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Did the Black Death Cause Economic Development by "Inventing" Fertility Restriction?

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Abstract

Voigtländer and Voth argue that the Black Death shifted England towards pastoral agriculture, increasing wages for unmarried women, thereby delaying female marriage, lowering fertility, and unleashing economic growth. We show that this argument does not hold. Its crucial assumption is inconsistent with the evidence: women wanting to do pastoral work after the Black Death did not have to remain unmarried, so improved pastoral opportunities did not necessitate later marriage. There is no consensus that late female marriage emerged after the Black Death. Furthermore, the relationship between pastoralism and female marriage age in England provides no support for this argument.

JEL-Codes: E020, J120, J130, N130, N330.

Keywords: European marriage pattern, black death, land-labour ratio, arable and pastoral agriculture.

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1. Introduction

The European Marriage Pattern (henceforth EMP) has recently been put forward as a major cause of long-term economic growth. Under the EMP, women in parts of pre-modern Europe married late or not at all, thereby reducing fertility (Hajnal 1965, 1982). Historical demographers have long speculated that the EMP might have helped calibrate population growth to available resources, thereby freeing pre-industrial economies from Malthusian limits (Wrigley and Schofield 1981; Laslett 1988; Solar 1995). Several more recent contributions by economists and economic historians have gone much further, arguing that the EMP played a major causal role in European economic growth (Greif 2006; Voigtländer and Voth 2006; Greif and Tabellini 2010; De Moor and Van Zanden 2010; Foreman-Peck 2011; Foreman-Peck and Zhou 2018). This focus on the EMP raises the important questions of when the EMP itself emerged, and what brought it into being.

One conjecture has been that the EMP was caused by the Black Death, a virulent epidemic that killed upwards of one-third of the population in many European economies around 1350. The most fully worked out argument to this effect has been advanced by Voigtländer and Voth (2013) (henceforth VV). The Black Death caused the EMP, according to VV, by increasing the land-labour ratio, thereby making land-intensive pastoral agriculture more profitable. Women were more productive in pastoral than arable agriculture, so the Black Death increased demand for their labour as servants in pastoral work instead of as wives in arable work; this caused women to marry later and have fewer offspring. Because the economy had the Malthusian feature that living standards were negatively related to population size, this fall in fertility increased per capita income. VV base their theoretical and empirical analysis on medieval and early modern England, but use it to explain development differences across Europe and between Europe and China. If VV's claim were correct, it would provide a unifying framework in which to explain demographic and economic divergence before industrialisation.

A basic objection to this argument applies to any claim that the EMP played a major role in economic growth. As Dennison and Ogilvie (2014, 2016) have shown, the EMP was associated with rapid economic growth in early modern England (at least after c. 1650) and the Netherlands (at least before c. 1700), but with slow growth in many other central, western and nordic European economies. England and the Netherlands did not in fact display extreme versions of the EMP, which was most pronounced in slow-growing economies such as those of central and nordic Europe. These findings cast considerable doubt on the idea that the EMP was instrumental in pre-industrial European economic development.

This paper leaves aside such scepticism about the growth-promoting role of the EMP, focusing instead on the idea that the Black Death caused the EMP to emerge. First, VV state that there is a scholarly consensus that the EMP originated in the

aftermath of the Black Death. Section 2 shows that this is not the case: rather, scholarly views differ fundamentally on the origins of the EMP, because the evidence on medieval demography is too fragile to support a definitive conclusion. Second, the VV theoretical model derives its fertility results from the crucial assumption that females desiring to earn higher wages in pastoral agriculture after the Black Death had to remain unmarried. But, as Section 3 shows, this assumption is inconsistent with the historical evidence: women did not have to be unmarried to work in pastoral agriculture, so there was no reason that better female employment opportunities in pastoral work should lower fertility. Finally, VV provide an empirical analysis to support their argument that the Black Death caused lower fertility by inducing a shift from arable to pastoral agriculture. However, Section 4 shows that the VV empirical analysis cannot support this conclusion.

