‘Goths and Vandals’ or ‘Civilised’ Farmers?
Common Lands and Agricultural Productivity in Early 20th Century Spain

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Abstract

By analysing the different factors affecting labour agricultural productivity in early 20th century Spain, this paper shows that common lands were not detrimental to agricultural development. Even though privatisation fostered output per worker by bringing more land into cultivation, the role of the commons as provider of pasture and fertilising materials counteracted that effect, especially in humid regions. The supposed advantages of dismantling the communal regime are thus not supported by the data, so liberal thinkers were simply wrong or, given who mostly benefited from the sales, were seeking to promote vested interests.

1. Introduction

The privatisation of common lands has traditionally been considered a precondition to foster agricultural productivity and economic growth. Liberal thinkers and agrarian reformers, such as Arthur Young, eagerly advocated for the privatisation of the commons on the theoretical grounds of facilitating the adoption of more advanced farming methods and thus raising efficiency[1]. Even though concerns about the subsequent deprivation of the peasantry, exemplified by the work of the Hammonds (1911), loomed in the public minds, several authors in the 1960s and 1970s supported the liberal views and the inevitability of the privatisation process (Chambers and Mingay 1966; McCloskey 1975)[2]. According to these critics, apart from preventing individual entrepreneurship and encouraging over-exploitation, the ambiguity of the implied ownership rights and the need to reach consensus impeded the diffusion of agricultural improvements[3].

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[1] See Allen (1982) and Allen and O’Grada (1988) for a critical overview of his writings.

[2] Overton (1996, 18-20) provides a recent reaffirmation of this view. According to McCloskey (1975; 1991), although hindering efficiency due to higher transport and transactions costs, the open field system was relatively efficient during the Middle Ages because, in the absence of insurance markets, scattered landholdings provided a risk-insurance mechanism for farmers. However, this institution would be no longer necessary as modern markets for savings and insurance developed.

[3] Individual private rights also permit using land as collateral when accessing the credit market (Federico 2005, 120). The supposed over-exploitation of these resources, known as the ‘tragedy of the commons’ was influentially put forward by Hardin (1968).

However, the negative view surrounding the communal regime has been challenged by a new wave of empirical research that considers common property regimes to be efficient and sustainable, thus revaluating the role that common resources had for the local communities that managed them, and pointing to the compatibility between the persistence of common lands and economic development. In this sense, while British agricultural productivity stagnated during the golden era of the enclosure movement, significant growth had already taken place before that period and improvements in farming methods had been actually implemented in open fields (Allen 1992; 1999; 2001). Likewise, the longstanding belief that rents increased after privatisation is not accounted for by growing productivity, but mostly by inflation and by lands being freed from tithe, not to mention a significant redistribution of the existing agricultural income from tenants to landowners (Clark 1998; Allen 1992)[4]. Recent research on continental commons has also contributed to this positive reassessment of the role of the commons (Vivier 1998; De Moor *et al* 2002; De Moor 2009; Beltrán 2012)[5]. It should be stressed that a crucial factor behind these finding is that, contrary to previous belief, the commons were not open-access resources, but were conscientiously regulated by the village community[6]. Even though the view that enclosure did not foster economic growth has almost become the new paradigm (Allen 2003), the lack of agreement between historians, especially focusing on the British case, still prevents making a definitive assessment of this issue.

This paper seeks to contribute to this debate by analysing the effect that the privatisation of common lands had on labour agricultural productivity in 19th and early 20th century Spain. Displacing the lens of the economic historian to other areas is especially relevant because the 'successful' English example was followed by agricultural reformers all across continental Europe (Clark 1998, 74; Demelas and Vivier 2002). In this sense, by providing pasture, wood, fertilizer and fuel, together with the possibility of temporary cropping, common lands were a key component in the

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4 Instead of focusing on efficiency, other scholars, in the spirit of the Hammonds' pioneering contribution, have stressed the negative impact that the loss of common rights had on the living standards of the lower rural classes (Humphries 1990; Neeson 1993; Tan 2002). These claims, nonetheless, have also been contested (Shaw-Taylor 2001; Clark and Clark 2001).

5 McKean (1986) show that, in Japan, common meadows and forests were also efficiently managed by rural villages for centuries.

6 Access limits were widespread, both in terms of who was entitled to use the commons and what (and how much) could be extracted from them (Allen 2001, 4; De Moor 2009, 4-10). Assemblies of users, by-laws, courts and self-monitoring mechanisms, were set up accordingly to securing the proper management of the system.

organic-based Spanish preindustrial economy (Iriarte 2002)[7]. These communal resources were actually a crucial element of an organic system in which agricultural activity was completely integrated with cattle breeding and forestry. However, the strong liberal bias towards the supposed benefits of enclosure, exemplified by the well-known Young's words comparing 'the Goths and Vandals of open fields' with 'the civilization of enclosures'[8], was widely echoed by Spanish liberalism. The Ministry of Development in 1872, for instance, regarded the communal regime as a harmful remnant of a primitive rural culture which had to be replaced by individual property rights if economic progress wanted to be unleashed[9]. The transformations resulting from the emergence of the new liberal state, together with increasing market pressures, triggered the gradual dismantling of common lands throughout the 19th and early 20th centuries. Despite numerous warnings arising from the local rural communities, the liberal state actively promoted this process, particularly by passing the so-called *General Disentailment Act* in 1855[10]. Interestingly for this paper, the intensity of the privatization process, together with the agricultural performance of each region, was geographically diverse.

In order to analyse the distinctive effect of privatisation on agricultural productivity, this article exploits a data set at the provincial level at 1900 and 1930. The employment of partial productivity measures has been criticised on the grounds that, apart from responding to diverse environmental contexts, different productivity levels may not be the result of technical change or improved efficiency, but the outcome of employing more of other inputs. As Federico (2005, 69) points out, if blessed by a rich endowment of land, output per worker can be relatively high in backward economies or, alternatively, yields per hectare can be higher in densely populated countries which are able to work the land more intensively. Therefore, apart from quantifying the stock of common lands and agricultural productivity, this article draws on data on the different inputs affecting the level of agricultural output. This includes information on agricultural labour force, diverse types of land and capital, both in terms of livestock

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7 Pasture seems to be, nonetheless, the most important use on the commons (GEHR 1999; 2002).

8 Quoted in Allen and O'Grada (1988, 97).

9 In Sanz Fernández (1986, 165). Similar statements by prominent liberal figures can be found all over the 19th century (Moreno 1998; 102; Gómez Urdañez 2002).

10 See Sanz Fernández (1985), GEHR (1994), Balboa (1999), Jiménez Blanco (2002) and Iriarte (2002) for detailed account of this process and an analysis of the factors behind the diverse regional persistence of the communal regime in Spain. Examples of the contemporary opposition to the liberal policies can also be found in Montiel Molina (1992), Linares (1995; 2001), Sánchez Salazar (1995), González de Molina and Ortega (2000), Gómez Urdañez (2002), Serrano (2005) and Lana (2008).

and of modern inputs such as artificial fertilisers and modern ploughs, threshing machines and tractors. By considering the commons as another productive factor, this paper aims to assess their effect on agricultural productivity. Given their role as provider of pasture, the link between common lands and livestock is also included in the analysis. Focusing on cross-regional differences during the period between 1900 and 1930, on the one hand, assures that the potential ultimate effect of the developments taking place throughout the 19th century is taken into account. This approach, on the other hand, also enables the possibility of contrasting the role of the surviving commons in a dynamic period characterised by the increasing diffusion of modern agricultural inputs. The results show that, on average, the different stock of common lands did not explain the differences on the levels of output per worker between provinces. Even though privatisation fostered labour productivity by bringing more land into cultivation, the role of the commons as provider of pasture and fertilizing materials counteracted that effect, especially in humid regions. The supposed advantages of dismantling the communal regime are thus not supported by the data, so liberal thinkers either were simply wrong or, given who mostly benefited from the sales, were seeking to promote vested interests.

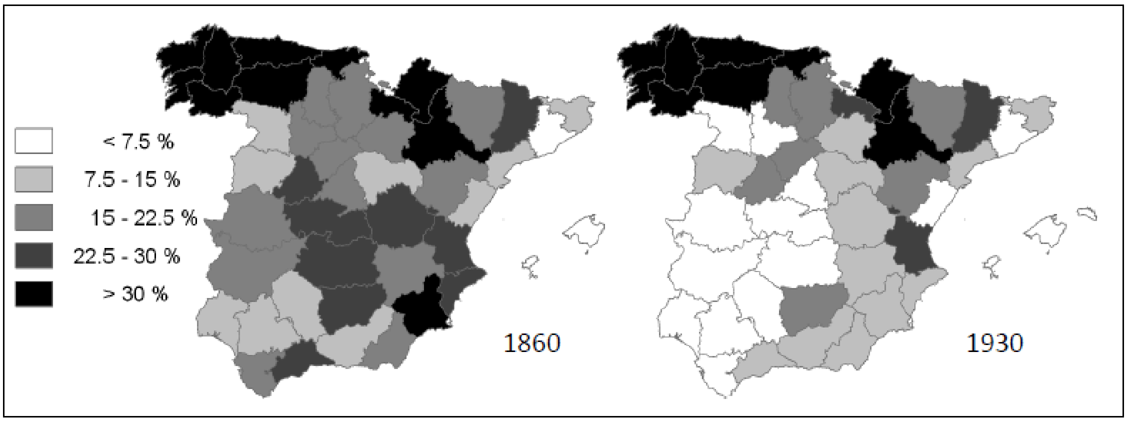
2. Common lands, agrarian reform and agricultural modernisation in Spain

Sharing the same enlightened spirit prevalent in Europe, Spain also bred its own Arthur Youngs. Gaspar Melchor de Jovellanos was actually the leading figure when advocating the need for agricultural reforms in the last third of the 18th century (Sánchez Salazar 1986, 429; Robledo 1993)[11]. His ideas, as reflected in the *Informe sobre el Expediente de Ley Agraria*, included the superiority of private property over other

[11] Interestingly, Jovellanos himself also intensely travelled across Spanish regions and the information gathered, together with his impressions, which he kept in a diary, served as a source of material for his subsequent writings (Caso González 2000). Although it is unclear whether Jovellanos got to directly know Young's work, he shared both the physiocrats' idea about the important role of agriculture and Smith's view on the role of economic freedom (Grice-Hutchinson 1993, 140). However, the discussion of foreign ideas, including those of Young's, was a major activity in the *Sociedades del Amigos del País* (*Societies for Friends of the Country*), economic societies which sprang up all over Spain during the second half of the 18th century in an attempt to find solutions to the nation's economic problems (64). In any case, Young's work and that of other English liberals praising the benefits of enclosure became, directly or indirectly, increasingly influential among Spanish liberals from the late 18th century onwards (Almenar 2000; Sidney Smith 2000). The journal *Semanario de Agricultura y Artes*, for instance, which ran from 1797 to 1808, published translations of Young's work (Almenar 2000, 19). In this sense, after having read Young's writing, Canga Arguelles, a prominent liberal figure who wrote the preamble to the Constitution of 1812, wondered at the ability of the English farmer to increase yields (Sidney Smith 2000, 320). For the reception of English liberalism in Spain, see the different contributions in Fuentes Quintana (2000).

property regimes and, accordingly, the application of market mechanisms for the land factor or, in his own words, 'the suppression of the obstacles which prevent the free action of the individual interest' (Jovellanos 1795, 10). Although some timid attempts were made trying to distribute private user-rights over the commons during the 1760s and 1770s, his political stance only gradually crystallised throughout the 19th century, driven not only by market pressures and ideological considerations, but also by the fiscal problems of both the Crown and municipalities (Sanz Fernández 1985; García Sanz 1985)[12]. This period certainly witnessed a massive privatisation process: around 10 million hectares changed hands between 1770 and 1930 (Rueda 1997)[13]. The privatisation of property rights was also paralleled by a privatisation of the user-rights over the remaining commons. Interestingly, the success of the privatisation process was geographically uneven (GEHR 1994). As shown in figure 1, the dismantling of the communal regime was particularly intense in the half south of the country, while common land persistence was especially high in North-western Spain[14].

