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The Fruit of the Vine? An Augmented Endowments-Inequality Hypothesis and the Rise of an Elite in the Cape Colony

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Abstract

The arrival of European settlers at the Cape in 1652 marked the beginning of what would become an extremely unequal society. Comparative analysis reveals that certain endowments exist in societies that experience a 'persistence of inequality'. This paper shows that the emphasis on endowments may be overstated. A more general explanation allows for 'non-tropical products' to contribute to the rise and persistence of an elite, and consequently inequality. The focus shifts to the production method used in the dominant industry – in this case, slave labour in viticulture – and the subsequent ability of the elite to extend these benefits to products that were typically not associated with elite formation in other societies (such as wheat). The Cape Colony is used as a case study to show how the arrival of French settlers (with a preference for wine-making) shifted production from cattle farming to viticulture. A large domestic and foreign market for wine necessitated an increase in production volume. Given differences in fixed and variable costs, this resulted in knecht (wage) labour being supplanted by slave labour, an event which institutionalized the elite and ensured that the Cape remained a highly unequal society, with ramifications for present-day South Africa.

Keywords: Elites, South Africa, inequality, VOC, role of government, Engerman and Sokoloff

JEL classification: D31, D63, N37

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Tables and figures appear at the end of the document

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1 Introduction

The arrival of European settlers at the Cape in 1652 marked the beginning of what would later become a highly unequal South African society. The endowments hypothesis put forward by Engerman et al (2000) explains the persistence of high inequality in newly settled societies by emphasizing two 'prerequisite' initial conditions, namely fertile land (coupled with a suitable climate) and a large native population. This paper extends the view of the endowments hypothesis to refocus attention on how industries may operate within this set of conditions. We argue that what is more appropriate in explaining inequality is the production function used in the dominant industry (which does not necessarily have to be a 'tropical cash crop'), particularly in the absence of sufficient capital and arable land. The evidence suggests that while the endowments hypothesis may be broadly valid, the factors proposed by Engerman and Sokoloff are neither necessary nor sufficient conditions for inequality to persist.

The Cape Colony is used as a case study to illustrate these propositions. We use farmers' tax records that were collected by the Dutch East India Company (*Verenigde Oost-Indische Compagne* or VOC) to monitor the production methods within various industries, using different combinations of labour types in respective periods. In particular, we consider the impact of the rise of viticulture on elitism, the role that slavery had in switching production technologies and how the combination of these events altered the approach in the production of other goods.

The arrival of French settlers (with a preference for wine-making and supported by a mercantilist Dutch East India Company) resulted in an exogenous change in the production methods used in an economy that initially focussed only on supplying passing Dutch ships with fresh supplies of food. These developments increased the demand for labour, and necessitated the importation of large numbers of slaves, which were easily sourced along the routes of the passing ships. This particular path of expansion was followed for a number of reasons: first, wine was in high demand, both in the Cape and abroad, and increased production following the arrival of the French satisfied this need; second, while slave labour had higher initial fixed costs than wage labour, greater production volumes lowered the average costs of slave labour (allowing economies of scale to be realized). The Colony acted on these incentives and wage labour was substituted by slave labour. Yet, the decision to import slaves (instead of encouraging immigration from Europe to supplement the labour force) institutionalized the elite, as these economies of scale could only be exploited on the largest farms. In effect, the wine industry became highly concentrated in the hands of a small group of affluent viticulturalists. Even with a *small* native population and relatively *infertile* soil, institutions evolved that resemble the Engerman-Sokoloff initial endowments hypothesis, giving rise to an elite that would protect its economic position (at the cost of other groups). These institutions, later to be reinforced by the mining industry, would ultimately have an effect on present-day South Africa, which has become one of the most unequal economies today.

Furthermore, the production changes in the wine industry served as a catalyst for a metamorphosis in wheat production. The Engermann-Sokoloff conjecture contrasts wheat-producing societies with others, where wheat-producers are usually considered to

be more equal. While this was true during the early period at the Cape, the economies of scale in wine production were also harnessed in wheat production, so that the large slave force was used to further advance the position of the elite by this mode of production. In line with the more conventional predictions, rye and barley production (along with cattle) was not affected by the exogenous change in the economy.

The rest of this paper is structured as follows. Section 2 reviews the Engerman-Sokoloff endowments hypothesis and proposes a simple model in order to generalize these observations to societies with slightly different circumstances. Section 3 highlights the initial conditions prevalent at the Cape, while Section 4 provides an overview of the situation of the Cape elite. Section 5 discusses the data, while section 6 presents empirical evidence to support the adjusted version of the endowments hypothesis. Section 7 concludes.

2 A simple model of an augmented endowments hypothesis

The endowments hypothesis is a dominant view put forward to explain the rise and persistence of inequality in newly settled regions. As the main proponents of this hypothesis, Engerman et al. (2000) and Engerman and Sokoloff (2002; 2003; 2005) have stated two preconditions for the rise of inequality in a newly settled society: 'climate and soil conditions that were extremely well suited for growing crops' or 'extensive native populations' (Engerman and Sokoloff 2002: 3). The colonies located in the tropics were endowed with fertile conditions conducive for growing cash crops, specifically sugar, coffee, cocoa, bananas, tobacco and rubber that are subject to large economies of scale. To realize economies of scale required labour, either sourced from the local population (where this was available) or through slave imports. Moreover, according to Engerman and Sokoloff, in more temperate zones, the availability of a large native population may give rise to industries that are highly labour-intensive. In both settings, as industries that favour labour-intensive production develops, an elite secures economic power which it maintains by creating institutions that promote the status quo, i.e., mostly through securing property rights and limiting access to education. In Latin America and the Caribbean, for example, these production functions resulted in high initial inequality between (colonial) land owners and (native or slave) labourers. In contrast, the temperate zones of the British Americas were generally not conducive to cash crops and also lacked a large native population. In these territories, institutions developed that promoted equity, lowering inequality and improving growth opportunities.

The initial differences in factor endowments is thus key in understanding the way institutions evolved. Over time, institutions would develop in resource rich regions that would reinforce the high levels of inequality, compared to the more egalitarian institutions in North America. Thus, ultimately, the initial wealth distribution was determined by the early endowments of land and labour. This hypothesis is tested by Easterly (2007) who finds that certain types of agricultural endowments do, in fact, explain higher inequality which, ultimately, retards economic development.

We posit that this perspective is too limited. While the Engerman and Sokoloff hypothesis has been critized on various grounds (Coatsworth 2005; 2008; Nugent and Robinson 2005), we argue that the focus on agricultural endowments as a narrow explanatory factor that determines inequality – together with a large native population –

may be oversimplified. Following standard trade theory, the supply (endowments of land, labour, capital and technology creating a comparative advantage) *and* demand (both local and foreign) may determine the dominant industry that emerges (cash crops in the tropics, mining in Mexico, Peru and Bolivia, and wheat and maize in North America). To be sure, fertile conditions, as Engerman and Sokoloff put it, are important for the production of certain commodities (as confirmed by Easterly (2007)). Yet, we posit that a dominant industry arose not simply because of the specific endowments or attributes (on the supply side). Rising product demand, as in the case of the Cape Colony, may also explain why certain industries flourished.

The focus on a large *native* population to exploit economies of scale may also be too narrow. While the availability of slaves (or a large native population) was not a cause of inequality, as shown by Nunn (2007), the prolonged availability of a large and relatively inexpensive labour force, be it from native or slave labour, reduced the costs of slave labour vis-à-vis wage labour. In the absence of less expensive wage labour or capital, plantation owners therefore made an efficient production decision to use slave labour. However, importing slaves had social and political consequences (one could say that it imposed negative externalities), reinforcing the economic power of the elite (owners) and resulting in persistent institutions that protected their position.

We show below that the introduction of viticulture at the Cape caused a greater demand for labour, resulting in higher slave imports. While this is not inconsistent with the Engerman-Sokoloff hypothesis per se (as one could envisage a non-trapical cash crop that makes profitable use of slavery), it does suggest that inequality does not simply depend on either tropical conditions or a large native population, the two preconditions defined by Engerman and Sokoloff. However, we also show that the importation of slaves increased not only the labour-intensity of viticulture (and the subsequent economies of scale), but also that of wheat production at the Cape. This finding is inconsistent with the Engerman-Sokoloff hypothesis. We find that slave production of wheat at the Cape, different to British America, seems to have intensified over the period. While economies of scale were modest in wheat production, the complementarity between wine and wheat production ensured the dominance of an elite, the persistence of severe inequality, and institutions that secured its survival.

We incorporate these amendments to the endowments-inequality hypothesis into a simple theoretical model, drawing on the classic paper by Paul David in explaining the mechanization of reaping in the American Midwest (David 1966). We substitute David's production methods (between the scythe and sickle, and the reaper) with two types of labour available at the Cape – *knecht* (European wage) labour and slave (capital) labour.[1] *Knecht* labour exhibits low initial fixed costs, but relatively higher variable costs. As *knecht* labourers were European immigrants (often Company officials), they required no initial investment. Their wages were, however, above the subsistence costs of slaves (de Chavonnes 1918). Slave labour had high fixed costs (the price of slaves often exceeded the annual wage of a soldier in the Company) but relatively lower variables costs.

1 In this context, slave labour may be seen as a form of capital, which has to be purchased (fixed cost) and maintained (variable cost).

Figure 1 plots the average total cost curves for *knecht* and slave labour, based on the fixed and variable cost structures noted above. Both average cost curves reach a minimum at different respective production volumes; *knecht* labour at Q_k and slave labour at Q_s. A different optimal production volume exists for each type of labour; the minimum cost for slave labour is attained at a larger production volume than for *knecht* labour. This implies that at low production volumes, *knecht* labour would be utilized in production where economies of scale for this input is evident (before Q_k). Slave labour is not employed at all at these low levels of output owing to high fixed costs. However, as the variable costs of wage labour dominate, diseconomies of scale are realized using this mode of production (between Q_k and Q_e). At this moderate level of production, the incentive to substitute to slave labour becomes prominent, but is limited by the ability to cover the high fixed costs of slave labour. Therefore, high demand for products and the ability to expand supply is a prerequisite for this substitution to commence. Given that the VOC was a monopsonist that regulated prices, many farmers did not have the incentive to embark on this transition while their operations remained sufficiently small. At a certain production volume (Q_e) there is no difference between employing *knecht* or slave labour. Beyond Q_e, using slave labour is the more efficient production method, with distinct economies of scale allowing large farmers to extend their production to very high levels (up to Q_s). Effectively, the new production method shifts the limits of the economies of scale that can be realized with wage labour to much higher levels (given that farmers have the capacity to move to these levels of production).

We posit that the initial phase of Dutch settlement (pre-1688) was characterized by low production volumes, with farmers using predominantly *knechts*. The land was not suited to plantation farming as in the tropics, nor were there any known precious mineral deposits (diamonds and gold would only be discovered roughly two centuries later in the interior). Cattle ranching and wheat farming were initially the dominant industries, with the main purpose to supply the passing ships. French Huguenots arrived in 1688, changing the dominant industry from cattle to wine production. Domestic and foreign demand for wine was high. An increase in production volume, however, required more labour. Slaves substituted *knecht* labour as production volumes increased beyond the relevant thresholds. To realize the large economies of scale on wine farms, however, slaves had to be concentrated on large farms. This allowed elites to emerge and inequality increased. The Engerman-Sokoloff premise therefore manifested, but by a somewhat different mechanism to their original hypothesis. Furthermore, wheat production trailed viticulture, being somewhat anomalous in the context of the broader Engermann-Sokoloff framework.