2. Did the European Marriage Pattern Emerge at the Time of the Black Death?

A first question is whether the EMP actually did originate at the time of the Black Death. VV state that "there is a consensus that EMP only became fully developed after the Black Death in 1348-1350" (VV, p. 2228). But this is not the case. No such consensus exists. The demographic evidence for medieval England is sparse and ambiguous. Historical demographers disagree fundamentally about when the EMP developed. Some believe that it already prevailed in England long before 1350. Others argue that that England was characterized by early and universal marriage throughout the medieval period, and that the EMP only emerged in the sixteenth century. A minority of scholars posit a discontinuity in marriage behaviour around 1350, but hold diametrically opposed views, with some arguing that the Black Death in fact made women marry earlier and more universally to replace population losses while others contend that it created incentives for them to marry later and less universally – though mainly in towns.

VV adduce two references to support their statement that there is a scholarly consensus that the EMP developed in the aftermath of the Black Death (pp. 2228, 2232). The first is Hajnal (1965). But this is puzzling. Hajnal in fact concluded that for England, "the little fragmentary evidence which exists for the Middle Ages suggests a non-European pattern" (Hajnal 1965, p. 134). He regarded English marriage patterns in 1377, a generation after the Black Death, as being "not at all like that of the eighteenth-century Europe, but much more like that of non-European civilizations" (Hajnal 1965, p. 119). He speculated that that the fundamental shift in marriage behaviour might have occurred "between 1400 and 1650" (p. 122) and that the origins of the EMP "lie somewhere about the sixteenth century" (p. 134). Hajnal, the

originator of the concept, did not think the EMP arose in the aftermath of the Black Death; his best guess was that it dated from centuries later.

VV's second reference, Herlihy (1997), cannot be said to represent a consensus view. In this unpublished 1985 lecture, which appeared posthumously, Herlihy interpreted a positive association between wealth and household size as implying that medieval Europeans adjusted fertility to match their resources. His main source on the positive association between wealth and household size was a document dating from the ninth century, demonstrating that this association long pre-dated the Black Death (Herlihy 1997, pp. 53-4). Herlihy tentatively speculated that the Black Death might have moved a larger share of the population into social strata which engaged in such prudential adjustment, but he did not present any evidence to support this conjecture (Herlihy 1997, pp. 56-7). Nor did he consider alternative explanations: small households among the poor need not indicate prudential fertility, but could instead reflect poor families shedding offspring or suffering higher mortality. Herlihy's tentative conjecture has never been widely adopted.

By contrast, a substantial group of historical demographers hold that the EMP already existed in England before the Black Death (Smith 1979, pp. 96-101; Smith 1983, pp. 120-4, 128; Hallam 1985, pp. 55-6; Goldberg 1986b, pp. 142, 152-5; Smith 1990a, p. 173; Smith 1990b, p. 55; Goldberg 1991, pp. 88-9; Bennett 2015, pp. 302, 307-10, 318). Quantitative data on medieval English marriage are sparse and scattered, but these scholars interpret them as indicating behaviour consistent with the EMP in the period before 1350. According to Smith (1990a, p. 173), "In England, late age and low incidence of female marriage seem to be attributes widely characteristic of society ... from at least the thirteenth century". Qualitative evidence is more plentiful, and this strand of scholarship points out that before 1350 England manifested all the social features typically associated with the EMP: female life-cycle service, limited segmentation of the labour market by sex, legal institutions enabling females to be economically active without being married, high geographical mobility for women, companionate marriage, bilaterally defined kinship, neolocal residence at marriage, high levels of remarriage, narrow age-gaps between spouses, and a significant number of brides older than grooms at first marriage. This combination of quantitative and qualitative evidence is held to demonstrate that at the time of the Black Death "the European marriage pattern was firmly in place with other necessarily attendant features of the social structure" (Smith 1990b, p. 55). By 1982, such evidence had already led Hajnal to abandon his original conjecture that the EMP emerged in the sixteenth century, concluding instead that behavioural features associated with the EMP "can be traced back for perhaps four centuries prior to 1600" and that "aspects of the Northwest European household formation system can be shown to be very old indeed" (Hajnal 1982, p. 477).

