Porto Municipal Archive

Coimbra and its hinterland

University of Coimbra, Refectory: Archive of the University of Coimbra

Hospital of the University, Accounts and Administration: Archive of the University of Coimbra

Hospital of Nossa Senhora da Conceição, Accounts: Archive of the University of Coimbra

College of São Pedro, Kitchen: Archive of the University of Coimbra

Colégio de São Pedro, Book of purchases: Archive of the University of Coimbra

Expenditure on the Churches of the Reverend Chapter of the See of Coimbra: Archive of the University of Coimbra

Chapel of S. João da Sé, Revenue and Expenditure: Archive of the University of Coimbra

Chapter of the See, register of expeditures: Archive of the University of Coimbra

Fabric of the College of São Pedro, Registo of Expenses : Archive of the University of Coimbra

Municipal Council of Coimbra, Revenue and Expenditure: Archive of Coimbra

Municipality Works of the Church of the See of Coimbra, Expenses: Archive of the University of Coimbra

University of Coimbra, Receipts and Expenditure: Archive of the University of Coimbra

Hospital of São Lázaro, Receipts and Expenditure: Archive of the University of Coimbra

Holy House of Mercy of Coimbra, Income and Expenditure: Archive of the Holy House of Mercy of Coimbra

Episcopal Mitre of Coimbra, Expenses: Archive of the University of Coimbra

Register of the Granary of the Chapter of Coimbra: Archive of the University of Coimbra

Royal Hospital of Coimbra, Registers of Expenditure: Archive of the University of Coimbra

Évora and its hinterland

For Évora, we rely on Santos (2003) and Godinho (nd) secondary sources plus the following primary sources:

Royal Public Granary of Évora, Accounts: Archive of the District of Évora

Évora Aqueduct, Accounts of the Repairs and Maintenance: Archive of the District of Évora

Repairs of Évora City Streets ,Wages and other Expenditure: Archive of the District of Évora

Casa Pia Orphanage, Revenues and Expenditures: Archive of the District of Évora

Casa Pia, Hospice of Nossa Senhora da Piedade, Accounts: Archive of the District of Évora

Holy House of Mercy, Books and Accounts: Archive of the District of Évora

Convent of Paraiso, Accounts: Archive of the District of Évora

Convent of the Saviour, Accounts: Archive of the District of Évora

College of Nossa Senhora da Purificação: Archive of the District of Évora

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Godinho, Vitorino Magalhães (1955). *Prix et monnaies au Portugal 1750-1850.* Paris: Livre Aurmant Colin

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