FIG. 1 COMMON LAND PERSISTENCE IN SPAIN (percentage of total area)



Source: Artiaga and Balboa (1992), GEHR (1994) and Gallego (2007). No data for the Basque Country is available.

[12] See Sanz Fernández (1985), López Estudillo (1992), Balboa (1999), Jiménez Blanco (2002), Gómez Urdañez (2002) and Iriarte (2002) for detailed summaries of the process during the 19th century. See Nieto (2002, 276-279) for a review of the policies carried out in the 1760s-1770s.

[13] Apart from sales and distributions carried out by legal means, illegal usurpations and appropriations also occurred (López Estudillo 1992, 83-90; Balboa 1999, 111; Jiménez Blanco 2002, 148-149). It is worth mentioning that the private appropriation of the commons is not a new phenomenon of the 19th century but can be traced back to the Modern Period, being this process especially intense in some areas of Andalusia, Catalonia and Madrid (Bernal 1997; Congost 2002; Moreno 2002; Esteve and Hernando (2007). The importance of sales and private appropriations carried out during the first half of the 19th century, the 'silent disentailment', has been stressed by Cabral (1995), Jiménez Blanco (1996) and Iriarte (1998).

[14] The regional picture was definitely more complex. See GEHR (1994) for a more detailed description by region.

The reasons behind this diverse outcome have been analysed elsewhere (GEHR 1994; Jiménez Blanco 2002; Beltrán 2010). What it is interesting to stress here is that Spanish historiography, while regretting the potentially negative effects on the living standards of the rural poor, has mainly agreed with contemporary commentators about the necessity of removing old barriers for land to become a perfectly marketed commodity (García Sanz 1985; Herr 1988; Simpson 1995). The usual argument is that these reforms, although probably not able to significantly change farming methods and raise productivity, would have helped agriculture to feed a doubling population and meet an increasing international demand for Mediterranean products such as wine or olive oil. In this view, the negative consequences of enclosure on the bottom part of the population were viewed as the price to help bringing about the market mechanisms required for a better allocation of resources. However, the appropriateness of having the commons dismantled has been subjected to mounting criticism[15].

By providing pasture, firewood and fertilising materials, as well as constituting a reserve of arable land, the commons were a key element within the agrarian sector, which can only be properly understood as an integrated system where arable, pasture and forest land complemented one another (González de Molina 2001; Iriarte 2002, 34; Moreno 2002, 159; Balboa 1999, 112; Linares 2001; Jiménez Blanco 2002, 141-142; Serrano 2005; Lana 2008)[16]. Importantly, commons were not, as often wrongly assumed, an open-access resource, but were subject to tight formal and informal regulations and enforcement mechanisms, thus ensuring that user-rights were appropriately enjoyed (Moreno 1998; Iriarte 1998; Serrano 2005; Lana 2008).

[15] Broadly speaking, the interpretation of this Spanish historical episode has followed a similar evolution as the one on the English enclosures. While contemporaneous agrarian reformists and liberal elites encouraged privatisation, this stance was strongly resisted in other spheres. This criticism peaked at the end of the 19th century and first decades of the 20th century coinciding with the end of the process and the realization of its poor results (Costa 1898; Carrión 1932). Although heavily influenced by this school of thought, the first wave of professional historians, instead of revaluating the role of the commons, negatively stressed the way the disentailment was carried out, which was seen as a lost opportunity to promote a more equal access to land (Malefakis 1970; Simón Segura 1973; Tomás y Valiente 1978). A different view nonetheless emerged from the 1970s onwards. Perhaps influenced by Anglo-American historians and social scientists, the focus shifted to the potential positive effects of private property and market mechanisms (Herr 1974, 1988; García Sanz 1985; Simpson 1995). However, as pointed in the text, a new wave of researchers has revaluated the contribution of the commons by considering its central role for the sustainability of the whole agrarian system.

[16] Also in Wrigley (1988). Commons in Spain not only indirectly provided manure by feeding livestock, but also by supplying organic fertilizers obtained from the decomposition of different varieties of fern, which was a fundamental element of the Atlantic areas (Balboa and Fernández Prieto 1996; Moreno 2002, 159; Fernández Prieto and Soto Hernández 2010, 244). See also Linares (2001, 24) for a detailed description of how this system was not only integrated through space but also through the different seasons.

Furthermore, the expansion of arable land itself is likely to have quickly run into diminishing returns as marginal lands were put under the plough.

Some studies have especially stressed how the liberal reforms, by favouring arable land and reducing pasture land, may have negatively affected livestock numbers (GEHR 1979, 142-149; Garrabou and Sanz Fernández 1985, 121; González de Molina and Pouliquen 1996, 166). The importance of the commons for maintaining livestock was well-known by the contemporaries. During the 19th century, multiple warnings were raised over the damage that an excessive reduction of the commons would cause on the possibility of keeping adequate numbers of livestock and on agricultural yields (Artiaga and Balboa 1992, 103)[17]. The opposition to the sales was indeed widespread in the responses given by municipalities to the Questionnaire sent by the Parliament in 1851 regarding this issue (Moral Ruiz 1979; Sánchez Salazar 1995; Gómez Urdañez 2002). Those answers stressed the crucial functions fulfilled by the commons mentioned above but especially pointed to the common fear that privatization, and subsequent ploughing up of new land, would break down the mixed husbandry and forestry equilibrium, thus reducing the availability of manure and subsequently agricultural yields. The same idea can be found in the writings of prominent Spanish economists and social reformers such as Joaquin Costa (1911) or Flores de Lemus (1926). Although it seems that livestock density maintained its importance between mid- 18th and mid- 19th century (García Sanz 1994, 91-92), the ploughing of new arable land between 1860 and 1880, coinciding thus with the peak of the privatisation process, may have reached a threshold which made the preservation of livestock numbers impossible. However, this relationship remains unclear because the reduction in pasture could have been counterbalanced by an expansion of fodder crops and by an expanding demand for animal energy (García Sanz 1985, 37). In this sense, the maintenance of the livestock density between 1750 and 1865 would have been compatible with the expansion of arable land due to simultaneous changes in the relative composition of the herd between different species. This process was reflected in the expansion of animals employed in agricultural tasks, especially mules which were particularly well adapted to work in the semi-arid conditions that characterise most of Spain (Garrabou and Sanz Fernández 1985, 121;

[17] An official report about the province of Teruel in mid-19th century is highly eloquent: ‘every first-quality land is already under cultivation; [...] and even some plots which should only be employed as pasture or waste land have unfortunately been ploughed and now they are useless for either of them’ (quoted in Moral Ruiz 1979, 35).

García Sanz 1994, 91-95)[18]. Fuelled by an increasing demand for working animals, meat, and dairy products, livestock numbers recovered previous figures during the first decades of the 20th century, which also led to an expansion of fodder crops (GEHR 1978, 1979).

To sum up, in order to fully examine the effect of privatisation in Spanish agriculture, this paper proposes to examine three different potential channels: firstly, the hypothesis that the commons, as defended by many liberal thinkers, were directly harmful to agricultural productivity; secondly, the possibility that, by expanding the area under cultivation, privatisation positively contributed to a raise in productivity; thirdly, the indirect link through which, by supporting livestock density, these collective resources may have sustained agricultural development.

3. Methodology

3. 1. Common lands and agricultural productivity

The effect of the persistence of common lands on agricultural productivity can be assessed by framing it within the context of agricultural modernisation. Despite being traditionally considered as a failure (Nadal 1973; Tortella 1987), Spanish agriculture nonetheless underwent significant transformations from 1860 onwards (Gallego 1993; Simpson 1995; Pujol *et al* 2001). Not only arable land increased considerably, but the crop-mix evolved towards more market-oriented products. Likewise, artificial fertilisers and modern machinery were increasingly applied, especially during the first decades of the 20th century (Gallego 1986a, 1993). Other improvements were the expansion of irrigation and the reduction of fallow. The geographical distribution of these transformations was nonetheless extremely varied[19]. Agricultural productivity therefore evolved differently depending on the region analysed. By considering the commons as another productive factor, this paper assesses their distinctive effect on agricultural productivity. As pointed out in the introduction, relying on partial productivity measures has been criticised on the grounds that different productivity levels may not be the result

[18] While oxen and mules gained relative importance, sheep became less and less important over time (GEHR 1979, 155-156). The evolution of pigs was different since, although it suffered significantly during the second half of the 19th century, its growth afterwards was extremely fast.

[19] The transformation of the organic agriculture from the last years of the 19th century especially affected the irrigated lands of the Mediterranean periphery and the Ebro valley and the dry-farmed cereal crops of this last region and the north of Castile, together with the presence of big threshing machines in the large exploitations of Cádiz and Seville. As for the rest of Spain, the agrarian sector went on as in the 19th century, increasing their productions and transforming their methods basically leaning on the typical methods of an organic agriculture (Gallego 2001, 43).

of technical change or improved efficiency, but the outcome of intensifying the use of other inputs. However, the model developed here takes into account the relative contribution of different inputs and therefore attempts to avoid that problem. In order to do so, a detailed panel data set on the different inputs involved in the agricultural production process is gathered at the provincial level in two different periods (1900 and 1930) and contrasted with information on agricultural productivity[20].

Drawing on previous literature based on the Cobb-Douglas production function (Hayami and Ruttan 1985; Craig *et al* 1997)[21], an empirical exercise is thus carried out to uncover the causes behind different levels of labour productivity by estimating a model which attempts to explain variation in productivity across regions and over time:

$$ln(Y)_{it} = \beta_0 + \sum \beta_j ln(X_j)_{it} + \sum \delta_i + \alpha_t + u_{it}$$

where Y refers to agricultural productivity measured by output per worker. Given that the levels of output depend on the crop mix, the whole agricultural sector has been considered when accounting for the numerator[22]. This choice is also forced by the impossibility of distinguishing between the fraction of the labour force devoted to either farming, cattle breeding or forestry. Likewise, even though the commons were primarily used as a source of pasture, some of them were allocated for cultivation among neighbours but the available information cannot discriminate between them.

The right-hand side of the equation contains the set of input factors, X_j, potentially contributing to agricultural productivity divided by the size of the agricultural labour force measured by the economically active male agricultural population[23]. On the one hand, three different types of land are considered: arable land, common land and other

[20] The sources and methodology employed to compile the data is presented in the Appendix.

[21] More recently, Martin-Retortillo and Pinilla (2012) applies it to labour productivity differentials across Europe from 1950 to 2000.

[22] In this sense, Kander and Warde (2011, 10) consider that narrowing agricultural practice down to the arable sector prevents a proper assessment of relative agricultural performance because it produces biases towards the practices of any of the regions involved in the comparison.