So fragile is the evidence on medieval English demography that Hajnal is not the only scholar to have changed his interpretation of it. Goldberg, for instance,

originally held that the EMP was an abiding feature of English demography pre-dating 1350 (Goldberg 1992c, pp. 204-15, 324-8). More recently, however, Goldberg has come to place greater weight on change in the aftermath of the Black Death (Goldberg 2013, p. 11). But neither his original nor his recent view supports the VV notion that the EMP emerged after the Black Death in the *rural* economy. Goldberg believes that it was women in *towns* who manifested behavioural patterns associated with the EMP – to some extent before the Black Death and increasingly afterwards (Goldberg 1986b, pp. 153-6, 160, Goldberg 1992c, pp. 108, 112-3, 122, 225-32; Goldberg 2013, pp. 9-10). In the countryside, female marriage remained early and universal long after 1350: "Age data are confined to the century or more after the Black Death ... these suggest that by this later date women in rural society often married in their late teens or early twenties, whereas in towns women married later ... perhaps nearer their mid twenties" (Goldberg 1992c, p. 112). In towns, according to Goldberg, the labour scarcity caused by the Black Death accelerated the emergence of the EMP by offering women more attractive industrial and commercial jobs which encouraged them to delay leaving the labour force to get married; he thus ascribes the emergence of the EMP in England to a changing trade-off between two female labour-market choices which are not included at all in the VV model: non-agricultural work and leaving the labour force altogether (Goldberg 2013, pp. 13-4, 24-6).

The fragility and ambiguity of the data on medieval demography are strikingly illustrated by the existence of a diametrically opposed strand of medieval scholarship, which holds that the EMP only arose in England after 1500 (Hatcher 1977, pp. 56-7; Razi 1980; Hatcher 1986; Bailey 1996; Mate 1998, pp. 21-31; Mate 1999, pp. 59-60; Hatcher 2003, pp. 93-5; Hatcher, Piper and Stone 2006; Benedictow 2012). According to these scholars, medieval English mortality was so high that it would have required universal and early female marriage simply to maintain population size (Dyer 1980, pp. 229-30; Hatcher 1986; Harvey 1993, pp. 114-29; Bailey 1996, p. 2; Ecclestone 1999, pp. 21-7; Hatcher, Piper and Stone 2006; Benedictow 2012, pp. 10, 13-4, 22-3). The earliest surviving English parish registers of the 1540s and 1550s display virtually universal marriage and high birth-rates, suggesting the survival of a non-EMP marriage pattern from the medieval period into the mid-sixteenth century (Hatcher 1977, pp. 56, 65-6; Hatcher 2003, pp. 100-4). These scholars conclude that medieval English women married between the ages of 15 and 20 both before and after the Black Death; the EMP only emerged between the first and second quarter of the sixteenth century with the disappearance of the crisis mortality that had sustained the medieval demographic regime of early and universal marriage (Bailey 1996, p. 16; Hatcher 2003, pp. 94-6, 100-3, 113; Benedictow 2012, pp. 27-8).

These scholars are also sceptical of claims that EMP-supporting behaviour such as female servanthood prevailed before the late fifteenth century (Bailey 1996, pp. 4-14). They argue that there is no clear evidence concerning "the numbers of male or female servants, either before the Black Death or after it, so that it is impossible to say

whether the proportion of single female servants actually increased, or whether they stayed at work longer than they had done earlier" (Mate 1999, p. 59). In so far as female servants existed, "a significant number of young women left service before their mid-twenties in order to marry" (Mate 1999, p. 60). These scholars do not deny that *some* women in large towns delayed marriage until their mid-twenties, but argue that the data are too fragile to establish that "the *majority* of women, over the country at large, married late", and they are particularly doubtful that late marriage can have been common in rural areas (Mate 1999, p. 60).

Some adherents of this view go so far as to argue that England moved further away from the EMP after 1350. Hatcher and Bailey, for instance, hold that the Black Death increased wage levels and land availability, enabling couples to marry younger and more universally, pushing up fertility (Hatcher 1977, pp. 56-7; Bailey 1996, p. 3). Razi argues that peasants married early and universally before 1350 despite land scarcity and low wages; after the Black Death, plentiful land and high wages encouraged them to marry "as early in life as the previous period, or even earlier" (Razi 1980, pp. 60-3, 74-91, 131-8). Across the whole period from 1270 to 1400, he argues, marriage behaviour among English peasants resembled that of fourteenth-century Italy, not the EMP of later sixteenth-century England (Razi 1980, p. 137). According to Bailey and Mate, early and universal marriage was compatible with plague-induced wage increases and rising female labour-force participation: "Women ... married relatively early, but supplemented the familial income with casual labour after marriage" (Mate 1999, p. 59 (quotation); Bailey 1996, pp. 13-4).