The rest of this chapter aims to uncover these assertions with empirical support. We show that viticulture supplanted cattle and wheat farming after the arrival of the French in 1688 and that slave labour then substituted for *knecht* labour. We furthermore illustrate that economies of scale in wine did emerge after a period of transition, which entrenched an elite. These assertions are framed within the existing literature and recent quantitative work (Guelke and Shell 1983; Fourie and von Fintel 2010).

3 Initial conditions at the Cape

The Cape Colony was first settled in 1652 by the Dutch East India Company (VOC) to serve as a 'halfway' refreshment station along its trading route from Europe to India. Prior to this period, some European ships had passed, but no formal attempts at settling

the territory had been undertaken. At the same time, the local Khoekhoe population lived a nomadic lifestyle. The period under study therefore commences at a time when no formal agriculture had yet been established, nor any formal institutions that governed economic allocation. Therefore, the initial conditions which the Dutch found are an important feature in understanding the trajectory along which this society progressed. More importantly, the manner in which the Dutch responded to these circumstances reveals how institutions that favour an elite can allow inequality to continue well into the future.

When the first nine Company servants were released to become farmers in 1657, the commander of the station, Jan van Riebeeck, had envisioned a community of tight-knit European farmers around the fort, supplying the settlement and passing ships with fresh produce, meat and fuel (wood). Van Riebeeck thought the Mediterranean climate at the Cape to be ideal for small-scale, intensive agriculture, much like that of European farms, with crops planted on a rotational basis and a limited holding of cattle, from which manure was collected for fertilizer (Guelke 1980). Seven years later, however, 15 farmers inhabited the entire area which Van Riebeeck hoped would support more than a thousand families. The farmers – nearly all of them former Company servants – found the climate and soil less than ideal for intensive farming (especially the strong south-westerly winds that time and again destroyed promising crops). They had little previous experience of intensive farming and possessed nearly no working knowledge of the terrain, soil and seasonal weather patterns of the Cape. Many farmers were also discouraged by the continuous theft of cattle and dangers posed by the native Khoekhoe population (Giliomee 2003). This setting therefore does not coincide with the 'fertile conditions' associated with the endowments hypothesis.

In addition, high trade barriers imposed by the Company as a result of its mercantilist approach to international trade provided few incentives for farmers to invest in their farms (de Kock 1924). Low prices offered by the monopsonist Company offered farmers little opportunity for economic profits on their investments. Coupled with the high risks attached to agriculture and the availability of relatively free land, many farmers consequently turned to pastoral farming, expanding the borders of the Colony and curbing Van Riebeeck's vision. Given the scarcity of (native) labour and capital and the restrictions imposed on prices, production shifted to cattle for which land (which was relatively freely available) was the most important input.

Yet, the demand from the passing ships for fresh produce (especially wheat) exceeded what the Company could produce from its own gardens (up until the eighteenth century). While final prices were kept low, the Company decided to lower the input costs of farmers to incentivize production for these purposes. Small loans were provided to the farmers for essential capital equipment (such as cattle, seeds and tools), although this was barely enough to improve the farmers' precarious position (de Kock 1924). More importantly, the Company also began importing slave labour from Angola, and later Mozambique, Madagascar, Indonesia and India (Armstrong and Worden 1988), although the first slaves were mostly used for Company purposes close to the fort.[2]

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2 Local Khoekhoe labour, although probably of greater value than foreign slave labour because of their knowledge about local conditions, could by decree of the Dutch East India Company not be enslaved. As European settlers moved into the interior, the Khoekhoe migrated further North or East, died from European diseases, notably smallpox, or opted to stay on the farms of Europeans in exchange for their services, either as labourers or as servants.

A group of 155 French Huguenots arrived at the Cape in 1688 and settled in the relatively fertile area west of the first mountain ranges (Botha 1939; Leipoldt 1942). The French took up viticulture (although viticulture was not restricted to the Huguenots, and not all Huguenots were viticulturalists). The wine industry was encouraged by the Company, both for local consumption (including the sailors and soldiers on the passing ships) but also as an export product to Batavia, in competition with French exports. In fact, Boshoff and Fourie (2008; 2010) show that the arriving ships at the Cape had a strong impact on the wheat and wine industry. During the eighteenth century, on average 10,000 sailors and soldiers arrived annually at the Cape to refresh after months at sea. Local wine, especially, was in high demand for immediate consumption and for the remaining part of the journey. Wine was also exported, mostly to Batavia because of the poor quality. Yet, some farms (notably Constantia), gained a reputation as high-quality wine makers. Napoleon, by way of anecdote, frequently requested Constantia wine while exiled on St. Helena. The demand for wine was therefore an important determinant of its widespread cultivation after the Huguenot arrival.

Viticulture, however, required a large labour force and was an industry subject to economies of scale if cheap labour with low variable costs could be sourced. The demand for labour was satisfied by increasing slave imports (in all probability, also reducing the price of slaves – the fixed costs – although there are as yet few time-series records of slave prices for this period). In the aftermath of a smallpox epidemic in 1713 that ravaged the Cape population – killing nearly 9 out of every 10 Khoekhoe according to some estimates (Armstrong and Worden 1988; Giliomee 2003) – the VOC requested a response from the Cape Council of Policy on whether additional European settlers were needed at the Cape. A year later, in 1717, seven of the eight members of the Council of Policy petitioned the Company to discourage European immigration in favour of slave imports. The reasons that were given support the notion of elite persistence: the governor, M.P. de Chavonnes, noted the already high levels of poverty among some European settlers ('I am of opinion that more [European] people are not needed, especially as it is feared that poverty may increase') and the lower cost of slave imports ('I am of opinion that the former [farm-labourers] would be more troublesome and expensive than slaves') (de Chavonnes 1918: 88). The shift from cattle to wine and wheat production, therefore, induced a growing demand for labour. Slave labour, as the low-cost alternative, was preferred to wage labour from Europe.

By 1720 the entire area west of the first mountain ranges was inhabited by European settlers. Agriculture (mostly wheat and wine) constituted the major industry, except in Cape Town where some secondary and tertiary activity – especially in service of the passing ships – occurred. Slave labour was the most important input into agriculture and slaves were widely dispersed across the rural Cape (Guelke and Shell 1983).

4 Evidence of a rising elite at the Cape

The distribution of wealth and income at the Cape has so far received scant attention in the economic history (and particularly the cliometric) literature. The qualitative historical perspective has mostly highlighted the plight of *poor* farmers and the adverse conditions which seemed to persist (de Kock 1924; Guelke 1980; Schutte 1980). Yet some historical records document evidence of a rising elite after the turn of the century. Mentzel (1921), a German immigrant, divided the Cape society of the 1730s into four

groups. While the first group included wealthy Company officials and merchants living in Cape Town, the second group were colonists who owned large farms and lived lavishly. The third and fourth groups were poorer settlers, either wheat and wine farmers who owned few slaves, or pastoral farmers of the interior. While many farmers struggled to make a living, it is clear that a small group of farmers became exceptionally wealthy (Giliomee 2003).

Further proof of a growing elite is provided by the imposition of sumptuary laws in 1755. The Governor and his council issued a *plakkaat* (ordinance) with the view of 'limiting the number of horses, carriages, jewels, slaves, etc., which an individual of this or that rank might possess' (Giliomee 2003: 30). Although similar ordinances had been issued earlier, the High Government in Batavia noted in the preamble to the 1755 ordinance that the 'splendour and pomp among various Company servants and burghers … reached such a peak of scandal' that the issue had to be dealt with more seriously (Ross 1999: 9). This sumptuary law was concerned with the display which was allowed on the horses, carriages and guides, and the number of horses used.

Visitors also noted the expensive taste of some farmers. In 1783 a traveller to the region wrote that on several farms he had observed 'nothing except signs of affluence and prosperity, to the extent that, in addition to splendours and magnificence in clothes and carriages, the houses are filled with elegant furniture and the tables decked with silverware and served by tidily clothed slaves' (Naudé 1950). De Kock (1924: 35) argues that such luxurious habits were, in part, a consequence of the social conditions created by slavery.

This qualitative evidence is supported by the only thorough investigation into the gentry of the Cape Colony by Guelke and Shell (1983). Guelke and Shell (1983: 275) rely on aggregated data of the *opgaafrollen* (as introduced in the next section) to show that the minimal majority of 1731 had considerably greater capital assets per household than their counterparts in 1705, although 'the distribution of wealth remained virtually unchanged'. They argue that the increased costs of arable farming (the increase in the price of land and labour, the latter because of the smallpox epidemic of 1713), combined with a generally weak market for grain and wine, put pressure on farmers to improve the efficiency of their landholdings. According to Guelke and Shell (1983), given the extensive agricultural system, such improvement involved getting the most out of each unit of labour rather than increasing output per unit of land. This strategy therefore required the realization of economies of scale in production, which could only be achieved by intensive use of slaves[3] and the amalgamation of farms into larger units that were concentrated in ownership. 'In the period from 1705 to 1731 the ownership of freehold land was increasingly concentrated in the hands of a small elite. In 1731, each member of the minimal majority had, on average, three freehold farm properties' (Guelke and Shell 1983).

Using a per capita asset index for the period 1663 to 1757 to measure inequality in the Cape Colony, Fourie and von Fintel (2010) find empirical support for the Guelke and Shell (1983) hypothesis of a rise in elitism after 1705. Although they find evidence of *declining* inequality after the 1700s, this can be explained by the increase in wealth

3 The use of wage labour meant that the economies of scale that *could* be realized with this input stopped short of the high levels of production that could be achieved by using slaves.

indicators of the poorer section of the distribution. However, a rise in inequality is discernable towards the latter end of the sample, and is driven by the sharp increases in the wealth of a small group of affluent farmers since the 1730s.

5 Measuring and defining the elite

This analysis implements detailed household level data that was collected for the evaluation of tax burdens by the VOC authorities, and have been transcribed from company archival sources. The *opgaafrollen*, as they were called, spanned the entire Dutch occupation, and also extended into British rule. Here the datasets from 1663 to 1773 are analysed. This timeframe includes the period shortly after the Dutch settled at the Cape in 1652, then continues into the period of transition after the arrival of the French Huguenots in 1688, and then traces the period in which both the wine industry and slavery expanded until 1773.

Many households specialized in subsistence non-market production because of the strongly centralized role of the VOC in organizing markets and transactions. For this reason most figures are not measured in monetary values, but represent the fluctuations in production of various goods, as related to the emergence of an elite and their production inputs. This section continues to establish which indicators are important to analyse the hypothesis in light of data limitations. As shown in Fourie and von Fintel (2010), a combination of many indicators can be used to distinguish between the elite and the rest of the population. However, the focus here shifts to the production processes implemented by these households. The full set of indicators is discussed in that paper, although a few are briefly highlighted below.

The *opgaafrollen* did not record the size and types of farms that were cultivated. Given that fertile land was one of the 'prerequisite' endowments for inequality in the Engerman and Sokoloff hypothesis, the data does not allow a full critique of the mechanisms they propose. It is, however, known that the freehold land granted by the VOC to farmers was coupled with restrictions that meant that *burghers* did not have entirely free choice in the acquisition and sale of this property (de Kock 1924: 30). Furthermore, the subsequent loan farm system implied that property rights were not cemented in the colony. This suggests that this particular endowment may not have been as critical in determining the emergence of elites. Information on labour inputs (the other initial endowment) is, however, recorded in detail in the inventories. This is, in contrast to land, an input that could be freely required in the market – particularly in the market for slaves. Furthermore, slavery is known to have been a strong predictor of farming success, particularly in wine and wheat production. In particular, Armstrong and Worden (1988: 137) note that '... [wheat and grain farmers] were the most efficient at exploiting their slaves largely because they made more intensive use of them throughout the year'. They confirm that the correlation between slave ownership and output was the strongest in these sectors. The number of European wage labourers employed by each household is also recorded in the data. No further characteristics of workers of either type are available, so that within each of these types of labour, homogeneity is assumed.