[23] The lack of consistency between censuses regarding female working population advices to rely only on male workers, a usual procedure both in Spanish and international historical literature (Van Zanden 1991; O'Briend and Prados de la Escosura; Erdozain and Mikalerena, 1999; Nicolau, 2005; Prados de la Escosura, 2008). In any case, employing the total agricultural labour force instead does not change the results of the analysis. Consistency between censuses also recommends using data of 1877 instead of 1860. It seems nonetheless that the population distribution did not change much between 1860 and 1877, while there was enough variation between 1877 and 1900. Ideally, the labour input should be converted into hours actually worked in agriculture but it has not been possible to establish regional differences in working intensity. However, this approach has the advantage of allowing labour productivity to be lower where underemployment was an important issue.

types of land comprising pastures, meadows and uplands[24]. Regarding the arable land and given the importance of considering differences on the quality of different land types (Craig *et al* 1997, 1069), the fraction of land left fallow, as well as the fraction of irrigated land, is included in the analysis as interaction terms. On the other hand, the stock of capital is split up between livestock, measured in live weights, and modern inputs. The latter separately include both artificial fertilisers, measured in equivalent nutrient units of nitrogen, phosphorous and potash, and modern machinery, which accounts for the use of modern ploughs, threshing machines and tractors[25]. Lastly, the error term, u_{it}, represents random disturbances that are uncorrelated with the other variables.

However, inputs' choice and agricultural productivity may depend on external factors, such as the constraints imposed by the economic, social or environmental context where farmers are immersed[26]. In order to deal with this source of endogeneity and given the wide geographical and climatic differences that characterise the diverse Spanish areas, a set of time-invariant environmental and geographical controls, δ_i, will be included in the specification. These variables include average monthly rainfall and its interaction with the coefficient of variation of monthly rainfall, average temperature, altitude, a ruggedness index, the pattern of population settlement, distance to big cities and a dummy for those provinces with access to the sea[27]. Likewise, a dummy for the

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[24] The communal regime in Spain involved two main types of access to the land: a direct but regulated access for all members of the community (*comunales*) or a temporary cession of user-rights to particular individuals in exchange for a monetary income (*propios*). The privatisation process not only affected their property rights but also the way these resources were used and, consequently, the proportion of private user-rights over the remaining commons grew over time (GEHR, 1999). In order to take this distinction into account, adding an interaction term between the stock of common lands and the importance of collective user-rights was considered but, since this variable always turned out to be statistically insignificant and did not affect the outcome of the analysis, it has been removed for the reported results.

[25] The series for modern ploughs, thresher machines and tractors are collapsed together under the category of modern machinery by employing average prices provided by Martínez Ruíz (2000, 90, 144). Although this category omits other type of farm equipment and therefore is a crude indicator of total capital, it can be safely assumed that it is an adequate proxy for the use of modern machinery. Given that the numbers in 1900 require taking some arbitrary decisions, robustness checks using different figures were employed and the results remained unaltered.

[26] The importance of 'state' variables, defined as 'constraints, incentives, available technology, physical environment and political environment', in empirical research dealing with agricultural productivity is analysed in Mundlak (2001, 20).

[27] Rainfall, rainfall variation and temperature account for climatic factors affecting yields. Terrain ruggedness not only influences agricultural productivity by determining the arability of land, but also transportation costs. The altitude variable complements terrain ruggedness in these two aspects and adds the potential for extreme weather. The population settlement pattern may have an effect on the ability to effectively work distant plots. Coastal provinces and distance to big cities, namely Madrid, Barcelona and Bilbao, are intended to complement the urbanisation variable when accounting for access to markets.

year 1930 is also considered in order to account for technological progress or increasing market integration.

Furthermore, in order to account for other potential influences coming from outside the agricultural sector, an augmented model will be considered. On the one hand, Schultz (1964) forcibly contends that, by facilitating the acquisition of useful knowledge, higher educational levels enhance agricultural productivity. The stock of human capital, proxied by literacy rates, is thus included in the model. On the other hand, the existence of market incentives is usually seen as a major factor behind variations in land and labour productivity (Hayami and Ruttan 1985). Demand from the non-agricultural sector both increases the incentives to raise productivity and facilitates the reallocation of surplus labour. Likewise, the industrial sector provides artificial fertilisers and modern machinery, thus easing the constraints imposed by the inelastic supply of internally-generated inputs[28]. The urbanisation rate is employed in order to account for the new opportunities created by economic development. Lastly, there is a wide literature debating how both different levels of access to land and farm size may affect agricultural efficiency (Deininger and Feder 2001; Eastwood *et al* 2010). Inequality in access to the land, and indirectly farm size, is thus accounted as the fraction of landowners over active agricultural population[29].

The previous specification may nonetheless suffer from reverse causality problems, potentially biasing the estimated coefficients. Firstly, although what it is being tested here is the effect of common lands on agricultural productivity, it is plausible that, in those areas with better agricultural potential, privatisation pressures were more intense (Allen 1992; Clark 1998). Secondly, as well as the non-agricultural sector may foster agricultural development, growth in agricultural productivity may increase the demand for industrial products and release labour force for other sectors (Johnston and Mellor 1961; Timmer 2002; Gollin 2010). Thirdly, it may be the case that higher levels of educational attainments foster output per hectare and per worker but a more advanced agricultural economy may also facilitate both the supply and the demand for human capital (Huffman 2001, 374). Lastly, similar arguments can be made regarding the relationship between inequality and agricultural productivity. In order to

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[28] An advanced industrial economy may also contribute to agricultural growth by supporting effective transportation and communication systems and by fostering agricultural research (Hayami and Ruttan 1985, 132).

[29] Data on land ownership is only available for 1860 and 1920. Therefore, linear interpolation is employed to estimate that figure for 1900 and, for 1930, the data on 1920 is used.

address these concerns, an instrumental variable approach, where the previous variables are considered as endogenous and instrumented by their lagged values in 1860 and 1900 respectively, will be implemented.

3. 2. Common lands and livestock

According to the arguments outlined in section 2, the commons played an essential role as providers of pasture, so that link should be analysed in order to fully assess the influence of common lands on output per worker. The contribution of the stock of common lands to support livestock is assessed by estimating the following model[30]:

$$ln(Y)_{it} = \beta_0 + \beta_1 ln(X)_{it} + \sum \theta_j ln(Z_j)_{it} + \sum \delta_i + \alpha_t + u_{it}$$

While Y is the importance of livestock measured in live weight and X the stock of common lands[31], Z_j refers to other potential determinants of livestock numbers as discussed by the literature. Apart from the commons, pastures, meadows and forests owned privately were used to support livestock, so a proxy accounting for this variable is considered. The role of the arable land is however more complex. Although the expansion of cropland may have reduced the stock of spontaneous pastures, it may also have contributed to feeding livestock by producing fodder. Likewise, the proper cultivation of arable land also demanded draught energy, which in turn increased the demand for working animals, especially in a period when tractors were still rare artifacts (Martínez Ruiz 2000)[32]. However, some crops, such as vines or olive trees, made little use of animal power (Kander and Warde 2011, 4-5), so a distinction between the arable land which was employed in these cultivations should be made[33]. Furthermore, it is important to note that customary practices allowed livestock to be fed in the area of arable which was left as fallow. However, Federico (2005, 88) argues that fallow produced only a meager pasture, so any substitute would be welcome, providing that the nutrients extracted from the soil by farming could be reintegrated. The diffusion of new rotations first and of chemical fertilizers later would ease these constraints. In this sense,

[30] Data sources and how the different variables are constructed are explained in the Appendix.

[31] The importance of collective user-rights on the common was also considered but, since it was insignificant in all specification, it was dropped from the model.

[32] In 1932, only an average of one tractor for every 5,128 hectares was available (Martínez Ruiz 2000, 132).

[33] A series accounting for the importance of vines and olive trees have been assembled using data from GEHR (1991).

although the coexistence of organic and modern modes of productions has been widely found in the literature, the diffusion of chemical fertilizers, thresher machines and tractors, by making manure and animal draft energy less necessary, may have reduced the demand for livestock (Knibbe 2000; Olmstead and Rhode 2001). In order to control for these hypotheses, proxies accounting for these potential determinants of livestock density are included.

As in the previous exercise, the potential effect of technological progress or increasing market integration, as well as climatic and geographical differences, is accounted by considering a time dummy for 1930 and a set of time-invariant provincial characteristics[34]. Likewise, an augmented model is preferred again because livestock numbers could have also been influenced by other factors than those purely input-related. The pull of urban markets, for instance, may increase incentives not only to raise agricultural productivity by employing more animals in agricultural tasks, but also to directly increase the production of meat and dairy products (GEHR 1979; Van Zanden 1991). Moreover, commercial networks facilitate the purchase of fodder, easing land, either arable or pasture land, from the constraint to feed animals. These trends will be proxy by urbanisation rates[35]. Arguments similar to those already made in the previous empirical exercise also justify considering literacy rates and levels of access to land when explaining livestock numbers. Lastly, in order to avoid endogeneity and further test the robustness of this analysis, an instrumental variable approach will be implemented using the lagged values of these three variables, together with that of the commons themselves, as instruments.

4. Results

Table I reports the results from estimating the equation explained above[36]. While column (1) shows the estimated coefficients of the baseline specification accounting for the different inputs affecting labour agricultural productivity, columns (2) and (3) add the state variables, together with the climate and geographical controls. The model employed accounts for 85 per cent of the variation in productivity, what suggests that it

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[34] These are the same as in the previous empirical exercise. Climatic conditions, together with geographical features conditioning market access, clearly influenced livestock densities in Spain (Simpson 1995, 103; González de Molina 2001).

[35] Note that the possibility of accessing other markets is also controlled by including distance to big cities and the coastal dummy in the set of controls referred to above.

[36] See Appendix A for the full specification.

fits remarkably well the subject under study. The IV approach, reported in columns (4) to (6), mostly confirms the results obtained using OLS. Contrary to the liberal ideology, the commons did not seem to have been directly detrimental to labour productivity. The coefficients are always positive but hardly statistically significant, although it should be noted that, when the effect of the state variables is controlled for, their positive impact becomes (weakly) significant. The comparison with the estimated effect of pastures and forests held under private property, which is always negative, is also revealing. Columns (3) and (6) highlight that the supposed negative link between the commons and efficiency was perhaps better reflecting the environmental conditions in which these resources were immersed than their actual productivity. Once climate or geographical variables are taken into account, the commons actually seem to have a positive influence on the agricultural sector. Given that the direct effect of livestock on agricultural productivity is already accounted for the specification, this positive impact of the commons is explained, as argued in section 2, by their role as provider of organic fertiliser based on different types of fern, especially in humid Spain[37]. In order to focus now on the role of the commons, the results of the other variables are commented in the next section.

TABLE I. TOTAL LABOUR PRODUCTIVITY, 1900-1930

	Dependent variable: Agrarian output / Active agricultural population					
	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
Commons	0.02 (0.03)	0.03 (0.04)	0.07* (0.04)	0.02 (0.04)	0.03 (0.04)	0.09* (0.05)
Other inputs	Yes	Yes	Yes	Yes	Yes	Yes
State variables	No	Yes	Yes	No	Yes	Yes
Controls	No	No	Yes	No	No	Yes
Observations	89	89	89	89	89	89
R-squared	0.75	0.76	0.85	0.75	0.76	0.85

Robust standard errors between brackets; *, **, or *** denotes significance at 10, 5 or 1 per cent level. A time dummy for 1930 is included in all specifications. Other inputs refer to arable land, including its interaction with the fraction left fallow and irrigated; pastures, meadows and forests; livestock; chemical fertilisers; and modern machinery. All input variables are computed in relation to the labour force and expressed in natural logs. State variables refer to urbanisation, literacy and access to land. The instruments are the lagged values of the endogenous variables (commons, urbanisation, literacy and access to land). Controls include temperature, rainfall, rainfall interacted by its coefficient of variation, ruggedness, altitude, population settlement pattern, distance to Madrid or Barcelona and a coastal dummy. See Appendix A for the full specification.

[37] Including the part of the agrarian output corresponding to forestry as a regressor does not significantly change the results obtained above.