There is thus no consensus that the EMP emerged in the aftermath of the Black Death. The available evidence is so fragile and ambiguous that it supports a wide range of incommensurate views. Some argue that the EMP originated well before the Black Death, others that it did not arise before the 1540s. Some think the Black Death changed things, but in the opposite way to the EMP, by improving incomes which encouraged early and universal marriage. Even those who speculate that the Black Death encouraged later marriage think it did so by improving women's opportunities in towns, while females in the rural economy continued to marry early and universally.

In sober fact, the data are inadequate to reach a definitive conclusion about when the EMP emerged. Reliable statistics on marriage age and lifetime celibacy require sources such as parish registers and village censuses, which are unavailable for England before the 1540s (Dennison and Ogilvie 2016, p. 211). The few data available are insufficient to sustain the proposition that the EMP emerged in England in the aftermath of the Black Death, and there is certainly no scholarly consensus that it did so. However, it is also not possible to rule out the possibility altogether. In the remainder of this paper, we set to one side the question of whether the Black Death actually changed marriage behaviour, and turn our attention to whether, if there were

anything to explain, the theoretical model and empirical approach used by VV would explain it.

3. Does the Historical Evidence Support the Key Assumptions of the VV Theoretical Model?

VV explain the emergence of the EMP in some, but not all, European economies after the Black Death using a two-sector general equilibrium model with endogenous marriage decisions. This model assumes that the only way to control fertility is by delaying marriage. In the model, it is possible for an increase in the land-labour ratio to delay marriage by improving women's employment opportunities in pastoral agriculture. Thus it is possible that an event such as the Black Death, by raising the land-labour ratio, moved the economy from a steady state with high fertility and low per capita incomes to one with lower fertility and higher per capita incomes. Whether an increase in the land-labour ratio does have this effect depends on various characteristics of arable and pastoral agriculture as well as the demand for pastoral output. The model is thus in principle able to explain why the Black Death might have led to the emergence of the EMP in some parts of Europe, but might not have had the same effect in other parts of Europe or, for instance, in China (VV 2013, pp. 2250-2).

The maximum fertility of a woman in the VV model is the number of children to which she gives birth if she spends her entire adult life married. All women are assumed to have the same maximum fertility. VV define the EMP as a demographic regime in which actual fertility has two features: it is below the maximum because some women remain unmarried for part of their adult lives, and it increases with per capita income.

In the model, all women supply the same total amount of labour irrespective of marital status or employment opportunities. The only labour supply choice for a woman is whether to work in arable or in pastoral agriculture. Women differ in their labour productivity in the arable sector but are all equally productive in pastoral work. Women can only work in the pastoral sector if they are employed by landlords as servants, and if they do this they must stay unmarried. A woman who marries has to work on the family farm, which can only engage in arable production. Whether women decide to remain unmarried and work in pastoral agriculture depends on their preferences for children and the wage they can earn in the pastoral sector relative to their marginal product in the arable sector. The wage that women can earn in the pastoral sector depends on the land-labour ratio in that sector, which moves in the same direction as the economy's aggregate land-labour ratio, provided that both arable and pastoral production take place. Whether a woman with a particular marginal product in the arable sector can earn more in the pastoral sector thus depends on the

aggregate land-labour ratio. Provided that this land-labour ratio is such that at least some women can earn more in the pastoral than the arable sector, and provided that one other condition (discussed below) is met, these women will choose to remain unmarried for some time. How long they choose to do so depends on their preferences.

VV specify women's preferences for children and a composite consumption good such that there is a basic-needs level of consumption of arable output below which the marginal utility of consumption is very high and above which the marginal utility of consumption falls rapidly. This means that, if the income of a woman working in the pastoral sector is below the basic-needs consumption level, increases in income lead her to increase her consumption but not her fertility; she will work for as long as possible in the pastoral sector and not choose to marry any earlier. But if the income of a woman working in the pastoral sector is above the basic-needs level, increases in income will lead to both higher consumption and higher fertility, i.e., she will not work for as long as possible in the pastoral sector but will choose to marry earlier. Women who cannot earn more in the pastoral sector than their marginal product in the arable sector will marry as early as possible, because there is no benefit to offset the cost of remaining unmarried, and hence their fertility will be at the maximum possible. Since fertility depends on the age at which women marry, the aggregate land-labour ratio, and thus the wage women can earn in the pastoral sector relative to their marginal productivity in arable agriculture, will determine overall fertility in the economy.