Some portions of this study rely on slave ownership to measure the elite group in the Cape Colony. This decision is supported in the historical literature, which suggests that slave ownership was a strong indicator of wealth. In their definition of the Cape gentry

(elite), Guelke and Shell (1983: 270) use wealth in land, slaves and livestock as measures to estimate the size of the elite, although they maintain that 'the exact limit of the gentry classes is difficult to define using quantitative measures alone'. Giliomee (2003) is more definite, prescribing a lower bound of 26 slaves per household to define the wealthiest category of farmers. Below, an elitist household is defined by three measures to circumvent the subjectivity of this arbitrary threshold. Farming households owning more than 15, 20 and 25 slaves define the respective criteria to be considered as a part of the gentry. However, the commencement of large-scale slave imports more clearly alters the labour intensity of economic activity, and as a result, the structure and growth of output. Slavery as an input into this analysis is more important.

Apart from labour inputs, agricultural indicators dominate the data. This paper uses the outputs rather than the inputs to gauge the economies of scale (with respect to slaves and *knechts*) in each of these sectors over time. The number of vines planted and leaguers of wine produced annually are recorded in detail and form the central focus of this paper. In addition, the number of muids of grains sown and reaped (wheat, barley and rye), are available for analysis. The possession of livestock (cattle, sheep and pigs) are also investigated, particularly because frontier districts were dominated by this type of farming. The number of horses is also included in the data: while highly correlated with slavery and elitism, this is not considered alongside the other livestock variables, as they were important mostly for private use only, and not in the production process or for sale in the market.

It is evident that most variables relate to agriculture, because the *opgaafrollen* were designed to impose taxes on these outputs. However, as noted in Fourie and von Fintel (2010), a large section of this population located mainly in Cape Town registered zeroes for all of the outputs mentioned here. However, these households possessed slaves and weapons (not used in this analysis) and also employed *knechts*. It is therefore evident that other (non-agricultural) business activities are not fully captured in the data, and that these households are likely to constitute a 'non-farmer' population that operated mainly in other commercial activities. Very little useful information is available for this non-farmer population, making it difficult to establish whether they were engaged in activities that secured their positions as a gentry class. However, in light of the theoretical drivers of elitism in settler societies, we are interested in establishing how economies of scale have manifested for *farmers* to secure and maintain their balance of power in economic exchange. Henceforth we only consider this sub-population.

6 Results and analysis

We test the hypothesis that the production method shifted from *knecht* to slave labour after the arrival of the French Huguenots in 1688. As viticulture supplanted cattle farming – and the production volume increased – we would expect to see the use of slave labour increasing vis-à-vis *knecht* labour. We also test whether the increase in slave labour was concentrated on larger farms in order to utilize economies of scale, causing a rising elite and higher inequality. To do this, we use various *opgaafrollen* from 1663 to 1773. For both hypotheses, we consider descriptive statistics which are later enriched by distributional analyses. We also derive micro-level partial correlations between (*knecht* and slave) labour and output types in respective periods. This analysis illustrates that a shift from *knecht* to slave labour preceded the realization of economies of scale once wine farms became large and slave labour used more intensively. These

correlations control for the fact that multiple outputs were produced by the same workers.

6.1 Descriptive statistics

Using the simple Giliomee (2003) definitions of elitism based on the numbers of slaves owned, it is evident from the descriptive statistics (Table 1 and Table 2) that the beginning of the eighteenth century marked a turning point in the proportion of farmers that employed large numbers of slaves (and as a result signalled the advent of a rising gentry). During this period the number of *knechts* (or paid European labour) employed per farmer was in long-term decline. After 1731, when the average farmer owned in excess of six slaves, *knechts* became a virtually insignificant form of labour. This suggests that slave labour substituted paid labour at the Cape, which corresponds to the simple model explained above and qualitative evidence (the decision by the Council of Policy in 1717 to discourage European immigration in favour of slave imports (Reports of de Chavonnes 1918)).

The turn of the eighteenth century not only signified an expansion of slavery, but coincided with the period shortly after viticulture emerged at the Cape. This increase in slave ownership, however, is not directly mirrored by similar increases in the wine production of the average farmer. However, as shown below in the distributional analysis, the maturation of the wine industry did not necessarily benefit the *average* farmer, but promoted the formation of elites over time. It is furthermore evident that after 1738, farmers held relatively fewer heads of cattle, indicating the decline of this particular industry (which is also true at points in the distribution away from the average). In sum, it is evident that there is an apparent concurrent increase in slavery and the emergence of the wine industry, while other forms of agriculture declined relatively.

6.2 Estimates of labour intensity of various outputs

We now turn to estimates of (*knecht* and slave) labour intensity of various industries across time. The estimates in Table 3 and Table 4 present OLS equations that 'explain' slavery. These functions are somewhat unusual compared to the norm. Usually it is assumed that labour (as a production input) influences the production of goods, rather than the other way around (as implied by the estimates). However, the estimates presented below are not conducted to infer causal relationships, but to establish the size of the conditional partial correlation between the size of farmers' slave labour force and the composition of its various production outputs.[4] We regress the total number of slaves owned by each farmer[5] on the various outputs obtained from the land.[6] Each of

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4 It is of course possible to simply calculate bivariate correlations between slaves and particular forms of production. However, it is not possible to apportion slaves to particular outputs in the dataset. For this reason we wish to control for other outputs in determining the correlation between the use of slavery and particular forms of production.

5 Note that the sample has been restricted to those households in the *opgaafrollen* that had positive amounts for at least one agricultural indicator.

6 We exclude horses, as very few farmers reared horses other than for their own use. They were furthermore not exported. However, when this measure is included, it has a strong statistically

the output quantities was standardized[7] so that coefficients may be interpreted as the relationship between one standard deviation of the production input and the number of slaves employed in production. This approach allows us to compare directly which output type employed more labour, given that the other goods were produced. The reason we follow this unconventional approach, is because there is no way of inferring how labour was allocated to the production of different goods with the raw household level data. However, a high coefficient suggests that the relevant product was cultivated using more slaves. The further benefit of this approach is that we are able to see which types of production contributed most to the rise of the elite in different periods (by the supposition that slave ownership signified elitism). However, as a result of this 'incorrect' specification, the automatic danger of endogeneity arises. The lack of any exogenous information in this dataset precludes any sensible instrumental variable estimation.[8]

The first estimates present a pooled OLS model for the entire sample period (1663-1773).[9] To establish whether the impact has remained stable over time, OLS estimates are repeated separately for each year. An increasing coefficient over time suggests that the respective product has become more slave intensive, while small coefficients suggest that slave labour was not important in this mode of production.[10] Declining coefficients can indicate different underlying processes: the first possibility is a substitution of labour away from that industry towards another, while the second is that economies of scale were realized, as *burghers* that owned large farms learnt how to 'get the most out of each slave' (Guelke and Shell 1983). The former, however, is only

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significant relationship with slaves. We should not make the same inferences with regards to these coefficients (as with the other products), but simply acknowledge that just as slaves served as an indicator of elitism, so did horses. This is evident in the limitations that were placed on the illustrious horse carriages under the sumptuary laws. Results are robust to the inclusion and exclusion of horses; the former sets of estimates are not presented here to conserve space.

7 We follow two standardization approaches. First, we standardize each of the outputs in each year which enables comparison across products for each cross section. However, a second approach is required, given that the standard deviation of most products changes across time and loses its meaning in an intertemporal context. For instance, the standard deviation of wine increases across time (signifying higher levels of inequality in the production of this commodity) as is evident in Table 1. The second approach standardizes across the pooled sample to enable intertemporal comparability.

8 We further use 'horses' as the dependent variable to test the robustness of the association between various industries and elitism (these results are not reported here, as they do not contribute to the understanding of the production method component of elite formation). Indeed, the sumptuary laws restricted the numbers of *horses* and carriages owned by the growing elite, and this therefore serves as a good indicator of gentry status. Using horses as the dependent variable supports the notion that the elite emerged from the group of wine farmers. While horses were sometimes used in the production process and would thus give rise to the same endogeneity problems as slaves, at the Cape they were often used to display prestige rather than to produce goods. (The sandy soil of the Cape flats made horses inefficient as a means of transport with farmers preferring oxen as draft animals). Therefore causality from production to the possession of horses is more plausible, suggesting that the large correlations between viticulture and slavery are indeed an indication of elite formation.

9 The *opgaafrollen* can be synthesized into a panel dataset, though the reliability of the matches is not sure without more careful genealogical research. Nevertheless, fixed effects estimates over this period present a similar picture to the pooled OLS estimates.

10 Some coefficients were negative, which makes no economic sense. However, each of these cases was statistically insignificant, so that by implication no slaves were implemented in that specific mode of production.

possible if we notice that another industry's labour intensity rises at the same time as the decline in the initially labour intensive industry.

From the pooled OLS it becomes clear that the wine, wheat, cattle and sheep production are strongly related to the use of slave labour over the whole period, while the other forms of agriculture were less important. The pooled model suggests that a one standard deviation increase in wine production required about 2.5 additional slaves, compared to just more than 2 slaves per standard deviation of wheat production. For livestock these figures are substantially lower. First, therefore, it is evident that the wine and wheat industries contributed most to the establishment of the elite (measured by slave possession).

Given, however, that this economy was still in flux, with new areas being settled and new crops cultivated, these ratios were likely to change over the sample period. Indeed, viticulture was only reported in any significant numbers from 1695. This followed the establishment of Drakenstein with the arrival of French winemakers in 1688. Similar results for each cross section are presented in subsequent columns of Table 3.[11]

Before discussing the behaviour in the various industries, it is important to note that the intercept has risen consistently over the period, except for slight declines from the 1750s when the sumptuary laws were imposed. This represents the average number of slaves that were used in production other than the outputs included in the model. In 1663 insignificant numbers of slaves were used outside of the production methods controlled for, but by 1738, this reach a peak of 7.5 slaves. This highlights the extent to which slavery became an important part of the household, and not only as a production input. This corroborates Naudé's (1950) qualitative evidence of well-dressed slaves serving in the homes of elites.

For the various products, it is evident that for the period 1663 to 1695, few coefficients appear statistically significant, so that it is difficult to discern *any* association between slave labour and all forms of production. This coincides with a period of rising inequality in the Cape Colony (Fourie and von Fintel 2010): it was, however, not attributed to a rising gentry, but to the constant arrivals of immigrants who were relatively poor[12] compared to the existing farming population. Therefore this period signifies a non slave-intensive economy, but also one in which not much economic progress was yet registered. This time coincides with a period where the high fixed costs of slaves and the infancy of the wine industry meant that economies of scale (with respect to slaves) could not yet be realized (before Q_k in Figure 1).

The beginning of the eighteenth century was the commencement of a period of declining inequality, which coincided with limits on European immigration. It is evident in the estimates that this also coincided with a structural break in production methods,

11 These results were all replicated using quantile regressions that centred the model around the respective quantiles that were approximately close to 15, 20 and 25 slaves (our thresholds of elitism). As is evident in the distributional analysis, focusing on explaining the average farmer is not representative of the underlying processes. However, the empirical results do not lead to different conclusions anywhere along the distribution and are not shown here.