It is true nonetheless that one of the declared aims of the disentailment was to put more land under the plough[38]. The estimated coefficient on arable land is positive and significant and, therefore, by converting pasture and scrubland into cultivated land, privatisation may have indirectly favoured agricultural productivity[39]. Table II shows the results of regressing the fraction of land that became private on the fraction of land that was turned into crop land. Although the privatisation process appears to have contributed to expanding arable land, the strength of that relationship is not that clear. Both variables show a weak positive relationship between 1860 and 1900 but the link between them completely disappears between 1900 and 1930. There is indeed evidence that the persistence of common lands, at least in some regions, was compatible with the expansion of arable land and increasing yields even in the first decades of the 20th century, a period witnessing a significant modernisation process (Iriarte 1998, 135; Balboa 1999, 113; Linares 2001, 43; Serrano 2005, 445)[40]. Studying Navarre, Iriarte (1998, 128) shows that 40 per cent of the ploughing of new land between 1850 and 1935 was carried out in common lands which had been leased out. In any case, given that the estimated coefficient of arable land on output per worker is 0.30, assuming that 34 per cent of the commons which were privatised helped feeding the expansion of crop land during the second half of the 19th century implies that, by potentially encouraging the expansion of land under cultivation, a one per cent decrease in the stock of common lands would have increased labour productivity by 0.102 per cent[41]. However, it should be noted that part of that land was kept fallow and, given that these lands show a negative relationship with output per worker, that figure should be adjusted. On average, in 1900, 36.5 per cent of the arable land was left uncultivated in order to replenish soil nutrients. Therefore, the final opportunity cost of maintaining the commons derived from its potential benefit if put into tillage would be 0.071 per cent[42]. When this figure is compared with the 0.09 per cent effect of common lands on output

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[38] However, apart from the need to expand arable land in dry region in order to meet the increasing demand for agricultural products, an unequal distribution of access to land was behind the massive dismantling of the communal regime in the more unequal regions (GEHR 1994; Jiménez Blanco 2002; Beltrán 2010). Large landowners actually promoted privatisation in those areas because those resources were likely to end up in their hands.

[39] However, there are no reasons why the expansion of arable land could not have equally taking place under a communal regime.

[40] The expansion of cropping on land held in common was also a widespread mechanism to cope with the increasing demand for land during the 18th century (Sánchez Salazar 1988).

[41] Arable land expansion was subject to diminishing returns, so this figure should be taken as a maximum of the actual effect.

[42] The estimated coefficient on the land left fallow is -0.26.

per worker, the supposed advantage of expanding arable land resorting to the commons becomes negligible or even negative[43]. Furthermore, these estimates are based on the period ranging from 1900 to 1930, when the increasing availability of chemical fertilisers made the expansion of crop land on marginal lands potentially more productive. This possibility was seriously limited during the second half of the 19th century when extensification quickly ran into diminishing returns (González de Molina 2001, 69).

TABLE II. ENCLOSURE AND ARABLE LAND EXPANSION, 1860-1930

	Dependent variable: Expansion of arable land (% of total land)	
	1860-1900	1900-1930
Privatisation of the commons (% of total land)	0.34* (0.20)	0.16 (0.54)
Observations	46	46
R-squared	0.06	0.00

Robust standard errors between brackets; *, **, or *** denotes significance at 10, 5 or 1 per cent level. For simplicity, the intercept is not reported.

However, according to the arguments outlined in section 2, the commons played an essential role as providers of pasture. Given that the previous analysis shows that livestock density was significantly associated with higher levels of agricultural productivity, the link between those collective resources and livestock numbers should be explored in order to fully assess the role of common lands on agricultural development. Table III reports the estimation of the model presented in section 3.2. which, taking into account other potential determinants of livestock density, confirms the importance of the stock of common lands in supporting livestock. The estimated coefficient, computed based on information of the early 20th century, should be taken as a minimum. It is likely that, during the second half of the 19th century, the role of the commons was even more important given the lack of alternatives to organic manure and animal draught energy.

[43] It should also be taken into account that the relationship between privatisation and the expansion of crop land was also very weak statistically speaking.

TABLE III. COMMONS AND LIVESTOCK, 1900-1930

	Dependent variable: Livestock (live weight)					
	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
Commons	0.18*** (0.05)	0.24*** (0.06)	0.20** (0.09)	0.23*** (0.05)	0.28*** (0.06)	0.24*** (0.09)
Other variables	Yes	Yes	Yes	Yes	Yes	Yes
State variables	No	Yes	Yes	No	Yes	Yes
Controls	No	No	Yes	No	No	Yes
Observations	89	89	89	89	89	89
R-squared	0.56	0.59	0.72	0.55	0.59	0.69

Robust standard errors between brackets; *, **, or *** denotes significance at 10, 5 or 1 per cent level. A time dummy for 1930 is included in all specifications. Other variables refer to other potential determinants of livestock numbers: pastures, meadows and forests; arable land, including its interaction with the fraction left fallow and the fraction devoted to vines and olive trees; chemical fertilisers; and modern machinery. All these variables, including the commons, are expressed in natural logs. State variables refer to urbanisation, literacy and access to land. The instruments are the lagged values of the endogenous variables (commons, urbanisation, literacy and access to land). Controls include temperature, rainfall, rainfall interacted by its standard deviation, ruggedness, altitude, population settlement pattern, distance to Madrid or Barcelona and a coastal dummy. See Appendix A for the full specification.

Therefore, if this indirect effect is taken into account, the positive assessment of the role of the commons on sustaining agricultural productivity becomes stronger. Given that a one per cent increase in the stock of the commons is associated with a 0.24 per cent increase in livestock numbers, and that the estimated effect of livestock on output per worker was 0.31, the indirect effect of the commons on agricultural productivity would be 0.074. Table IV summarizes the overall influence of the commons on agricultural productivity. These figures should not be understood literally but as an educated guide about the processes at play. In any case, since the two first effects somewhat counterbalanced each other (both in economic and statistical sense), the net effect of the stock of common lands on output per worker remains positive and significant. According to these estimates, the attack on the commons, which mostly took place during the second half of the 19th century, and by which 33.5 per cent of these resources became private (7.7 per cent of the total land), reduced Spanish labour productivity a minimum of 2.3 per cent, a negligible amount but also very far from the advocated potential benefits it was supposed to bring about.

TABLE IV. COMMON LANDS AND LABOUR PRODUCTIVITY, 1900-1930

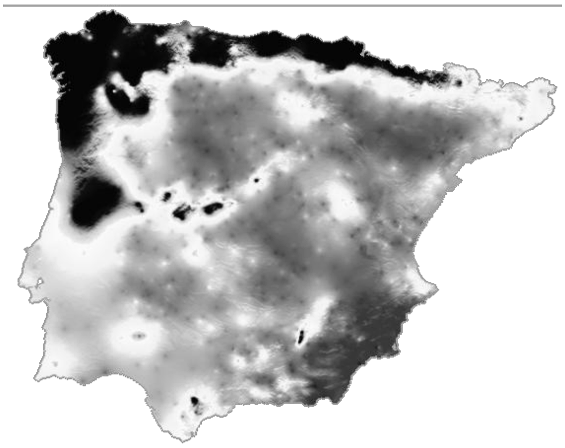
	Direct effect	Crop land potential	Sustaining livestock	Net effect
Estimated effect	0.09*	-0.07*	0.07***	0.09***

*, **, or *** denotes significance at 10, 5 or 1 per cent level. These figures reflect the estimated effect (in percentage points) of a one per cent increase in the stock of common lands.

5. Common lands and agricultural development in arid or semi-arid Spain

Apart from the power of large landowners to promote the dismantling of the communal regime, the analysis of the factors explaining the dissimilar regional outcome of the privatisation process shows a higher degree of privatisation in dry regions (GEHR 1994; Beltrán 2010). In contrast to the intensification process carried out in humid Spain, farmers in arid or semi-arid regions were likely to have been compelled to the extension of cultivated land if production wanted to be increased. The commons in both areas may have subsequently played different roles, so this section explores this possibility by replicating the previous empirical exercise but leaving aside those provinces that enjoyed an Atlantic climate[44]. The importance of aridity in constraining agricultural productivity has been widely acknowledged (Tortella 1994; González de Molina 2001; Gallego 2001), yet cross-country comparative studies often tend to overlook climatic and geographical differences when accounting for the backwardness of Spanish agriculture. The lack of water certainly constituted the primary restraint on agricultural yields in dry regions, which, as figure 2 shows, refers to most of the country. Therefore, and following the typology presented by Gallego (2001), the Atlantic provinces are dropped from the analysis[45]. The results of this exercise are reported in tables V to VII in Appendix A.

FIG. 2. ANNUAL RAINFALL IN THE IBERIAN PENINSULA



Source: Ninyerola, Pons and Roure (2005).

[44] This exercise also serves as a robustness check of the previous results.

[45] The Atlantic regions include the four Galician provinces, Asturias, Cantabria and the three Basque provinces.

Although the results of assessing the relative importance of the different inputs on agricultural productivity remain relatively unchanged from what has been shown in the previous section, some differences are nonetheless significant. Comparing these results with those obtained with the whole sample of Spanish provinces thus unveils interesting conclusions. Firstly, the coefficient of the common lands is never significant here, which suggests that, due to their ability to support a higher volume of biomass, the commons were more productive in humid regions, especially regarding the possibility of providing fern-based fertilisers. In this regard, when a dummy for the Atlantic provinces is interacted with the common lands and added to the regression on the whole sample, its coefficient turns to be 0.29 and highly significant, while the general coefficient on the commons is positive but not statistically significant. This result strongly confirms the importance of the commons in providing non-animal fertiliser in humid regions.

Secondly, the land-labour ratio now has a much larger impact on output per worker, reflecting the logic of extensification in dry areas. Therefore, the possibility of bringing land into cultivation at the expense of commons had a higher potential here[46]. Table VI shows that the estimated relationship between the privatisation of the commons and the extension of crop land between 1860 and 1900 is not statistically significant at the 10 per cent level. However, its p-value is relatively low (0.123), which, given that the coefficient hardly changes with respect to the whole sample, is likely to be the result of the loss of degrees of freedom[47]. Assuming the estimated coefficients would imply that one percentage increase in the stock of common lands entailed an opportunity cost, in terms of the efficiency loss derived of not having transformed those lands into arable lands, of 0.195 per cent. However, as in the previous section, the negative effect of fallow should also be taken into account. On average, these provinces kept fallow 43.5 per cent of the cultivated area in 1900, a figure higher than the national average, what reflects the tougher constraints imposed by the lack of water. The adjusted impact would thus be 0.116 percentage points.

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[46] On the contrary, if we just focused on the Atlantic provinces, the coefficient on arable land would be lower than the one estimated previously (0.30) because excluding those provinces raise the coefficient to 0.64, what implies that the humid regions are counterbalancing that effect leaving the estimated coefficient at 0.30.

[47] It should be noted that, although weakly significant, the coefficient for the period 1900-1930 makes little economic or historical sense due to the fact that the amount of land privatised is really small compared to the expansion of cultivated land. In any case, in order to assess the effect of privatisation, I focus on the second half of the 19th century, which is the period when most of the privatisation took place.