In this framework, a large exogenous increase in the aggregate land-labour ratio such as the Black Death can lead to the emergence of the EMP, but only under certain conditions. Consider a woman who would otherwise have chosen to marry as early as possible and work in the arable sector. If the higher land-labour ratio results in a pastoral sector wage which is greater than her arable marginal product but earns her an income below the basic-needs level, she will choose to work in the pastoral sector for as long as possible and her fertility will fall from the maximum to the minimum. If her income is above the basic-needs level, the higher wage available in the pastoral sector will not be enough to compensate her for having to remain unmarried and have fewer children. In this latter case, she will still work in the arable sector, she will marry as early as possible, and her fertility will remain at the maximum. Thus an increase in the land-labour ratio will lead to a reduction in the fertility of a woman who would otherwise have married as early as possible and worked in the arable sector if and only if the wage premium that results from the higher land-labour ratio does not yield her an income above the basic-needs level, as Proposition 2 of VV shows. This is the additional condition required for a woman to stay unmarried. A corollary is that the features of the economy which favour the emergence of the EMP are the ones that are more likely to lead to the former of these two cases (VV 2013, p. 2245, Corollary 2). It is this corollary that enables the VV model to offer an explanation for why the Black Death, which occurred in most European societies, might have led to the emergence of the EMP in some societies and not in others.

Two key assumptions generate the results of the VV theoretical model: first, in order to work in the pastoral sector, women have to do so by working for landlords; second, in order to work for landlords, women have to do so as unmarried agricultural servants. If either assumption does not hold, the central links in VV's model – between higher land-labour ratios, higher female wages in pastoral agriculture, and lower fertility – will break. If peasant households can engage in pastoral agriculture, women will be able to work in the pastoral sector while being married and having children, even if servants working for landlords have to remain unmarried. If women can work in the pastoral sector for landlords while being married, for example as wage-labourers, then they will not have to reduce their fertility, even if peasant households do not engage in pastoral agriculture. VV state that these critical assumptions are empirically justified. But an examination of the historical evidence shows that this is not so.

3.1 Peasants and Pastoral Production in Medieval and Early Modern England

The first crucial assumption of the VV model is that the technology of pastoral production was available only to landlords and not to peasants. VV argue that size differences between arable and pastoral farms in medieval England justify assuming that only landlords engaged in pastoral agriculture (VV 2013, p. 2238). An alternative assumption which would achieve the same effect, they note, is that there was a minimum land requirement for pastoral production (VV 2013, p. 2238, n. 27). However, the rich evidence on English agriculture, both before and after the Black Death, shows that the technology of pastoral production was available to peasants operating on small landholdings.[1]

Keeping livestock was central to peasant agriculture in medieval England, even in primarily arable regions. In addition to growing grain, the medieval peasant had other sources of livelihood, of which the most important was the stock of animals. One major reason for keeping animals was that their manure was the dominant source of fertilizer for the arable fields. A typical peasant household kept animals which it turned out onto the one-third of its arable land that was left fallow each year in the three-field rotation system, and then released to graze on the stubble from the cultivated fields. Arable and pastoral farming were complementary. A second major reason to keep animals was that peasants used their animals' milk, meat, hides, and

[1] The VV model assumes only two types of agent, landlords and peasants, where the latter refers to "all economic agents that are not large landowners" (VV 2013, p. 2234 fn. 14). However, a third group emerged in England after the Black Death. These were "farmers", defined as non-landlord agriculturalists (often former serfs or peasants) who leased demesne farms (or parts of them) from landlords. To avoid terminological debates, in most cases we follow VV in using the term peasant to refer to all non-landlord agriculturalists. However, in cases of non-landlord agriculturalists who had leased former demesne land from landlords, we follow the relevant specialist literature in using the term farmer, although in the terminology of the VV model these are peasants.

(in the case of sheep) wool both for their own households and to sell on the market. The vast majority of peasant enterprises in medieval England were mixed farms, neither purely arable nor purely pastoral. Both landlords and peasants engaged in both arable and pastoral production, and both exploited all types of land: arable fields, meadows, pastures, and woodland (Dyer 2016, pp. 67-8). Indeed, landlords and tenants often shared assets, with both parties holding land in the open arable fields and both putting their animals out to graze on the same pasture (Dyer 2016, p. 65).