12 They arrived with no assets, but over time – through asset accumulation – could converge on the earlier generations of migrants.

with slaves becoming more important. In 1700 one standard deviation of wine production required 1.79 slaves, while cattle production was particularly labour intensive, with one standard deviation of heads of cattle associated with 2.97 slaves. In 1712 wheat farming appeared to join these ranks, requiring 1.70 slaves per standard deviation of production. Most of these figures rose or remained high over the period. To clearly discern the dynamic, Figure 2A plots the relevant standardized coefficients (based on the pooled sample's standard deviation) against time. The picture that emerges is that prior to the eighteenth century, slaves were most intensively used in cattle rearing (though in many periods the coefficients were not statistically significant, suggesting that slave labour was not effectively exploited in any form of production during this time). However, after the arrival of viticulture, attention diverted, so that slaves were substituted to wine and wheat production (now with large and statistically significant impacts, suggesting that the introduction of viticulture coincided with the more intensive use of slave labour at the Cape). In particular, the period from 1712-1738 saw the wine industry expanding and maturing, and the vehicle appeared to be the intensive use of slave labour to establish the viability of this new product. This coincides with a shift in production volumes from Q_k to Q_e in Figure 1, where diseconomies of scale emerged for wage labour, but where the average cost of slaves still exceeded those of *knechts*. A gradual course of substitution followed, but only where either production volume increased to negate the high fixed costs of slaves, or the fixed costs became sufficiently low to switch to the new production methods.

From about 1741 (a period when inequality started increasing as a result of a rising gentry), slave usage per standard deviation of wine production moderated. This signifies the commencement of economies of scale (in terms of slaves) in the lifecycle of the industry. Indeed, as shown below, the later years saw a smaller proportion of farmers in wine production. However, wine farmers started cultivating larger numbers of vines. This picture suggests the intensive use of slavery was required to establish the industry, but that this was followed by economies of scale that benefitted a relatively small proportion of large producers that were to constitute a new elite. This point signifies large scale production (approximating Q_s in Figure 1), where the fixed costs of slaves become negligible relative to the output that they produce.

Figure 2B presents the analysis when standardizing coefficients by the standard deviation of each year (full results are omitted). While the increase in slave intensity in the fledgling stages of the wine industry remains, the subsequent economies of scale are not as dramatic as in Figure 2A. Nevertheless, it does appear that this evidence remains regardless of the estimation strategy. However, the benefit of this view is that other trends emerge that are also found in unstandardized estimates. First it is evident that the slave intensity of cattle and wheat production track each other (at low levels) prior to the introduction of viticulture. For cattle there appears to be a somewhat muted and constant trajectory thereafter, again confirming that this industry did not use slaves intensively relative to the other industries. Although the gradual dominance of wine production over the period is maintained, it furthermore appears that the wine industry appeared to have a spillover effect on wheat production. The latter's slave intensity also increased somewhat until the 1740s and aided its massive expansion (as noted below).

The entire exercise was repeated for other types of labour: *knechts* (hired European servants) and own household members. Across the *whole* sample period, very few coefficients were statistically significant. Therefore, a similar pattern for slave and other

types of labour occurs in the period before the arrival of the French and the wine industry, and prior to immigration restrictions. In contrast, the significant use of slave labour (as opposed to the continued low uptake of other forms of labour) in the wine and wheat sectors *after* the beginning of the eighteenth century is, in this light, indicative of a structural break in these industries alone. This was induced only by the intensive use of slaves following the arrival of the Huguenots, which eventually allowed economies of scale to arise.

6.3 Distributional analyses

To establish that most of these changes in productivity were associated with the elite, it is necessary to consider the (upper tails of the) distributions of the various outputs and slavery. Kernel estimates of probability distributions illustrate the movements of modes and the weights of the upper and lower tails over time, while empirical cumulative distributions indicate whether intertemporal movements were stochastically dominant across the entire distribution.[13]

Figure 3A shows that from the turn of the eighteenth century the immigration and slave policy of the Dutch East India Company first allowed the slave labour force to expand rapidly without requiring an exogenous increase in the settler population to sustain growth in production. It is evident that the bottom weight of the distribution declined across time, but by 1700 a long upper tail emerged (and grew thereafter), suggesting that many farmers had access to large numbers of slaves by this period. Turning to Figure 3B, it is evident that in most years only about 40 per cent of farmers did not own slaves.[14] It is evident, however, that the post-1731 period signifies stochastic dominance, with all percentiles possessing more slaves in that period.

The distribution of *knecht* employment also changed over time, although not in the same manner as slaves (Figure 7). In 1678 about 70 per cent of households did not employ these workers (the lowest figure across the period), while some households employed in excess of 10 *knechts*. This shows that this form of labour was somewhat important at the beginning of the settlement. However, by 1773 more than 90 per cent of farmers did not employ this form of labour. At the turn of the century some households employed nearly 30 of these workers. This was, however, a turning point, with the discouraging of European immigration and the concurrent move to import more slaves. It is evident that in addition to the declining proportion of households employing any *knechts* at all, the upper tail progressively crept downwards, so that larger households also employed very few hired workers. In comparison with the large numbers of slaves employed by the elite in these later periods, the role of *knechts* was diminished to insignificance, with a clear substitution away from this form of labour to the intensive use of cheap slaves.

The distribution of vines planted (Figure 4A) offers an indication of the size of wine farms. In 1692, farms were still relatively small (despite some 'elite' farmers cultivating

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13 Refer to 'poverty dominance' analysis (see Fields (2001), for instance), though in this context we denote stochastic dominance to mean 'better endowed across all quantiles'.

14 1692 is the exception, when more than 80 per cent of farmers did not own slaves – this is a period shortly after the arrival of the French Hugenots, who may not yet have accumulated slaves by that point.

50,000 vines). By 1700 a small rightward shift in the *average* area of land cultivated indicates that the industry gradually became established. However, by 1731, once the impact of slave labour had been cemented, it is clear that a certain group of farmers was able to establish excessively large areas under cultivation (with about 100,000 vines each). Yet, the mode is similar to 1700, suggesting that the *average* wine farmer's area under cultivation remained largely unchanged over the period. However, by 1757 (with the upper tail undiminished), the mode shifts to the right, suggesting that slave labour also had a mild impact on 'average' wine farmers. Nevertheless, a clear elite emerged along the dimensions of both slavery and vine cultivation across a similar time period. This is evidenced in the strong relationship between these measures over this period in Table 3.

Figure 4B adds to this picture by considering the distribution of wine produced. The maximum of the distribution extends from less than 50 leaguers of wine in 1700 to beyond 150 leaguers of wine in 1773, indicating the expansion of production amongst the richest. Given that vine plantations did not expand at the same rate among the elite, it is evident that yields became progressively more efficient in the wine industry. It is furthermore evident that wine production became far more concentrated, with smaller proportions of farmers entering this industry. In 1700 only slightly more than 40 per cent of farmers do not produce wine. This figure increases, so that by 1773 in excess of 80 per cent of farmers do not produce any wine. This suggests that an elite developed around wine production once economies of scale enabled large producers to dominate the industry, while the majority of the farming population became progressively excluded. While some smaller farmers did own slaves, the size of their farms or slave contingents were not large enough to exploit economies of scale.

While the upper tail also shows some emergence in the wheat (Figure 5A) and cattle (Figure 6A) industries, by 1757 a substantial portion of the weight returns to the respective lower tails, suggesting that factors other than slave labour are at play here. It is particularly evident in Figure 6B that a distinct reversal in cattle breeding emerges: 1731 proves to be stochastically dominant, while all subsequent years are dominated by even 1700. This proves the diversion from cattle rearing as the wine industry emerged. Wheat's (Figure 5B) reversion is not as clear as for cattle, with particularly the upper tail still growing larger by 1773. This indicates that some spill-over effects from the wine industry were indeed noticeable, particularly for large elitist farmers. Contrary to the original Engermann-Sokoloff conjecture, it is evident that the elite could also build their fortunes on the back of grains. However, the evidence suggests that this resulted from a spillover from the wine industry, rather than being a catalyst for elite formation.

7 Conclusions

The Cape Colony of the seventeenth and eighteenth centuries shows that severe and persistent inequality may emerge even without the particular set of preconditions prescribed by the original endowments-inequality hypothesis. Instead, the production method (in this case, wage versus slave labour) of the dominant industry is posited here as a mechanism which drives inequality in a newly settled society.

The Cape Colony provides a unique case study of a region where high inequality persisted, but which was neither located in the tropics, nor had any meaningful mineral deposits (diamonds and gold further inland would only be discovered roughly two

centuries after the arrival of Europeans). Van Riebeeck's plan for agricultural production at the Cape Colony was based on a European blueprint – by all expectations this should have resulted in small scale farming, with low levels of concentration and inequality, as emerged in North America. This did not materialise, both as a result of harsh conditions and a shortage of capital and labour. The French settlers of 1688 were viticulturalists. Finding the area conducive to wine making (and supported by a large local market of travelling sailors and soldiers and the VOC's desire to compete with French wine exports), viticulture soon became the dominant industry at the Cape.

Soon after the arrival of the Huguenots, slave labour was encouraged while wage labour (European immigration) declined. (While slaves were already imported since 1658, the first slaves were mostly used by the Company). Theoretically we posit that two factors might drive this – the demand for Cape wine (both domestically and abroad) and greater economies of scale in production that could be utilized in viticulture relative to livestock. The slave population on the farms rose rapidly after 1717, when the Council of Policy at the Cape officially requested slave imports rather than European immigration.

Our quantitative results show that by the middle of the century, a group of wealthy farmers had indeed emerged, owning large farms and many slaves and realizing economies of scale. Small-scale viticulture had declined, with poor farmers substituting wine for other crops, or moving into the interior. Of greater relevance for the Engerman-Sokoloff hypothesis, this production method (slave labour instead of wage labour) may have been transferred to other crops (especially wheat). Whereas they argue that crops like wheat or barley did not allow slaves to be profitably used, we show that the introduction of wine-making at the Cape shifted the production function of *both* wine and wheat production to become more slave intensive, supporting a growing elite.

The elite could now influence economic and political policy in accordance with their wishes. The political protests of the Patriots movement in the 1770s provide some evidence to support the discontentment of the small farmers against the institutions imposed by the elite. These institutions would change slowly, even after the British took over the governance of the Cape in 1795 and again in 1806. Although debatable, one could argue that the discovery of diamonds (1867) and gold (1885) reinforced these institutions, again because of the production method and economies of scale of the (now newly) dominant industries. Indeed, modern-day South Africa's economy is characterized by one of the highest Gini coefficients internationally, which is reinforced by high levels of industrial concentration and a strong union contingent that sees its role as protecting unskilled workers against the business elite. Yet, as we argue here, the high level of inequality in South Africa today is, at the extreme, the fruit of the Cape Colony vine.