Lastly, table VII confirms that the estimated effect of the commons on sustaining livestock remains virtually unchanged with respect to the estimation that also includes humid regions. Taking all these considerations together, the effect of common lands on labour productivity in dry regions turns out to be different from the impact estimated in the previous section. As shown in table VIII, and assuming that no direct influence exists, the net effect of the stock of common lands on output per worker is now negative: a one percentage increase on the stock of common lands reduced output per worker by 0.06 per cent. However, compared to the catastrophic admonitions of liberal thinkers, the efficiency loss is almost negligible. During the second half of the 19th century, when most of the attack on the communal regime took place, an average of around 41.9 per cent of the commons was privatized in these provinces (around 8.1 per cent of the total land). Therefore, this process contributed to increasing Spanish agricultural productivity by only 2.5 per cent[48]. It should also be stressed that, given that the estimated elasticity of the extension of cultivated land on the dismantling of the commons was hardly significant, this figure should be taken as a maximum. Furthermore, as explained above, the growing accessibility of chemical fertilizers during the first decades of the 20th century made the expansion of crop land possible, while this strategy was much less productive during the second half of the 19th century, and especially so in the poor soils of dry Spain. The analysis carried out in this section also suggests that the diverse persistence of common lands, higher in humid areas and lower in arid or semi-arid regions, is partly explained by the different role that these collective resources played in these different contexts, thus suggesting that, given their respective constraints, farmers all over Spain behaved somewhat sensibly when deciding whether preserving the commons or not. This is not to deny that other factors were also affecting the privatisation process, especially the more unequal access to the land prevailing in Southern Spain (GEHR 1994; Jiménez Blanco 2002; Beltrán 2010).

TABLE VIII. COMMON LANDS AND LABOUR PRODUCTIVITY IN ARID SPAIN, 1900-1930

	Direct effect	Crop land potential	Sustaining livestock	Net effect
Estimated effect	0.06	-0.12***	0.06**	-0.06***

*, **, or *** denotes significance at 10, 5 or 1 per cent level. These figures reflect the estimated effect (in percentage points) of a 1 per cent increase in the stock of common lands.

[48] This figure is obviously based on the total average, so in provinces were privatisation was more intense, the estimated effect would be higher. However, even in Ciudad Real where 20.8 of the total provincial land ended up in private hands, the estimated effect would imply a 1.2 per cent increase in labour productivity, which is still a hardly significant figure given the amount of land transferred.

6. A general view on Spanish agricultural development

The methodology developed here allows testing other hypothesis regarding Spanish agricultural development during this period. In order to have a better sense of the relative importance of the different processes at play, table IX compares the estimated effect of each input on output per worker for the whole and the restricted sample, the actual rate of growth of these variables between 1900 and 1930, together with their subsequent contribution to the labour productivity growth registered during that period. Differences in the use of traditional and modern inputs help to explain the variation in output per worker. Firstly, the estimated elasticity of arable land on labour productivity ranges from 0.30, when the whole sample is used, to 0.63, when the Atlantic provinces are excluded, what points to the importance of the land-labour ratio in explaining agricultural development, especially when climate constraints made intensification difficult. Available land per worker actually increased between 1900 and 1930, thus raising output per worker. The expansion of arable land explains around two thirds of these improvements, while the reduction of the labour force was less dynamic[49], thus highlighting the pernicious effects on output per worker of those regions which were not able to release rural population[50]. Unsurprisingly, although necessary to maintain soil quality, keeping large parts of the land fallow partly offset the positive influence of expanding cultivated land on labour productivity. The improvements in the reduction of fallow meant an additional push to output per worker.

TABLE IX. INPUT INTENSITY AND AGRICULTURAL DEVELOPMENT IN SPAIN, 1900-1930

	Estimated coefficients		Input change (%)		Productivity effect (%)	
	Spain	Dry Spain	Spain	Dry Spain	Spain	Dry Spain
Arable land	0.30***	0.63***	46.76	47.97	12.75***	22.46***
* % fallow	-0.25*	-0.59***	-10.50	-9.97	2.63*	5.88***
Livestock	0.31***	0.26***	61.80	52.68	19.16***	13.70***
Chemical fertilisers	0.09***	0.08***	942.20	925.80	84.80***	74.06***
Modern machinery	0.01	-0.00	3,484	3,214.50	34.84	0.00
Urbanisation	0.01***	0.01**	4.94	4.85		
d_1930	0.17**	0.08				

All input variables are expressed in terms of units per labour force. The effect of the expansion of arable land is computed taking into account the effect of fallow. Given that urbanisation was not expressed in logs in the regression, change here is expressed as the increase in percentage points.

[49] On average, while arable land increased by 23.3 and 25.1 per cent respectively in the two samples considered, the active male agricultural population decreased by 15.5 and 14.2 per cent.

[50] According to recent research, although demand from other sectors contributed to the decline of the agricultural surplus labour, emigration abroad was the main cause behind that process.

The estimated coefficient for livestock ranges from 0.25 to 0.31 and remains largely stable throughout the different specifications, hence reinforcing their reliability. Note however that this variable is both an input and an output, so this coefficient is capturing its impact both through increasing the availability of animal products and through its contribution to farm output in the form of draught energy and organic fertilizer. It seems that livestock inputs appreciably contributed to crop production, so animal traction and manure continued to be a crucial production factor during this period[51]. The importance of livestock as provider of fertilisers and draught power in organic economies has been stressed by Wrigley (1988)[52]. Although chemical fertilisers and mineral-based energy began to slowly substitute these inputs, their importance as source of manure and 'blood engines' was still crucial in the eve of the Civil War (Gallego 1993, 246)[53]. The surge in livestock numbers during the first decades of the 20th century thus helped to sustain agricultural development.

Organic fertilisers were increasingly complemented with chemical fertilizers and this land-saving technology significantly contributed to the variation in observed productivity, as shown by its highly significant and virtually stable coefficient (0.08-0.09)[54]. Bearing in mind that initial levels were very low, the dramatic increase in the supply of these modern inputs was a major source of productivity growth during this period. Taken together, the growing availability of animal manure and artificial fertilizers explains a large part of the rise in output per worker, what supports the idea that the lack of fertilizing capacity was one of the main obstacles to maintaining soil fertility and increasing yields during the 19th century (Simpson 1995, 65; González de Molina 2001, 69).

However, the adoption of labour-saving technologies, in the form of modern machinery, seems to have had no effect on labour productivity. This is somewhat consistent with recent research that shows that animal energy still provided almost 95

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[51] Although I attempted to partition the contribution of livestock by separately measuring its working capacity and their supply of manure, multicollinearity prevented making sense of the results, so they were grouped together in the specification.

[52] The structural scarcity of fertiliser, together with the lack of water, constituted the primary restraint on Spanish agricultural yields, especially in dry regions (González de Molina 2001).

[53] According to Gallego (1986a, 197; 1999), while in 1907 animal manure accounted for around 94 per cent of the total fertilising nutrients supplied to the soil, its importance had only decreased to about 67 per cent in 1933.

[54] Even though it is true that it parted from very low levels, the consumption of modern fertilisers grew at a 8.6 per cent annual rate between 1892 and 1935 (Gallego 1986a, 177).

per cent of the total energy available in agriculture in the eve of the Civil War[55]. This conclusion should be nonetheless taken with caution for at least two reasons. Firstly, although the quality of the data may be a general concern here, the way this variable was constructed may impose further problems[56]. Secondly, the adoption of modern machinery is likely to be correlated to other processes considered in the analysis. In this regard, when only the different inputs are considered, the estimated coefficient of modern machinery, 0.02, is statistically significant at the 5 per cent level (Table II, columns (1) and (4)). Therefore, although the marginal importance of modern machinery in the whole agricultural sector may explain the lack of significance of its estimated coefficient, there might still be certain room for having a positive impact on agricultural development. The implementation of this technology rose spectacularly during the first decades of the 20th century. If a coefficient of 0.01 was assumed, output per worker would have increased by 34.8 per cent. In practice, neither this figure, nor a null effect either, may accurately describe the actual situation and, instead, something in between this range would come closer to reality.

Similar problems with the specification may prevent extracting sounder conclusions from other processes at play. On the one hand, the insignificant coefficient of the importance of irrigation in table I might well be explained by its high correlation with the use of modern fertilizers[57]. These two inputs are highly complementary and it has been argued that yields respond better if used jointly (Kawagoe *et al* 1985, 116;

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[55] The slow diffusion of technical innovations in Spain has been a common place in the literature and a constant source of regret for contemporaries (Gallego 1986a; 1993; Simpson 1987; Martínez Ruíz 2000). Some progresses were nonetheless evident. While, except in some regions, modern ploughs were hardly used in 1900, by 1932 the situation had changed dramatically and, on average, there was one mouldboard for every 10.8 hectares (Simpson 1987, 280). In 1932, around 22.3 per cent of the national cereal production was threshed by mechanical means (Martínez Ruiz 200, 74). However, these figures were rather low in international perspective. In Italy, for instance, there were seven times more thresher machines in the 1930s.

[56] The more problematic variable is the number of modern ploughs in 1900. Although the method is admittedly arguable (see Appendix B), the estimated figures are meant to be close to a lower-bound in order to allow for a substantial increase between 1900 and 1930. Despite this procedure, the estimated regression coefficient of modern machinery shows a minimal contribution to agricultural development even though it also contains information on thresher machines and tractors. Different robustness checks adjusting the assumptions made when constructing this index do not influence the results reported here. Another problem is that some provinces have values of 0 on this variable for 1900, so in order to work with logs, their value has been recoded to 0.001. However, the results hardly change if this variable is included in the model using the original values without logs.

[57] Galor () argues that, in these cases, the variable more poorly measured will lose its significance. Also, the expansion of irrigation between 1900 and 1930 was not that important and the within variation is thus somewhat low. Note also that the major change in irrigation technologies during this period was more qualitative, affecting the reliability of the year-round supply of water, and this is not captured by the proxy employed here.

Federico 2005, 103). Likewise, irrigation is also linked to a highly labour intensity tasks, so although it increases output per hectare, its effect on labour productivity is less clear. In addition, since we are not focusing only in cultivated land but in the total agricultural sector, the positive effect of irrigation on crop yields may have not been visible at this broader level[58]. Interestingly, when the Atlantic regions are excluded in table V[59], the coefficient on irrigated land becomes highly significant except when climate variables are controlled for, thus pointing to the importance of irrigation systems in dry areas.

On the other hand, the estimates on literacy seem to confirm those interpretations stressing that education did not cause an appreciable effect on agricultural productivity in pre-industrial or developing countries (Mitch 1992). However, information on literacy rates apply to the entire population, so it may not able to correctly measure the quality of the rural population[60]. Multicollinearity may also affect our coefficients. Part of the inputs included in the analysis reflects the use of modern techniques, so its implementation implies a prior diffusion of knowledge about that technology. According to Federico (2005, 93), literacy helped farmers to learn how to use a machine or how much fertilizer should be employed, so including all these variables together may hide some of the effects. In this sense, "education is a carrier of technical change" and is expected to be associated with the use of more advanced techniques (Mundlak 2001, 14). Likewise, higher levels of human capital have been widely linked with the reallocation of labour to non-agricultural sectors and outmigration (Huffman 2001, 372; Huffman and Orazem 2007, 2331), so the effect of literacy may either be indirectly captured through higher land-labour ratios or be even misleading, since the population remaining in agriculture may end up having lower educational levels[61].

Lastly, it should be stressed that, from a more general perspective, the explanation of the differences in labour productivity outlined here depends not only on the potential imprecision of the measured inputs, but also on the quality of those factors and on the

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[58] Since modern machinery or fertilisers were applied in arable land, this argument can also be extended to those inputs.

[59] As explained in Appendix B, the data on irrigation structures in North-Western Spain might be problematic and dropping those provinces helps clarifying the relationship between irrigated land and output per worker.

[60] The same concern is found in Kawagoe *et al* (1985, 116).