Peasants engaged in pastoral activities long before the Black Death. In the period 1287-1349, for instance, villagers on the Buckinghamshire manor of Iver supported themselves primarily through stock-raising and fishing (Bennett 1986, p. 26; Bennett 1987, p. 177). Surviving tax assessment rolls for 1290-1334 show peasants owning considerable numbers of sheep in pastoral districts such as Holderness, the South Downs, and Wiltshire (Bennett 1987 [1937], p. 90). In the thirteenth and early fourteenth centuries, Cotswold villages shared upland pastures, accused each other of exceeding pasturing quotas, and seized animals from inhabitants of other villages (Dyer 2005, p. 63). Throughout the medieval period, wool was produced by lord and peasant alike, who sold it in large quantities to merchants who traded it over long distances (Campbell 1993, p. 67).

Quantitatively, peasant pastoral production was substantial. Even before the Black Death, some peasants owned sizeable herds, in some cases comparable to those of landlords. A 1225 Wiltshire tax assessment shows the number of sheep per taxpayer varying across villages depending on the type of husbandry, but averaging 15 over the whole area (Hilton 1966, p. 107). Around 1250, 170 named peasants illegally erected animal sheds in the royal forest at Feckenham, with the offending animals comprising 280 draught beasts, 100 horses, 25 mares, 154 oxen, 40 cows, 135 goats, 550 sheep, and 122 pigs (Hilton 1966, pp. 109-10). In the Suffolk Hundred of Blackbourne in 1283, the stocking density (number of livestock units per 100 acres of sown land) was 2.2 times higher on peasant holdings than on the landlord demesne (Slavin 2015, pp. 13-4). On one Gloucester Abbey manor in 1291, two peasants were each grazing 100 sheep on the landlord's meadow, and 33 other peasants were illicitly grazing a total of 68 animals (Dyer 2005, p. 63-4). A tenant at Minchinhampton in 1294 was fined for having 100 sheep in the landlord's oats (Hilton 1966, p. 109). Around 1300, in one Gloucestershire village each new holder of arable land had the entitlement to graze four beasts, a horse, and 30 sheep on the common pasture (Dyer 2005, p. 64-6). In 1312, peasants in the Worcestershire village of Kemerton impounded 400 sheep belonging to villagers on the other side of Bredon Hill (Dyer 2005, p. 63). In 1313, in the Wiltshire village of Minety the average number of sheep per taxpayer was 13.4 and the median was 10; the largest peasant pastoral producers owned 60 sheep alongside numerous other livestock (Hilton 1966, pp. 107-8). In 1337, three peasants were fined on the Worcestershire manor of Overbury for grazing 400 sheep on the landlord's common; the normal number of sheep per peasant in such trespasses was 12 (Hilton 1966, p. 109). In

Lakenheath in Suffolk in the 1340s, tithe evidence reveals that peasants owned 2,340 sheep, compared with the manorial lord's flock of 2,280 (Bailey 1989, pp. 246, 250).

Peasants' behaviour testifies to the importance they placed on pastoral production both before and after the Black Death. They made cash payments to their landlords to be allowed to keep sheep on their own holdings instead of in the landlord's sheepfold (Hilton 1966, p. 108; Mate 1985, p. 22). They paid fines for pasturing large numbers of animals on the lord's meadow (Dyer 2005, pp. 64-6). They paid money to lease cows from landlords (Bennett 1987 [1937], p. 91). They spent money to employ village cowherds, swineherds, and shepherds (or their female equivalents) to ensure that their animals were taken to the best grazing at the appropriate time and did not damage peasant, communal, or manorial property (Bennett 1987 [1937], p. 92). When they lacked sufficient pasture rights to feed the amount of livestock they wanted to raise, they bought hay from the lord, often mowing it themselves (equivalent to taking short-term leases of grassland) (Hilton 1966, p. 118). Peasants incurred the costs of conflict with other peasants over grazing on common pasture and stubble, conflicts that proliferated after the Black Death as peasants moved massively into pastoral production (Dyer 2005, pp. 64-6; Dyer 2007, p. 5; Larson 2008, pp. 206-7, 212).