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Figure 1: The relationship between scale and the type of labour used

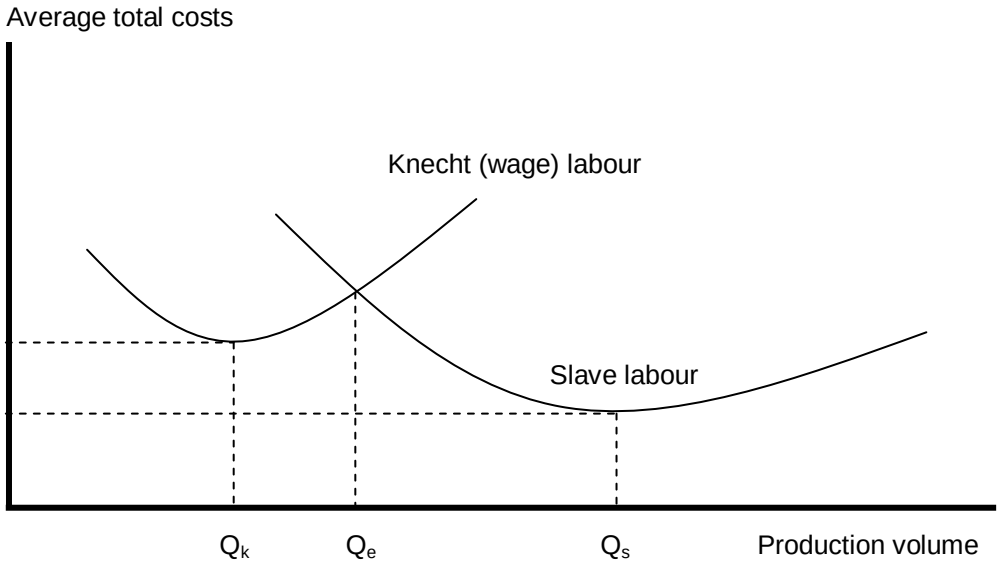


Table 1: Descriptive statistics

	Total slaves per farmer		Knechts per farmer		Elite1 (own >15 slaves)*		Elite2 (own >20 slaves)*		Elite3 (own >25 slaves)*		Wine in leauguers produced per farmer		Wheat (in muids) reaped per farmer		Rye (in muids) reaped per farmer		Barley (in muids) reaped per farmer	
Year	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
1663	0.83	1.72	1.52	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	197.30	278.73	0.00	0.00	0.00	0.00
1670	1.26	2.99	0.86	1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1678	2.71	3.94	0.53	1.41	0.02	0.14	0.01	0.08	0.00	0.00	0.00	0.00	11.05	23.74	1.86	4.14	1.21	3.02
1682	2.31	3.46	0.54	1.96	0.02	0.15	0.00	0.00	0.00	0.00	0.00	0.00	21.28	44.27	3.20	10.00	6.43	12.49
1685	2.61	4.21	0.59	0.93	0.02	0.15	0.01	0.11	0.00	0.00	0.00	0.00	18.98	28.65	3.19	5.02	2.07	3.73
1688	3.13	4.91	0.25	0.61	0.06	0.24	0.00	0.00	0.00	0.00	0.00	0.00	9.57	19.82	2.85	7.57	0.46	1.69
1692	1.36	4.28	0.29	0.82	0.03	0.16	0.01	0.09	0.00	0.07	0.00	0.00	25.89	46.21	5.30	8.63	1.76	7.70
1695	2.00	4.83	0.28	0.58	0.03	0.18	0.01	0.12	0.01	0.09	0.56	9.16	12.06	24.84	1.78	4.27	0.32	2.16
1700	2.99	5.69	0.25	1.80	0.03	0.18	0.02	0.15	0.01	0.10	4.19	6.25	14.25	24.23	9.15	15.04	2.18	8.44
1702	2.47	4.94	0.25	1.91	0.03	0.18	0.01	0.11	0.01	0.09	3.11	6.76	11.54	22.43	5.18	10.95	1.07	4.34
1712	4.37	7.87	0.22	0.72	0.07	0.26	0.05	0.23	0.03	0.18	2.65	5.85	30.86	54.20	1.75	7.48	2.94	16.87
1719	5.71	8.33	0.24	0.86	0.11	0.31	0.07	0.25	0.04	0.21	2.76	5.86	29.27	55.13	0.61	3.17	2.87	15.43
1731	6.32	9.41	0.14	0.48	0.12	0.32	0.08	0.27	0.05	0.22	2.87	7.22	29.28	62.49	3.10	12.99	4.71	18.57
1738	6.99	9.72	0.18	0.60	0.14	0.35	0.09	0.28	0.06	0.24	1.44	4.56	23.06	61.12	1.91	8.29	3.75	19.58
1741	6.00	9.86	0.16	0.59	0.11	0.31	0.07	0.26	0.06	0.23	1.36	5.03	38.18	103.43	2.70	13.13	3.98	20.55
1752	4.23	7.24	0.07	0.37	0.07	0.25	0.04	0.19	0.03	0.16	2.90	7.46	21.66	62.35	1.33	6.87	3.30	16.26
1757	5.36	8.01	0.10	0.39	0.10	0.31	0.06	0.24	0.04	0.19	3.32	9.21	13.17	42.71	0.40	2.53	2.03	11.97
1762	5.12	7.80	0.10	0.38	0.09	0.29	0.06	0.23	0.03	0.18	2.50	8.39	18.85	56.93	0.48	4.69	2.32	13.62
1773	5.65	8.93	0.06	0.35	0.10	0.30	0.07	0.25	0.05	0.21	4.65	14.62	20.74	58.20	0.05	0.93	1.33	9.61
Total	4.94	8.17	0.17	0.79	0.09	0.28	0.05	0.23	0.04	0.19	2.58	8.47	22.54	61.88	1.84	8.14	2.58	14.31

Notes: Sourced from the *opgaafrollen*. Only farmers, defined as households owning at least one agricultural input or producing at least one agricultural output, are included in the sample. Various definitions of elites* are depicted here, adapting the definition of Giliomee (2003). Each is a dummy variable with the relevant threshold number of slaves indicated above, and the descriptive statistics of these variables* are proportions.

Table 2: Descriptive statistics

	Cattle (head per farmer)		Sheep per farmer		Pigs per farmer		
Year	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Freq.
1663	11.70	12.31	44.74	50.40	2.22	2.76	23
1670	8.57	16.05	134.09	111.96	1.43	2.28	35
1678	21.40	30.47	122.98	209.17	1.10	2.25	146
1682	15.83	18.60	124.73	175.98	2.27	3.25	83
1685	26.07	36.89	170.60	254.33	0.85	2.29	85
1688	20.34	31.94	239.26	390.69	1.09	2.23	68
1692	22.77	45.96	213.00	491.44	0.62	2.09	222
1695	23.71	41.67	145.03	351.66	1.93	4.31	268
1700	35.08	50.81	192.73	441.58	1.38	4.04	271
1702	37.01	63.79	201.20	534.24	1.11	3.10	336
1712	42.76	63.08	281.54	446.70	0.58	2.60	404
1719	39.09	55.82	162.28	333.21	2.59	5.70	407
1731	42.32	59.20	218.54	300.28	1.50	5.81	568
1738	49.35	79.79	221.65	349.73	1.36	6.59	685
1741	41.53	72.23	193.04	335.65	0.91	4.99	759
1752	29.24	53.36	158.84	258.98	0.47	3.66	595
1757	27.81	44.65	150.47	232.83	0.40	3.73	884
1762	22.87	38.10	135.94	244.57	0.43	4.55	962
1773	23.71	38.92	177.29	284.24	0.31	3.84	1129
Total	32.19	54.76	180.52	328.05	0.90	4.49	7930

Notes: Sourced from the *opgaafrollen*. Only farmers, defined as households owning at least one agricultural input or producing at least one agricultural output, are included in the sample.

Table 3: OLS estimates of the composition of the slave labour force (dependent variable: number of slaves per farming household)

	Pooled	1663	1670	1678	1682	1685	1688	1692	1695	1700	1702	1712
Wine	2.546								0.000	1.790	0.762	3.382
	(12.18)**								(0.06)	(2.25)*	(1.14)	(5.30)**
Wheat reaped	2.158	-0.032		2.690	1.898	3.387	0.627	-1.150	-0.110	1.489	0.852	1.707
	(10.82)**	(0.50)		(1.35)	(1.82)	(1.66)	(0.35)	(1.45)	(0.08)	(1.81)	(1.00)	(3.66)**
Cattle	1.532	-0.896	-1.405	2.035	4.816	1.856	3.246	0.590	4.878	2.974	0.834	0.754
	(7.28)**	(0.71)	(0.87)	(2.11)*	(2.19)*	(1.62)	(1.78)	(1.05)	(3.67)**	(3.69)**	(1.33)	(1.30)
Sheep	1.179	6.746	5.179	0.801	0.885	0.809	1.768	1.592	0.381	1.001	1.364	2.061
	(5.03)**	(1.25)	(2.13)*	(1.33)	(0.97)	(1.31)	(2.50)*	(3.23)**	(0.75)	(2.28)*	(2.76)**	(4.24)**
Pigs	0.678	-0.536	-0.345	1.829	-0.091	0.501	0.431	2.696	0.021	0.151	1.262	0.556
	(3.70)**	(0.62)	(0.30)	(1.88)	(0.16)	(0.36)	(0.37)	(2.14)*	(0.07)	(0.40)	(2.57)*	(1.26)
Barley reaped	0.458			-1.017	-1.146	-0.353	0.818	1.243	-1.014	0.258	0.570	0.511
	(3.14)**			(0.58)	(1.85)	(0.19)	(0.09)	(2.86)**	(0.56)	(0.70)	(0.78)	(1.44)
Rye reaped	-0.243			-1.664	0.027	-0.953	-0.853	0.006	-0.678	-0.472	-0.126	0.464
	(1.50)			(1.62)	(0.09)	(0.89)	(0.80)	(0.03)	(1.21)	(1.81)	(0.76)	(1.40)
Constant	4.936	3.531	1.425	3.570	4.273	3.190	3.859	1.611	2.604	3.069	2.465	3.370
	(76.32)**	(1.19)	(1.32)	(7.63)**	(4.02)**	(6.12)**	(2.53)*	(5.69)**	(7.12)**	(9.85)**	(11.31)**	(17.62)**
Observations	7930	23	35	146	83	85	68	222	268	271	336	404
R-squared	0.50	0.32	0.30	0.30	0.46	0.34	0.46	0.53	0.62	0.69	0.64	0.71
Robust t statistics in parentheses												
* significant at 5%; ** significant at 1%												

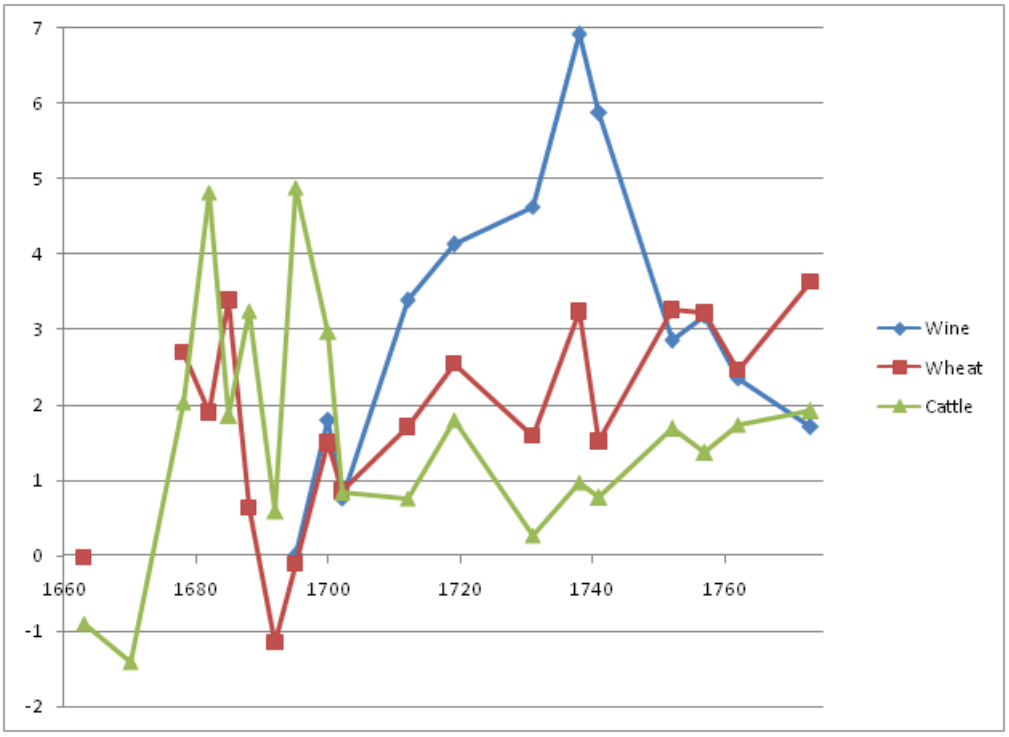
Notes: Own estimates from the *opgaafrollen*. Only farmers, defined as households owning at least one agricultural input or producing at least one agricultural output, are included in the sample. The dependent variable is the total number of slaves per farming household (it is not scaled nor centered). The explanatory variables are scaled and centered by the standard deviation and mean of the pooled sample, so that coefficients represent the number of slaves associated with a standard deviation change in production across the period, controlling for other forms of production. Estimates are not deemed to be causal but represent partial correlations between slave usage and production methods, taking into account that slaves worked on farms with other forms of production. Fixed effects estimates are similar to pooled OLS estimates, but are omitted because the panel constructed from this data has not been verified by genealogical research.