[61] In agriculture, while the returns to education increase as a country goes from traditional to modern agriculture, accumulated experience seems to work better than schooling in static environments (Huffman 2001, 355, 347). After reviewing the mixed empirical evidence, this author concludes that the weak effect of education in contemporary cross-country studies is more likely to be the result of data problems than of absence of real effects (368).

inputs that have not been possible to quantify. This effect will be either captured by the time dummy or by the different inputs themselves if it is correlated with any of the variables in the model. On the one hand, economic development and technological progress translated into improved implements and machinery, more efficient chemical fertilisers and a potentially healthier labour force[62]. On the one hand, innovations in crop rotations, seed selection or animal breeding, among others[63], may have also influenced agricultural development. Since it has been argued that the expansion of the use of chemical fertilisers and modern machinery is correlated with these other transformations (Gallego 1986a, 211), their effect is likely to have already been captured by the estimated coefficient of those variables. However, according to Pujol (1998), although some biological innovations in seeds and livestock species took place before 1930, their effect was probably unimportant, so the estimated coefficients are likely to have remained virtually unchanged.

Taking all these considerations into account, what it seems clear is that labour productivity differences in early 20th century Spain can be mostly explained by the intensification in the use of traditional inputs, together with crucial boost provided by chemical fertilisers. Increasing land-labour ratios due to the expansion of arable land and, to a lesser extent, the rural exodus, were sustained by the mounting application or artificial fertilisers and by the traditional capacity of livestock to supply manure and workforce. The contribution of modern labour-saving technologies, however, did not seem to have significantly affected this process, either because the diffusion of modern ploughs, thresher machines and tractors was too slow, or because its contribution is missed by the model. The existence of favourable market incentives reinforced these developments in some regions. The effect arising from urbanization and markets incentives is highly significant, evidencing that the demand pull has an important role to play in agricultural development[64]. Although not reported here, distance to big cities and the coastal dummy always turn out to be highly significant in the regressions. Having access to the sea and being closer to Madrid, Barcelona or Bilbao is associated

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[62] Kander and Warde (2011, 4), for instance, argue that technical change, in the form of improved equipment, could have permitted a more efficient application of animal energy.

[63] Other potential influences not taken into account in the specifications, mainly due to concerns about potential endogeneity, are the importance of agricultural cooperatives or the existence of agricultural experimental stations.

[64] A difference in 10 percentage points in the urbanization ratio implies a 10 per cent variation in output per worker. It should also be noted that market forces influenced input intensity, so part of their effect is already captured by the other variables in the model.

with higher agricultural productivity, thus reinforcing the importance of market incentives. Given these results, it seems that the weak development of the Spanish non-agricultural sector was actually an important factor preventing higher rates of agricultural growth, as stressed in the literature (Pinilla 2004; Clar and Pinilla 2009)[65]. Lastly, apart from the increasing productivity arising from changes in input intensity, the coefficient of the time dummy shows that output per worker grew by an additional 17 per cent between 1900 and 1930, which can be somewhat attached to general technological or institutional developments not captured by the model. These advances, however, appear to have been weaker in the dry-farming regions[66].

All these developments are in themselves evidence of a strong agricultural dynamism and show that a recipe based on the adoption of labour-saving technology is not the only path to agricultural growth. Although the identification of progressive developments within Spanish agriculture does not say anything about its relative performance against other European regions, it should be stressed that output per worker increased at an annual rate of 1.82 per cent between 1900 and 1930, a remarkable achievement even for the standards of more advanced countries (Van Zanden 1991, 229)[67]. Returning to the main theme of this article, it should be stressed that the persistence of the commons did not prevent this dynamism to happen and, in some regions, it even contribute to it.

7. Conclusion

The macro evidence presented here shows that Spanish peasants were not those 'Goth and Vandals' subjected to an irrational communal culture as claimed by liberal advocates, but 'civilised' farmers who knew how to adapt their agricultural practices to the constraints imposed by the wider economic, social and environmental context. Common lands were a valuable resource because, apart from sustaining livestock density, they provided significant amount of fern-based organic manure, especially in humid Spain. Admittedly, putting more land under the plough at the expense of the

[65] The urbanisation rate, accounting for the fraction of the population living in cities bigger than 5,000 inhabitants, only grew from 24.3 to 29.3 per cent between 1900 and 1930.

[66] While the coefficient on the time dummy is actually 0.17 and significant at the 5 per cent level when the whole sample is used, it decreases to 0.08 and loses its statistical significance when the Atlantic provinces are omitted from the analysis, thus pointing to the relatively better performance of humid regions in implementing the techniques leading to the agricultural revolution.

[67] See Van Zanden (1991, 229) and O'Brien and Prados de la Escosura (1992, 531) for surveys of agricultural productivity growth in major European countries.

commons increased the productivity of those spaces[68], although this effect should have been even lower during the second half of the 19th century, where most of the attack on the common took place, due to the impossibility of supporting that extensification with chemical fertilisers. In any case, the net gains from privatisation were small or even negative depending on the region analysed. If we took into account the necessary costs of implementing the dismantling of the commons, especially high after 1855 when, by passing the so-called *General Disentailment Act*, the central state became involved in the process, those partial gains would become negligible or even negative. Among others, these costs include commissioning an inventory of these resources, surveying land values, organising auctions, fencing plots, establishing a body of public agronomists and a police civil guard, together with the subsequent legal disputes that the process involved[69].

Furthermore, this article has only focused on the effect of commons on agricultural productivity and has therefore left aside other important and intermingled issues regarding their impact on the daily lives of the Spanish rural population[70]. A complete evaluation of the role of these collective resources in the workings of rural communities involves an even greater positive assessment. In this regard, common lands contributed to complementing household and municipal incomes, thus positively enhancing the wellbeing of the local communities (Beltrán, manuscript). On the one hand, due to their role supporting livestock density and, subsequently, as a source of animal proteins in the form of meat and dairy products, those regions where the dismantling of the communal regime was less intense enjoyed higher levels of life expectancy and heights. On the other hand, these resources contributed to funding the municipal budget, hence facilitating the provision of public goods, especially of schooling. In addition, the services that commons provided also helped to complement households' incomes, what in turn sustained the demand for education. Likewise, the social networks built around the use and management of these resources fostered social

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[68] However, as pointed out before, there are no reasons why the expansion of arable land could not have equally taken place under a communal regime, as the successful cases of Navarre, León and Extremadura testify (Iriarte 1998, 135; Linares 2001, 43; Serrano 2005, 445).

[69] Admittedly, by improving the public knowledge about Spanish natural resources and other potential positive externalities, all these expenses were not a complete waste of public resources.

[70] The widespread conflict and resistance that privatisation generated illustrates how this policy affected a crucial element of the rural economy (De la Torre and Lana 1999; González de Molina and Ortega Santos 2000).

capital and facilitated the emergence of agricultural cooperatives during the first decades of the 20th century (Beltrán 2012).

Not only did agriculture constituted an integrated system where the *ager*, the *saltus* and the *silvus* reinforced each other, but also did the overall functioning of the rural communities. The commons were an essential part of both organisms and removing that component greatly disturbed the whole system, especially if no other institution was established to take over the functions originally fulfilled by them. By only listening to the advocates of privatisation, who were usually defending vested interests, and forgetting the numerous warnings about the potential consequences of this policy, the General Disentailment Act triggered a chain of (not so) unintended consequences. State intervention only began to take care of some of these dysfunctions during the first decades of the 20th century but, by then, most of the damage was already done.

Appendix A

TABLE I. TOTAL LABOUR PRODUCTIVITY

	Dependent variable: Agrarian output / Active agricultural population					
	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
Commons	0.02 (0.03)	0.03 (0.04)	0.07* (0.04)	0.02 (0.04)	0.03 (0.04)	0.09* (0.05)
Arable land	0.18** (0.08)	0.19** (0.08)	0.30*** (0.10)	0.18** (0.07)	0.19** (0.08)	0.30*** (0.08)
* % fallow	-0.34** (0.15)	-0.33** (0.17)	-0.26 (0.16)	-0.35** (0.14)	-0.34** (0.15)	-0.25* (0.14)
* % irrigated	0.07 (0.22)	0.04 (0.22)	-0.24 (0.26)	0.06 (0.23)	0.04 (0.22)	-0.28 (0.22)
Pastures, forests…	-0.08** (0.04)	-0.07* (0.04)	-0.05 (0.04)	-0.08** (0.03)	-0.07** (0.03)	-0.03 (0.04)
Livestock	0.31*** (0.06)	0.29*** (0.06)	0.30*** (0.05)	0.31*** (0.06)	0.29*** (0.06)	0.31*** (0.05)
Chemical fertilisers	0.11*** (0.03)	0.11*** (0.03)	0.09*** (0.03)	0.11*** (0.03)	0.11*** (0.03)	0.09*** (0.02)
Modern machinery	0.02* (0.01)	0.01 (0.01)	0.01 (0.01)	0.02** (0.01)	0.02 (0.01)	0.01 (0.01)
Urbanisation		0.00 (0.00)	0.01*** (0.00)		0.00 (0.00)	0.01*** (0.00)
Literacy		0.00 (0.00)	-0.01*** (0.00)		0.00 (0.00)	-0.01*** (0.00)
Access to land		0.00 (0.00)	0.00 (0.00)		0.00 (0.00)	0.00 (0.00)
d_1930	-0.11 (0.08)	-0.10 (0.08)	0.12 (0.09)	-0.11 (0.08)	-0.11 (0.08)	0.17** (0.08)
Controls	No	No	Yes	No	No	Yes
Observations	89	89	89	89	89	89
R-squared	0.75	0.76	0.85	0.75	0.76	0.85

Robust standard errors between brackets; *, **, or *** denotes significance at 10, 5 or 1 per cent level. All input variables are divided between the active agricultural population and expressed in natural logs. The instruments are the lagged values of the endogenous variables (commons, urbanisation, literacy and access to land). Controls include temperature, rainfall, rainfall interacted by its standard deviation, ruggedness, altitude, population settlement pattern, distance to big cities and a coastal dummy.

TABLE III. COMMONS AND LIVESTOCK

	Dependent variable: Livestock (live weight)					
	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
Commons	0.18*** (0.05)	0.24*** (0.06)	0.20** (0.09)	0.23*** (0.05)	0.28*** (0.06)	0.24*** (0.09)
Pastures, forests…	0.27*** (0.06)	0.29*** (0.06)	0.37*** (0.08)	0.28*** (0.06)	0.28*** (0.06)	0.41*** (0.08)
Arable land	0.38*** (0.10)	0.40*** (0.09)	0.27** (0.13)	0.38*** (0.10)	0.37*** (0.09)	0.12 (0.14)
* % fallow	-0.15*** (0.03)	-0.16*** (0.03)	-0.07 (0.05)	-0.15*** (0.03)	-0.16*** (0.03)	-0.04 (0.04)
* % vines and olive trees	-0.10*** (0.03)	-0.12*** (0.04)	-0.14*** (0.05)	-0.09*** (0.03)	-0.12*** (0.04)	-0.12*** (0.04)
Chemical fertilisers	-0.11* (0.06)	-0.12* (0.06)	-0.04 (0.06)	-0.11** (0.05)	-0.12** (0.06)	-0.04 (0.06)
Modern machinery	0.00 (0.02)	-0.01 (0.02)	-0.01 (0.02)	0.00 (0.02)	-0.01 (0.02)	-0.01 (0.01)
Urbanisation		0.01** (0.00)	0.01** (0.00)		0.01*** (0.00)	0.01*** (0.00)
Literacy		0.00 (0.00)	0.01 (0.00)		0.00 (0.00)	-0.00 (0.01)
Access to land		0.17 (0.37)	-0.14 (0.49)		-0.07 (0.40)	-1.16* (0.65)
d_1930	0.65*** (0.21)	0.66*** (0.23)	0.42 (0.28)	0.65*** (0.19)	0.70*** (0.21)	0.63** (0.29)
Controls	No	No	Yes	No	No	Yes
Observations	89	89	89	89	89	89
R-squared	0.56	0.59	0.72	0.55	0.59	0.69

Robust standard errors between brackets; *, **, or *** denotes significance at 10, 5 or 1 per cent level. All variables expressed in natural logs. The instruments are the lagged values of the endogenous variables (commons, urbanisation, literacy and access to land). Controls include temperature, rainfall, rainfall interacted by its standard deviation, ruggedness, altitude, population settlement pattern, distance to Madrid or Barcelona and a coastal dummy.