On the eve of the Black Death, many landlords kept cows, but few tended to them directly or turned their milk into dairy produce. Instead, they leased cows individually to local peasants, who paid an annual sum for "lactage", and the peasant household supplied the labour required for calving, milking, butter-churning, cheese-making, and marketing; as we shall see, much of this labour was provided by married peasant women. Peasants hired these demesne cows to supplement their own stocks, a practice that can be observed at latest by the 1290s. The variations in these lactage rates, together with the varying proportions of cows among all demesne cattle, reveal that in many areas of eastern and southern England peasant dairy production was highly intensive and commercialized (Campbell 1992, p. 113-14; Campbell 2000, p. 146; Campbell 1995, pp. 291-4; Bailey 2007, pp. 81-4).

After the Black Death, the cost of labour rose, the price of grain fell (especially after c. 1375), and prices rose for meat, milk, cheese, and wool. Pastoral agriculture required only one-fifth of the labour per unit land needed for arable cultivation (Campbell 2000, p. 10). Peasants responded to these price-signals just as landlords did, by shifting from arable to pastoral production (Mate 1987, p. 525). Indeed, peasants moved over to pastoral agriculture on a "significant and cumulatively larger scale" than landlords (Dyer 2005, p. 72). In Berkshire, according to a Feet of Fines, a documentary source which recorded mainly non-demesne (i.e. peasant) land, the proportion of pasture rose from 6 per cent before 1349 to 41 per cent in the early fifteenth century (Yates 2012, p. 150). In Gloucestershire, pasture rose from 2 per cent of the total c. 1300 to 18 per cent in the early fifteenth century on the Cotswolds, and from 1 per cent to 14 per cent in the Vale of Gloucester (Dyer 2016, p. 82).

Even peasants who did not hire labour had an incentive to shift to less labour-intensive forms of agriculture given that they themselves could use their labour to earn higher wages rather than to work their own land (Britnell 2008b, p. 17). In some regions, peasants moved into convertible husbandry whereby they put down land to grass for several years during which they used it to feed livestock, but then shifted it back to the plough to gain good grain crops on the well-manured soil (Dyer 2005, p. 32). In other regions, such as the West Midlands and Devon, peasants converted all their arable land to pasture (Dyer 2005, p. 32). In still other regions, peasants intensified pastoral agriculture within the traditional common fields, for instance by cropping land less frequently and allowing more opportunities for fallow pasture or part of the arable fields to be grassed over (Dyer 2005, p. 72). Another pattern was to cultivate the arable land more intensively, but with fodder crops such as peas and vetch that were used for stall-feeding, which supported much larger numbers of livestock (Dyer 2005, pp. 72-3). Between 1375 and 1520, peasants in many parts of England can be observed responding to low grain prices, high wages, and high prices for dairy products and wool by using a larger share of their land as pasture and expanding production of animals, cheese, butter, and wool (Dyer 2005, p. 129).

The post-Black Death period saw a quantitative boom in peasant animal-raising, unsurprisingly given the shift from arable to pastoral and the move from landlord to peasant production (Dyer 1980, pp. 323-4; Watkins 1989, p. 19). In Warwickshire after 1350, peasant herds rivalled many landlord herds, as with the 30 cows owned by a peasant in Hampton-in-Arden in 1350, the 26 peasant oxen found at Tanworth-in-Arden in 1380, herds of 23, 20 and 16 cattle at Erdington in 1360 and 1379, and herds of 13-16 at Wroxall in 1360 and 1375 (Watkins 1989, p. 20). In 1381, two indebted peasants in an Essex village were recorded with 21 and 139 livestock respectively, including horses, cattle, sheep and pigs (Langdon 2015, p. 64). In 1417, the main agricultural asset of a peasant in the Cambridgeshire village of Soham consisted of 140 sheep (Dyer 2005, p. 129). In the 1420s, the Sussex manor of Alciston recorded nearly 2,000 sheep belonging to various tenants encroaching on landlord's pastures (Mate 1987, p. 525). In 1422/3, one of the five peasants leasing pasture on the manor of Lydden owned 200 sheep (Mate 1987, p. 525). In 1427, the Worcestershire village of Teddington listed 15 peasant sheep flocks, including three flocks of 80 animals, two of 160, and two of 200 (Dyer 2015, p. 99). By the late 1440s, a period when many English landlords had given up their sheep flocks, one peasant family in north Gloucestershire was grazing more than 2,000 sheep on a grange leased from a monastery landlord, and in the 1450s a Suffolk farmer (i.e. part of the VV peasant sector) bequeathed a flock of 840 sheep to his sons (Stone 2003, p. 2). In 1451, another farmer leasing two demesnes near York was running 799 sheep, 198 cattle, and 92 horses, operating a specialized pastoral enterprise in which he was fattening beef cattle for the urban market and breeding horses for sale (Dyer 2005, p. 206). Late-fifteenth-century tithe accounts for Warwickshire show 87 per cent of peasants owning cattle in