Table 4: OLS estimates of the composition of the slave labour force (dependent variable: number of slaves per farming household)

	1719	1731	1738	1741	1752	1757	1762	1773
Wine	4.127	4.627	6.916	5.869	2.855	3.176	2.346	1.701
	(4.38)**	(7.88)**	(7.87)**	(7.00)**	(7.46)**	(10.54)**	(6.86)**	(8.02)**
Wheat Reaped	2.550	1.582	3.232	1.515	3.257	3.211	2.460	3.627
	(3.58)**	(2.42)*	(6.00)**	(5.49)**	(9.68)**	(7.02)**	(7.95)**	(8.62)**
Cattle	1.794	0.272	0.966	0.772	1.681	1.363	1.732	1.915
	(2.91)**	(0.40)	(1.61)	(1.34)	(3.31)**	(2.21)*	(2.20)*	(2.56)*
Sheep	-0.278	1.993	0.610	1.491	1.027	2.139	1.822	0.619
	(0.39)	(2.65)**	(0.70)	(1.67)	(1.86)	(3.43)**	(2.68)**	(1.07)
Pigs	0.403	0.938	-0.236	1.051	-0.295	-0.142	1.082	0.339
	(0.87)	(3.64)**	(0.41)	(1.69)	(0.67)	(0.22)	(4.79)**	(0.72)
Barley Reaped	0.232	0.561	0.434	0.410	-0.291	-0.101	0.543	-0.364
	(0.65)	(1.71)	(0.84)	(1.14)	(0.95)	(0.45)	(2.21)*	(0.48)
Rye Reaped	2.280	0.099	-0.139	-0.416	0.087	0.332	0.930	0.685
	(1.87)	(0.47)	(0.26)	(0.79)	(0.37)	(0.50)	(2.92)**	(0.84)
Constant	5.293	5.484	7.502	6.279	4.322	5.910	6.110	5.812
	(13.79)**	(23.54)**	(25.51)**	(22.21)**	(25.12)**	(24.42)**	(27.61)**	(18.40)**
Observations	407	568	685	759	595	884	962	1129
R-squared	0.54	0.63	0.56	0.59	0.65	0.55	0.54	0.45
Robust t statistics in parentheses								
* significant at 5%; ** significant at 1%								

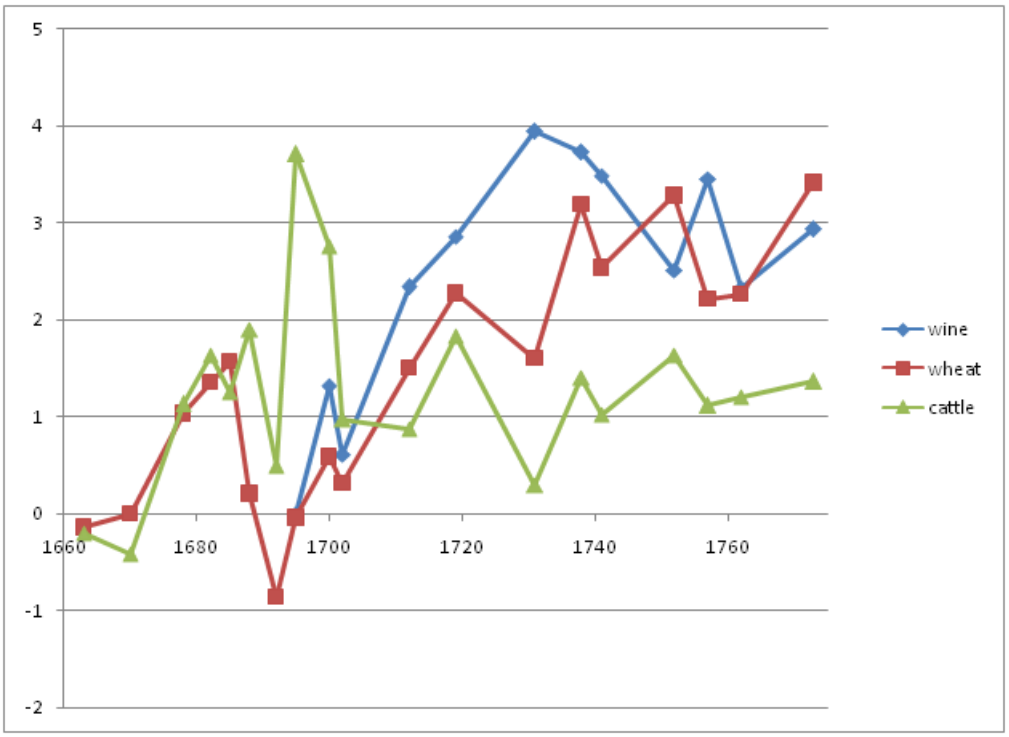
Notes: Own estimates from the *opgaafrollen*. Only farmers, defined as households owning at least one agricultural input or producing at least one agricultural output, are included in the sample. The dependent variable is the total number of slaves per farming household (it is not scaled nor centered). The explanatory variables are scaled and centered by the standard deviation and mean of the pooled sample, so that coefficients represent the number of slaves associated with a standard deviation change in production across the period, controlling for other forms of production. Estimates are not deemed to be causal but represent partial correlations between slave usage and production methods, taking into account that slaves worked on farms with other forms of production. Fixed effects estimates are similar to pooled OLS estimates, but are omitted because the panel constructed from this data has not been verified by genealogical research.

Figure 2A: Number of slaves required per standard deviation of production



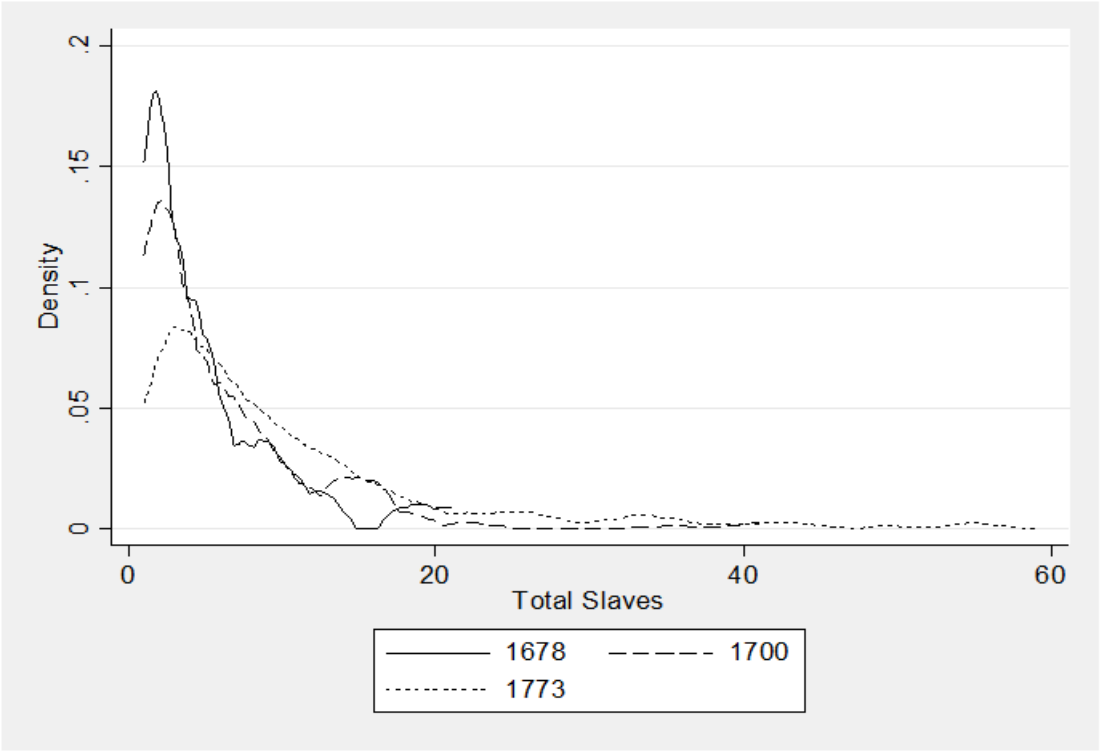
Notes: Own calculations from the *opgaafrollen*. Standard deviations of each production type are from the pooled sample. Estimates are obtained from Tables 3 and 4. All negative values were statistically insignificant. Only farmers, defined as households owning at least one agricultural input or producing at least one agricultural output, are included in the sample.

Figure 2B: Number of slaves required per standard deviation of production



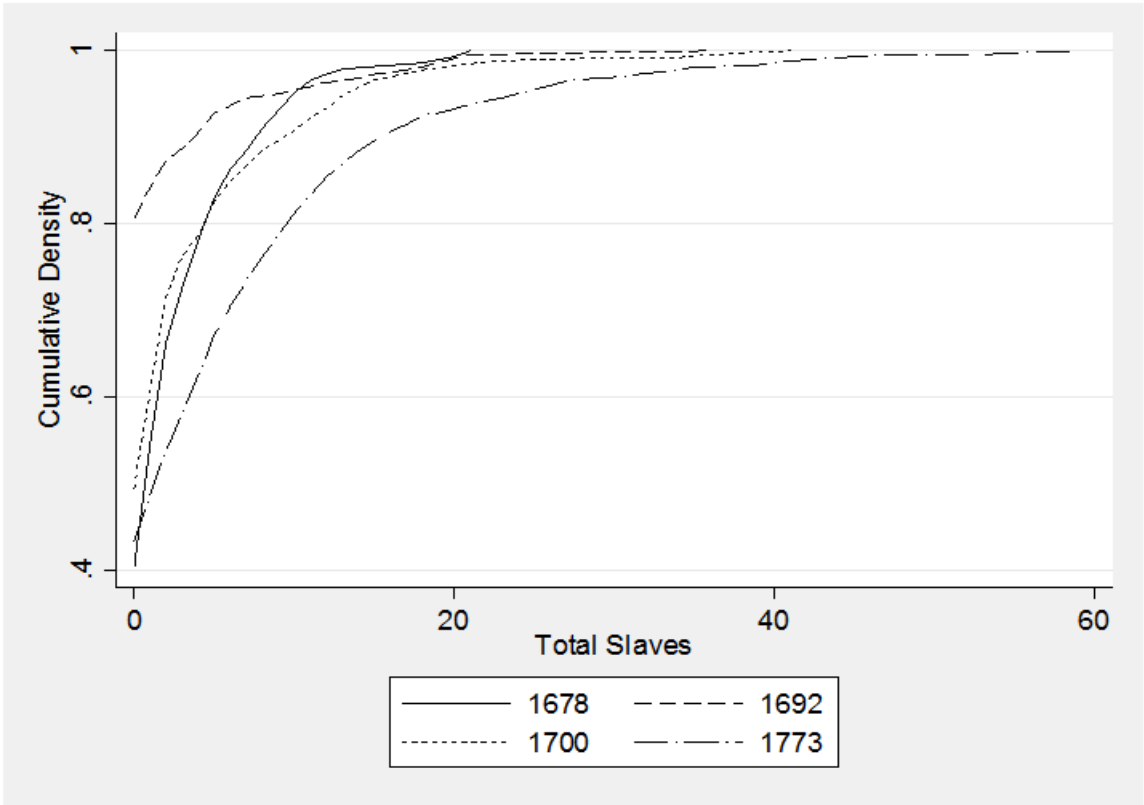
Note: Own calculations from the *opgaafrollen.* This figure is based on similar estimates to those depicted in Figure 2a. However, standard deviations are calculated for each year rather than across the entire period. All negative values were statistically insignificant. Only farmers, defined as households owning at least one agricultural input or producing at least one agricultural output, are included in the sample.