TABLE V. TOTAL LABOUR PRODUCTIVITY IN ARID SPAIN

	Dependent variable: Agrarian output / Active male agricultural population					
	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
Commons	-0.04 (0.03)	-0.02 (0.03)	0.06 (0.04)	-0.05 (0.04)	-0.04 (0.03)	0.06 (0.05)
Arable land	0.60*** (0.14)	0.60*** (0.15)	0.62*** (0.17)	0.61*** (0.13)	0.59*** (0.13)	0.63*** (0.14)
* % fallow	-0.72*** (0.21)	-0.68*** (0.24)	-0.58*** (0.20)	-0.72*** (0.19)	-0.66*** (0.21)	-0.59*** (0.16)
* % irrigated	0.66*** (0.24)	0.66*** (0.24)	0.20 (0.26)	0.74*** (0.24)	0.72*** (0.23)	0.24 (0.21)
Pastures, forests…	-0.02 (0.04)	0.01 (0.04)	-0.01 (0.04)	-0.01 (0.04)	0.01 (0.04)	-0.01 (0.04)
Livestock	0.22*** (0.06)	0.17*** (0.06)	0.26*** (0.07)	0.23*** (0.06)	0.17*** (0.06)	0.26*** (0.06)
Chemical fertilisers	0.10*** (0.03)	0.09*** (0.03)	0.08*** (0.03)	0.10*** (0.03)	0.09*** (0.03)	0.08*** (0.03)
Modern machinery	0.01 (0.01)	0.01 (0.01)	0.00 (0.01)	0.01 (0.01)	0.01 (0.01)	-0.00 (0.01)
Urbanisation		0.00 (0.00)	0.01*** (0.00)		0.00 (0.00)	0.01** (0.00)
Literacy		0.00 (0.00)	-0.00 (0.00)		0.00 (0.00)	-0.01 (0.01)
Access to land		0.00 (0.00)	0.00 (0.00)		0.00 (0.00)	-0.00 (0.00)
d_1930	-0.17* (0.09)	-0.19* (0.10)	-0.00 (0.17)	-0.18** (0.09)	-0.20** (0.09)	0.08 (0.18)
Controls	No	No	Yes	No	No	Yes
Observations	77	77	77	77	77	77
R-squared	0.80	0.81	0.87	0.79	0.81	0.86

Robust standard errors between brackets; *, **, or *** denotes significance at 10, 5 or 1 per cent level. All input variables are divided between the active agricultural population and expressed in natural logs. The instruments are the lagged values of the endogenous variables (commons, urbanisation, literacy and access to land). Controls include temperature, rainfall, rainfall interacted by its standard deviation, ruggedness, altitude, population settlement pattern, distance to big cities and a coastal dummy.

TABLE VI. ENCLOSURE AND ARABLE LAND EXPANSION IN ARID SPAIN, 1860-1930

	Dependent variable: Expansion of arable land (fraction of total land)	
	1860-1900	1900-1930
Privatisation of the commons	0.31	1.10*
(fraction of total land)	(0.20)	(0.63)
Observations	40	40
R-squared	0.06	0.08

Robust standard errors between brackets; *, **, or *** denotes significance at 10, 5 or 1 per cent level.

TABLE VII. COMMONS AND LIVESTOCK IN ARID SPAIN

	Dependent variable: Livestock (live weight)					
	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
Commons	0.10*	0.12*	0.14	0.11**	0.14**	0.23**
	(0.05)	(0.06)	(0.09)	(0.06)	(0.07)	(0.09)
Pastures, forests…	0.28***	0.37***	0.25**	0.28***	0.35***	0.14
	(0.08)	(0.09)	(0.10)	(0.08)	(0.08)	(0.13)
Arable land	0.47***	0.46***	0.33**	0.46***	0.45***	0.10
	(0.11)	(0.10)	(0.13)	(0.11)	(0.10)	(0.19)
* % fallow	-0.07*	-0.05	-0.03	-0.08**	-0.06	0.04
	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)	(0.05)
* % vines and olive trees	-0.07*	-0.05	-0.06	-0.06*	-0.05	-0.06
	(0.04)	(0.05)	(0.05)	(0.03)	(0.04)	(0.05)
Chemical fertilisers	-0.09	-0.06	-0.01	-0.09	-0.07	-0.07
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
Modern machinery	0.01	-0.00	-0.00	0.01	-0.00	-0.00
	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
Urbanisation		0.00	0.01		0.00	0.02***
		(0.00)	(0.00)		(0.00)	(0.00)
Literacy		0.01**	-0.00		0.01*	-0.03**
		(0.00)	(0.01)		(0.00)	(0.01)
Access to land		-0.10	-0.09		-0.28	-0.37
		(0.43)	(0.44)		(0.48)	(0.68)
d_1930	0.51**	0.25	0.51	0.52**	0.31	1.44***
	(0.25)	(0.29)	(0.35)	(0.23)	(0.28)	(0.54)
Controls	No	No	Yes	No	No	Yes
Observations	77	77	77	77	77	77
R-squared	0.54	0.59	0.75	0.54	0.58	0.69

Robust standard errors between brackets; *, **, or *** denotes significance at 10, 5 or 1 per cent level. All variables expressed in natural logs. The instruments are the lagged values of the endogenous variables (commons, urbanisation, literacy and access to land). Controls include temperature, rainfall, rainfall interacted by its coefficient of variation, ruggedness, altitude, population settlement pattern, distance to bid cities and a coastal dummy.

APPENDIX B

Total agricultural output

Data on agricultural production is taken from Gallego (1993). This author worked out information gathered by the GEHR (1991) to provide direct estimations of real agricultural output in 1900 and 1930[71]. Interestingly, this author provides disaggregated information on the different agricultural sub-sectors: agriculture, livestock and forestry.

Common lands

Given the hybrid nature that characterized the concept of the "commons" in 19th century Spain, this paper, following Iriarte (2002), identifies common lands as those lands that were collectively managed at the local level, in spite of their ownership being collective, municipal or public. See Beltrán (2010) for a discussion of this assumption.

However, the communal regime in Spain involved two main types of access to the land: a direct but regulated access for all members of the community (*comunales*) or a temporary cession of user-rights to particular individuals in exchange for a monetary income (*propios*). The importance of collective user-rights is measured by the fraction of total uses which were being enjoyed collectively (GEHR 1991). In order to avoid unexplained short-run variations in the data, the average proportion of collective practices over the periods 1861-70, 1903-13 and 1920-32 is used to account for the years 1860, 1900 and 1930, respectively. However, as mentioned in the text, this variable turned out to be statistically insignificant in all specifications so it was dropped from the analysis.

Land

Apart from the commons, two other main types of land are considered. On the one hand, following GEHR (1994, 136), the area of uplands, pastures and meadows (*montes, dehesas y pastos*) which was not held in common is calculated by substracting the total productive land from the arable land and the commons[72]. On the other hand, arable land is also taken from Gallego (1993) and GEHR (1994). However, the intensity

[71] Gallego (1993, 266-267) explains the methodology employed to deflate the figures of 1930.

[72] The total productive land, taken from Gallego (1993), is the result of substracting unproductive areas, such as marshlands, waterways and the space occupied by cities, from the provincial area.

of cultivation depended on the amount of land left fallow and the possibility to resort to irrigation, so the importance of both elements is estimated.

The intensity of rotations is measured through the fraction of land left fallow when cultivating cereals and leguminous plants. While data for 1930 is the average from 1930-1935, the figure for 1900 is the average from the periods 1886-1890 and 1903-1912 (GEHR 1991). Since no data is available for 1860, the data for the period 1886-1890 is used instead. The only exception is the province of Alicante which has no data for 1886-1890, so only the information in 1903-1912 is employed for both 1900 and 1860.

The amount of land irrigated is taken from Comisión de Estadística General del Reino (1859), Junta Consultiva Agronómica (1904; 1918), and Dirección General de Agricultura (1935). Irrigated area for 1930 is calculated by summing up the area irrigated for each crop. Given the lack of information regarding irrigation in some crops in this date, information from 1935 is used (DGA 1935). Since no distinction between dry-farming and irrigation is made for some crops, various decisions have been made. Among the cereals, the JCA (1904, 14) indicates that rice, millet (*panizo*) and pearl millet (*mijo*) are cultivated in irrigated land. Together with these two cereals, all *huerta* crops are assumed to be farmed in irrigated lands, while those fruit trees expected to be cultivated in dry-farming (*secano*) are left out (*higuera*, *almendro*, *castaño*, *nogal* or *algarroba*). Given that alfalfa, a fodder crop, 'was almost exclusively cultivated in irrigated land' (DGA 1935, 398), it is also assumed to be irrigated. In the case of artificial pastures, the percentage under irrigation in 1922, the only date when the area devoted to them is split up into dry-farming and irrigated, is applied to the area in 1935 (GEHR 1991)[73]. Particular crops presenting suspicious figures have been corrected using data from 1930. The figures so calculated are consistent with information coming from regional studies when available. The numbers obtained have been corrected if major flaws where found by looking up at regional studies[74]. For instance, Garrabou and Pujol (1987, 46) reduce the extremely high figure of Lérida in 1900. Also, Pérez-Picazo

[73] In some cases, the information appearing in the governmental surveys is dubious, so regional studies are looked up. For instance, the area devoted to artificial pastures in Asturias in 1922 is only 175 (and not irrigated) when it was 11,175 and 10,539 in 1910 and 1930 respectively (GEHR 1991, 193). Cantabria's artificial pastures are also considered to be cultivated in dry-farming (384). In the Basque country, the reports systematically show that all artificial pasture is not irrigated. Strange trends are also reported for Badajoz and Cádiz (250, 344).

[74] I would like to thank M.J. Prados Velasco, J.A. Serrano, A. Sánchez Picón and D. Soto Fernández and V. Pinilla for their feedback on this issue.

(1997, 104), Sánchez-Picón (1997, 112), Lana (1999, 366), Gallego (1986b) and Ibarra and Pinilla (1999, 407) provide more accurate figures for Murcia, Almeria, Navarra, Logroño and Zaragoza respectively. The divergence between the figures for Cordoba in 1860 and 1900 is likely to be a typo, so the former has also been corrected. Likewise, given its subsequent evolution, Alicante and Albacete present an extremely high number in 1900, so the information in 1914 is used instead. A case in point is that of some Atlantic regions in 1860. The historical source assigns them with large amounts of irrigated area, especially devoted pastures. It seems, however, that some of them were not proper irrigation systems but areas which simply took advantage of the humid weather. Given that these areas do not generally appear as irrigated in the historical sources used for 1900 and 1930, a conservative approach has been taken regarding these regions and, subsequently, the figures for La Coruña, Lugo, Orense and León have been corrected. Lastly, given its subsequent evolution, the source for 1860 is also likely to have overestimated the irrigated area in provinces such as Guadalajara, Palencia, Salamanca, Soria, Teruel and Zamora, so the number in 1900 is used instead.

Labour supply

The size of the agricultural working population is taken from different Population Censuses as collected by Rosés *et al* (2009). A number of problems arise when dealing with the agricultural labour force. Firstly, population censuses do not consistently distinguish between workers employed in agriculture, livestock breeding or forestry. However, as mentioned in the text, this is not a problem when analyzing the whole agricultural sector. Secondly, the lack of consistency between censuses regarding female working population advices to rely only on male workers, a usual procedure both in Spanish and international historical literature (Van Zanden 1991; O'Brien and Prados de la Escosura 1992; Erdozain and Mikalerena, 1999; Nicolau, 2005; Prados de la Escosura, 2008). Consistency between censuses also recommends using data of 1877 instead of 1860. It seems nonetheless that the population distribution did not change much between 1860 and 1877, while there was enough variation between 1877 and 1900.

Livestock

Provincial numbers of horses, mules, oxen, donkeys, pigs, goats and sheep have been taken from the livestock censuses published in 1865, 1905, 1929 and compiled by the GEHR (1991)[75]. These numbers have been transformed into a comparable figure using the live weights coefficients for each species provided by Flores de Lemus in 1917[76]. Given the lack of information, the size of animals and the fraction of them stalled are assumed to be constant throughout the period, although an increase in both variables may be in place, especially during the first decades of the 20th century. Since livestock provided traction and fertilizer, this variable has been partitioned into two: draught energy and organic manure.

On the one hand, given that only horses, mules, oxen and donkeys are able to be employed in agricultural tasks, their numbers have been transformed into potential draught power by applying the coefficients in Simpson (1987, 282)[77]. On the other hand, the fertilizing capacity is measured based on the livestock total live weight calculated above. Following the methodology employed in Gallego (1986a, 225) and Zapata (1986, 1538-1539), total live weights are transformed into tons of manure depending on the intensity in the use of manure in each area[78]. In addition, in order to be able to compare the livestock fertiliser capacity with that of modern fertilisers, its actual fertilising nutrients, in terms of phosphorus pentoxide (P_2O_5), nitrogen (N) and potassium oxide (K_2O), are computed for each type of animal. However, as mentioned in the text, multicollinearity problems prevent employing these series simultaneously in the regression analysis.

Chemical fertilisers

Gallego (1993) provides a complete picture of the provincial consumption of modern fertilizers in 1932. It can be safely assumed that, for 1860, apart from the early diffusion of guano in a few Mediterranean provinces (see below), no chemical fertilizers

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[75] The livestock census of 1891 has being dismissed given its low quality (GEHR 1991, 85; Simpson 1995, 104). Livestock censuses are extensively reviewed in GEHR (1978, 1979). Although the different censuses included young animals, somewhat reducing their reliability, the different studies that have analysed them have stressed their appropriateness to discern patterns and trends (GEHR 1978, 137; García Sanz 1994, 87).

[76] This is a standard strategy in Spanish agrarian historiography. See, for instance, GEHR (1978, 150; 1991, 83), Gallego (1986a), García Sanz (1994, 91), Simpson (1995, 103). Live weight is measured in tons using the following coefficients: horses (0.326), mules (0.326), donkeys (0.172), oxen (0.371), sheep (0.030), goats (0.034) and pigs (0.077).

[77] The draft energy coefficients are the following: 1 for mules, 0.75 for horses, 0.67 for oxen and 0.47 for donkeys. Kander and Warde (2011, 23) employ slightly different coefficients for horses (1) and donkeys (0.33) reflecting perhaps their relative performance in a different environmental context.

[78] Given that there is data on the actual manure consumption in 1919, the intensity on the use of manure is calculated by putting it in relation to the importance of livestock in that date. Logroño, Tarragona and Valencia show dubious figures, so they are calculated as the average of the neighbouring provinces.

were employed in Spanish agriculture. The situation in 1900 is somewhat different. Although their diffusion had been very slow in general terms, the use of these inputs had already progressed in several regions, especially in the Mediterranean coast and the Ebro valley (Gallego 1986a). Although no information at the provincial level is available for 1900, Alonso de Ilera (1909) provides an account of the consumption of chemical fertilisers by province in 1907 and 1908. Given that the use of these inputs at the national level increased between 1900 and 1907/08 (Gallego 1986a, 223), the provincial figures are adapted accordingly assuming that the relative distribution between provinces did not change between those dates. The figures obtained are mostly consistent with the qualitative assessments about the importance of the use of modern inputs in each province given by agronomists in several reports conducted by the central state (Junta Consultiva Agronómica 1891; 1904)[79]. Lastly, following Gallego (1986a, 224), these gross figures are converted into equivalent nutrient units of nitrogen (N), phosphorous (P_2O_5) and potash (K_2O)[80].

However, the assumption that there was no consumption of modern fertilizers in 1860 may be misleading since guano was relatively relevant in some areas during the second half of the 19th century (Gallego 1986a, 175). Guano was intensely used in paddy fields and orange grooves in Valencia (Simpson 1995, 102), a region which, together with Britain, pioneered in importing guano from Africa and South America[81]. Data on guano imports from Catalonia and Valencia is taken from Porqueres (1975). Although no other data is available about other provinces, the bias imposed by this lack of information is negligible due to the fact that these two regions consumed 97 per cent of the total Spanish imports of this fertilizer in 1862/63, a figure which had hardly decreased by 1900[82]. Given the availability of data and the need to prevent unexplained short-run variations, the average figures for the periods 1862/65 and 1895/1900 are employed. The total regional imports are allocated among each province using their relative importance in the consumption of chemical fertilizers in 1900. Finally, in order

[79] Taking into account that two provinces are missed due to the lack of data (Baleares and the Canary Islands), adding up the provincial consumption so computed (122,203 tons) is relatively similar to the national figure (143,000 tons) estimated by Simpson (1995, 120-123).
[80] A standard procedure widely employed in the literature (Hayami and Ruttan 1985; Craig *et al* 1997).
[81] The first shipment of guano arrived in Valencia in 1844, only four years later than to a British port (Mateu 1993, 53).
[82] Around 23,098 tons of guano a year were imported into these two regions between 1862 and 1865. These figures rose during the second half of the 19th century and began to decrease in the 1890s to become unimportant in the first decades of the 20th century (imports between 1895/1900 averaged 17,666 tons a year).

to homogenise these figures with those of chemical fertilisers, the actual chemical content of Peruvian guano is considered: nitrogen (12.3 per cent), phosphorus (9.5 per cent) and potassium (2.5 per cent) (Penhallegon 2012)[83]. In any case, the results reported in the text remain unchanged regardless whether the series on artificial fertilizers contains guano or not.

Modern machinery

A complete census of agricultural machinery, providing quantitative information about all sorts of different machines, is only available for 1932. Given that tracing back all this information for the previous periods is almost impossible, only three types of machinery are used as proxies for the introduction of mechanical innovations in cereal farming: modern ploughs, threshing machines and tractors[84]. Historical sources do not mention any of these innovations around 1860, so it is assumed a value of 0 to all of them at that date. Estimations for 1900 are based on the information provided by agronomists working in each province at the end of the 19th century (*Junta General Agronómica*, 1891)[85]. This qualitative and quantitative information is contrasted with regional regional figures provided by Gallego (1986b), Pinilla (1995), Simpson (1987, 1996), Fernández-Prieto (1997), Martínez Ruiz (2000) and Cabral (2000) and corrected if necessary.

Firstly, except in some regions, modern ploughs were hardly used in 1900 (Simpson 1987, 280). Bearing this in mind, the qualitative assessments provided by agronomists point to whether or not this new equipment was either completely ignored, known by a minority and relatively or widely spread. In order to transform this qualitative information into figures, each province is classified in one of those four groups. The estimated number of modern ploughs is then computed by assuming that, accordingly, each group had 0, 2.5, 5 or 10 per cent of the ploughs existent in 1930[86].

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83 This information is available online from the Oregon State University Extension Service at http://extension.oregonstate.edu/lane/sites/default/files/documents/lc437organicfertilizersvaluesrev.pdf

84 Modern ploughs refer to the sum of different types of mouldboards and multiple-furrow ploughs. They not only achieved more depth but also turned the soil, thus bringing nutrients to the surface (Simpson 1987, 280).

85 The situation in 1890 is representative of 1900 because, apart from involving almost negligible stocks of modern machinery, imports of machinery were only significant between 1875 and 1886 since the end-of-the-century crisis and subsequent protectionism dramatically cut back imports of modern inputs (Gallego 1986a, 209; Martínez Ruiz 2000, 46).

86 When there is some doubt in ascribing one province between two groups, an average is employed.

Secondly, regarding more advanced agricultural machinery, it can be safely assumed that it was not employed in 1860[87]. Although their importance at the national level was still anecdotal by 1900, the diffusion of labour-saving technology had nonetheless progressed in a few provinces, especially in Cádiz and Seville (Martínez Ruíz 2000, 23-24, 49)[88]. Information for 1900 is mostly qualitative but the sources sometimes stated the number of those apparatus that agronomists knew to be operating in a particular province. The total national figure obtained by this procedure is 177. Given that the total number of *locomóviles*, part of the 'set' including a thresher machine, imported between 1862 and 1893 was 310, and that not all of them were likely to be operating in 1890, this figure is plausible (Martínez Ruiz 200, 45-46)[89]. Additional corrections have nonetheless been made. The original source in 1891 points to the existence of numerous thresher machines in the province of Barcelona. Given that Cádiz and Seville, with 30 and 90 thresher machines respectively, were the provinces where this technology was more widespread, a figure of 30 apparatuses is assumed. Likewise, the source indicates the presence of 'some' thresher machines for rice in the province of Valencia in 1891. These 'some' is assumed to be 3[90].

Lastly, the number of tractors is considered in order to account for the motorisation of agriculture. Martínez Ruiz (2000, 114) shows that the first tractors arrived to the peninsula in 1902, so it can be safely assumed that tractors were unknown in 1860 and 1900. Complete quantitative information regarding tractors is available for 1930 (Gallego 1993).

Once a series for each of these inputs is obtained, they are collapsed together under the category of modern machinery by employing average prices provided by Martínez Ruíz (2000, 90, 144).

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[87] The first tests applying steam engines to agriculture in Spain were carried out at the end of the 1850s and throughout the 1860s (Martínez Ruíz 2000, 28; Cabral 2000)

[88] In this regard, while only 2.5 per cent of the national cereal output was threshed using steam power, the province of Seville threshed 19,7 per cent of its cereals by this means (Martínez Ruiz 200, 62). By 1932, the national figure had grown to 22.3 per cent (74).

[89] It should be noted that *locomóviles* and thresher machines were purchased together as a 'set'. In this regard, Clayton, one of the British companies selling this machinery in Spain, exported the same number of threshing machines than 'locomoviles' between 1961 and 1891 (Martínez Ruiz 2000, 45).

[90] A different series was computed grouping threshing machines and corn shellers together but the results of the empirical analysis remain unchanged.

Other variables

Urbanisation is measured as the proportion of population living in cities bigger than 5,000 inhabitants and the gross value added by non-agricultural activities per capita respectively (Tafunell, 2005). Literacy rates are taken from Núñez (1992). Inequality in access to the land is measured through the fraction of landowners over active agricultural population (Dirección General del Instituto Geográfico y Estadístico, 1863; 1922). Since data on land ownership is only available for 1860 and 1920, linear interpolation is employed to estimate the figure for 1900. For 1930, the information on 1920 is used.

Regarding the time-invariant factors, average rainfall, rainfall variation and average temperature come from long-term series data (Goerlich 2010). Likewise, while the ruggedness index quantifies terrain irregularity by comparing the altitude between neighbouring cells using GIS (Goerlich and Cantarino 2011), altitude is measured as the fraction of provincial land over 1,000 metres (Instituto Nacional de Estadística 2001). The population settlement pattern refers to the number of settlements per 100 km^2 (Comisión Estadística General del Reino 1860; Instituto Nacional de Estadística 2001). Lastly, distance to big cities, either Madrid, Barcelona or Bilbao, is computed as the minimum geographical distance from the provincial capital to any of those cities.

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