Figure 3A: Distribution of total number of slaves owned per farmer – various years



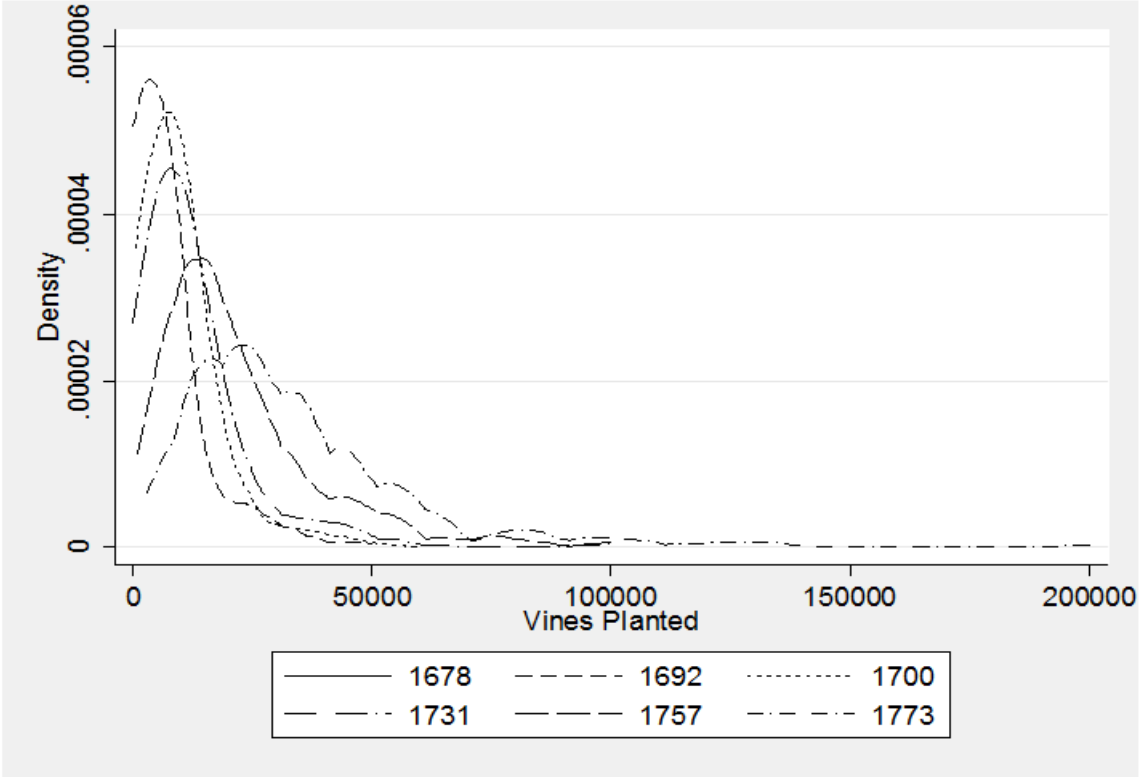
Notes: Own calculations from *opgaafrollen*. Only farmers, defined as households owning at least one agricultural input or producing at least one agricultural output, are included in the sample.

Figure 3B: Cumulative distribution of total number of slaves owned per farmer – various years



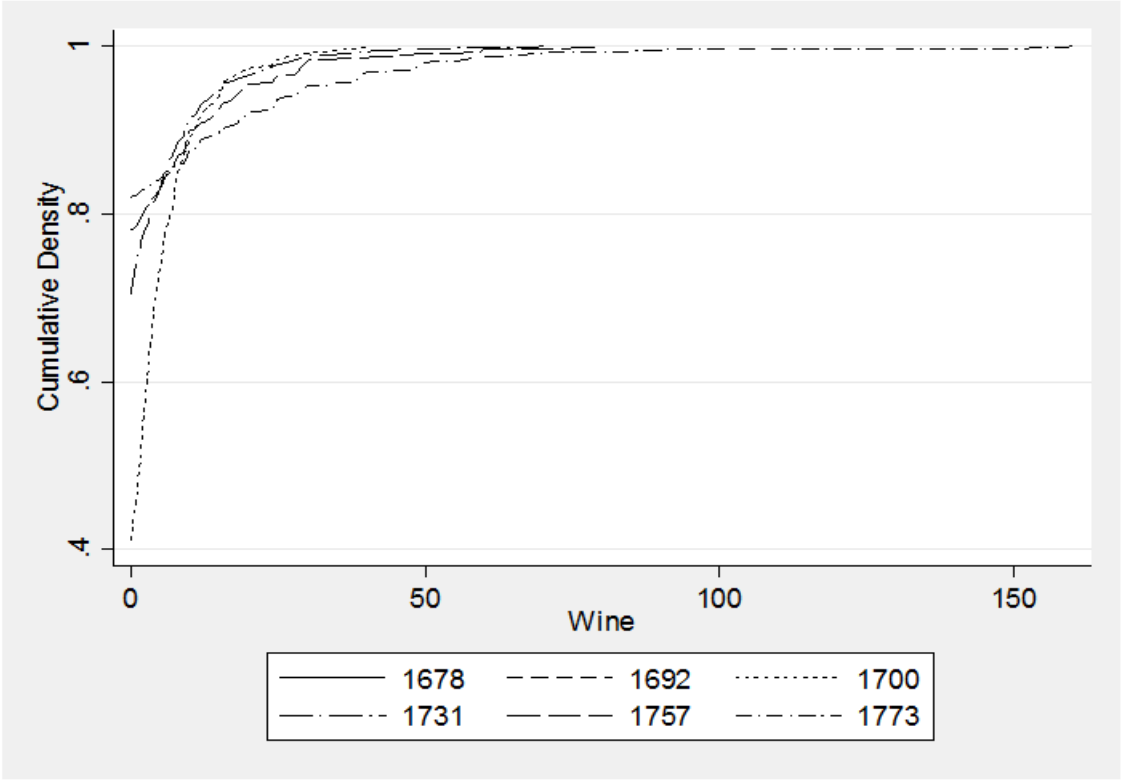
Notes: Own calculations from *opgaafrollen*. Only farmers, defined as households owning at least one agricultural input or producing at least one agricultural output, are included in the sample.

Figure 4A: Distribution of number of vines planted per farmer– various years



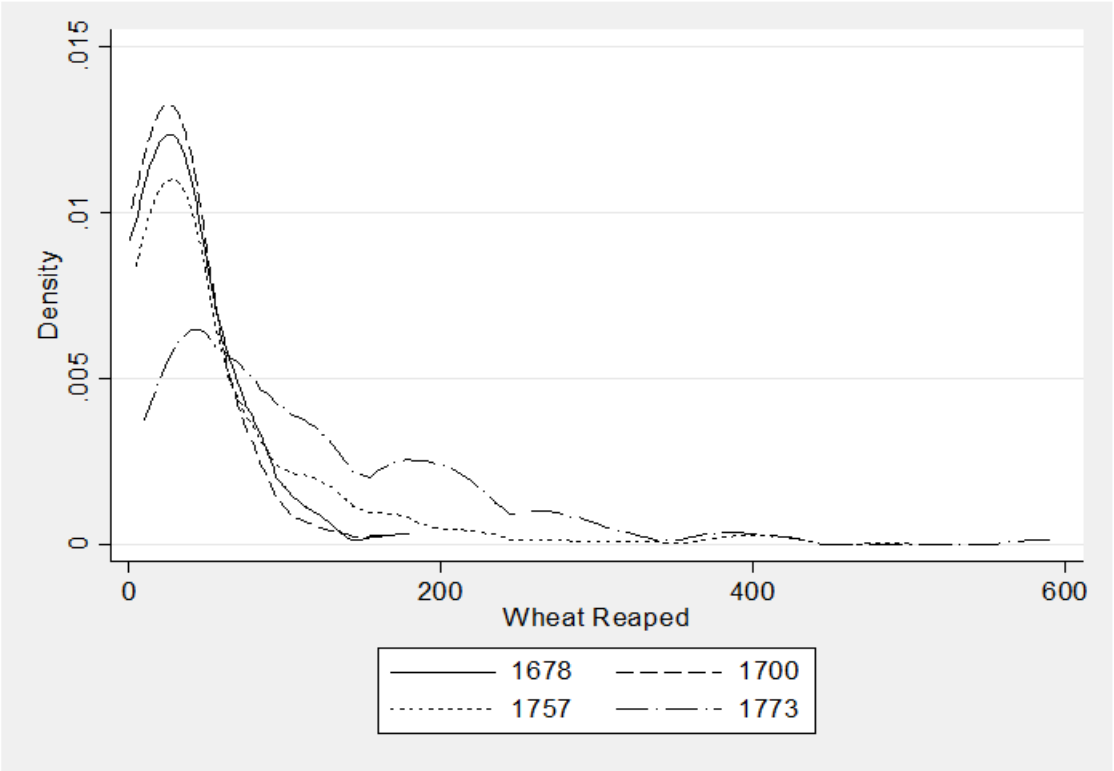
Notes: Own calculations from *opgaafrollen*. Only farmers, defined as households owning at least one agricultural input or producing at least one agricultural output, are included in the sample.

Figure 4B: Cumulative distribution of leaguers of wine production per farmer – various years



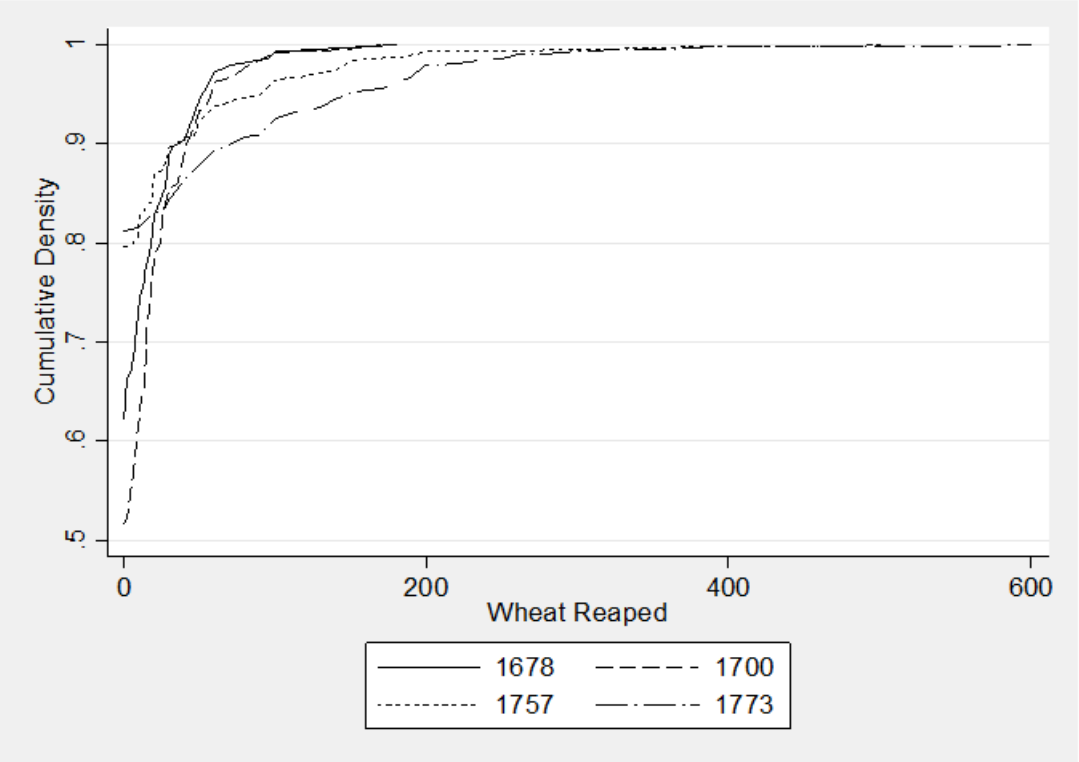
Notes: Own calculations from *opgaafrollen*. Only farmers, defined as households owning at least one agricultural input or producing at least one agricultural output, are included in the sample.

Figure 5A: Distribution of muids of wheat reaped per farmer – various years



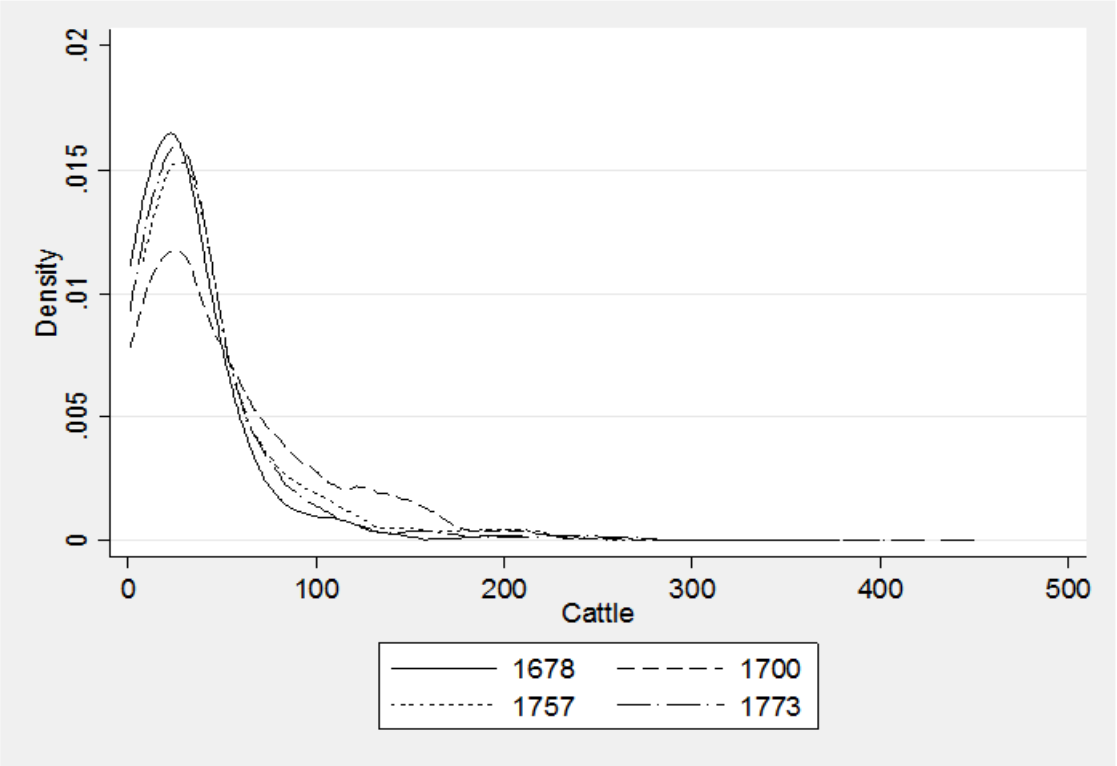
Notes: Own calculations from *opgaafrollen*. Only farmers, defined as households owning at least one agricultural input or producing at least one agricultural output, are included in the sample.

Figure 5B: Cumulative distribution of muids of wheat reaped per farmer– various years



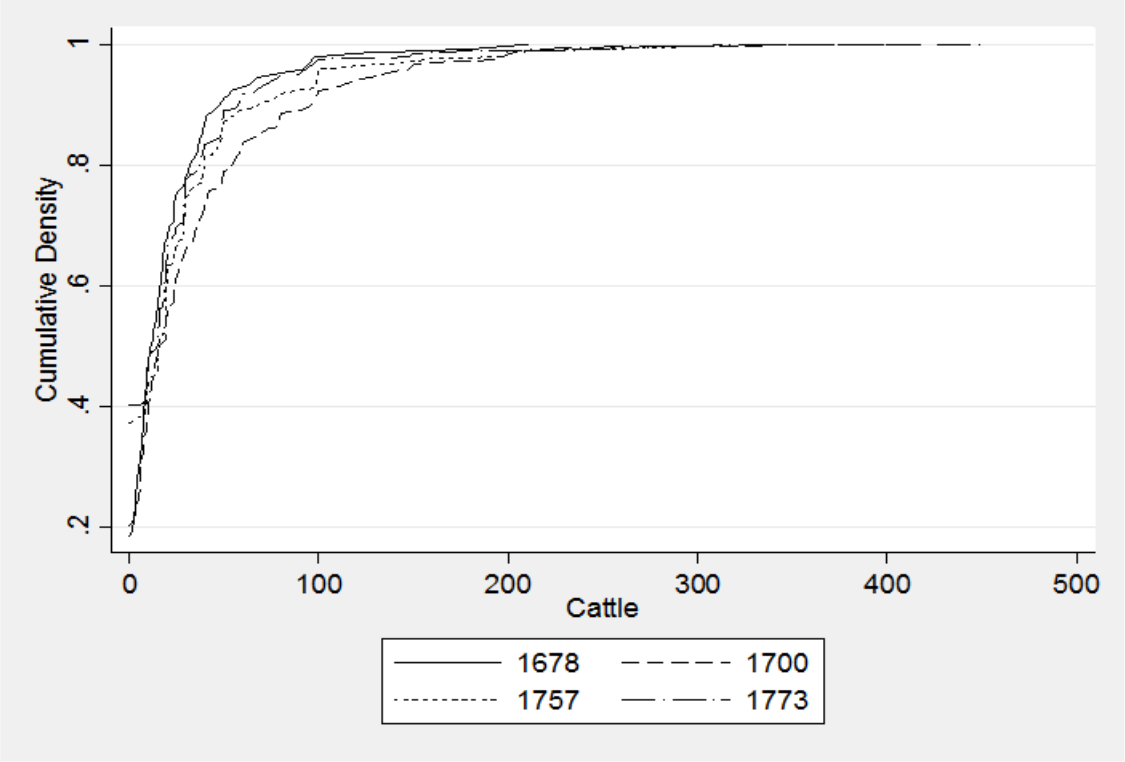
Notes: Own calculations from opgaafrollen. Only farmers, defined as households owning at least one agricultural input or producing at least one agricultural output, are included in the sample.

Figure 6A: Distribution of head of cattle owned per farmer – various years



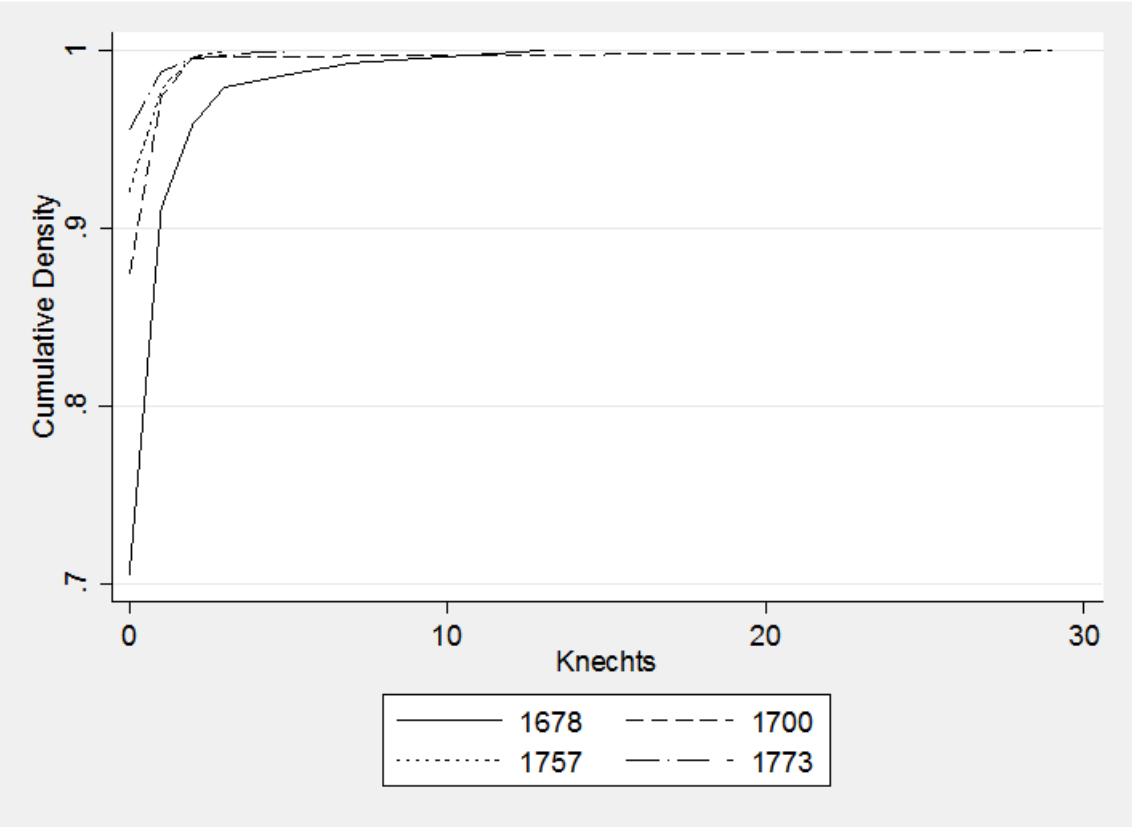
Notes: Own calculations from *opgaafrollen*. Only farmers, defined as households owning at least one agricultural input or producing at least one agricultural output, are included in the sample.

Figure 6B: Cumulative distribution of head of cattle owned per farmer – various years



Notes: Own calculations from *opgaafrollen*. Only farmers, defined as households owning at least one agricultural input or producing at least one agricultural output, are included in the sample.

Figure 7: Cumulative distribution of number of *Knechts* (European wage labour) employed per farmer – various years



Notes: Own calculations from *opgaafrollen*. Only farmers, defined as households owning at least one agricultural input or producing at least one agricultural output, are included in the sample.