Hartshill, 75 per cent in Oldbury, and 67 per cent in Mancetter (Watkins 1989, p. 20). Accounts for the Warwickshire village of Middleton in 1524 show that 95 per cent of peasant households were paying tithes for cows or calves (Watkins 1989, p. 20).

Some lords expanded their own sheep flocks and rabbit warrens after the Black Death, and some continued to exploit these directly throughout the late Middle Ages (Bailey 1989, pp. 245-56; Hare 2011, pp. 63-74). These were the least labour-intensive of pastoral enterprises, requiring a small number of full-time shepherds and warreners to supervise the stock for long periods of the year, supplemented by wage-labour for short periods during seasonal lambing, shearing, or culling: they did not require unmarried women servants as part of the labour force. Many lords did not expand their sheep flocks, however, or eventually leased them out: both practices presented peasants with major opportunities to expand their own activities (Britnell 2004, pp. 414-5; Hare 2011, pp. 76-9; Bailey 2007, pp. 214-9). In 1486, a Suffolk farmer was keeping 4,366 sheep in a market-oriented pastoral operation on the sites of two abandoned villages which he was leasing from a landlord (Dyer 2005, p. 206). In the late fifteenth century, two lessees of demesne lands in Wiltshire bequeathed 1,100 and 500 sheep respectively to their heirs (Hare 1981, p. 13). Peasant sheep farmers used family and hired labour, or hired male shepherds, and did not require unmarried women servants.

Another way in which peasants increasingly dominated the pastoral sector was through landlords leasing and selling pastures to peasants (Watkins 1989, p. 17; Dyer 2007, p. 2). Some of these were piecemeal leases of small parcels of demesne pasture and meadow surplus to the lord's requirements, but others were sizeable grants of vast rabbit warrens, extensive sheep grounds or even entire manors. The latter often included the lord's buildings, equipment and livestock as part of the lease. Such leases and sales already occurred in the early fourteenth century, expanded after c. 1325, and accelerated rapidly after the Black Death, so that by c. 1450 most English landlords had abandoned direct exploitation of their demesnes (Harvey 1969, p. 17; Lomas 1978, pp. 339-40, 345, 352; Campbell 2000, pp. 3, 58; Dodds 2008, p. 77). In Warwickshire after the Black Death some landlords leased out their entire demesne as single units, giving rise to a few very large peasant holdings, while others leased out pasture and meadow in small pieces, enabling numerous peasants to accumulate enough grazing to specialize in pastoral production (Watkins 1989, pp. 18-19). After c. 1400, Fountains Abbey increasingly leased its Yorkshire granges to peasant "keepers" who paid a money rent and a fixed quantity of butter and cheese in return for running cattle on landlord pasture (Dyer 2005, p. 199). In the mid-fifteenth century, a former serf leased the Suffolk manor of Chevington, which included extensive arable and grazing lands, the stable, the dairy, horses, cows, and a large sheep herd, thus hugely expanding his own pastoral operations and soon leasing the dairy cattle in turn to another peasant (Dyer 2007, pp. 9-10). Few lords maintained dairy herds after c. 1400, instead either selling off their stock to raise capital or leasing herds in their entirety to a single lessee

(Campbell 1992, p. 113; Bailey 1989, pp. 257-8; Bailey 2007, pp. 220-1). Many fifteenth-century lessees of demesne sheep flocks in Berkshire and Wiltshire were peasants (Yates 2007, pp. 200-3; Hare 2011, pp. 76-9, 101-5). In 1451, a peasant leasing two demesnes near York was running 799 sheep, 198 cattle, and 92 horses, operating a specialized pastoral enterprise in which he was fattening beef cattle for the urban market and breeding horses for sale (Dyer 2005, p. 206). A married woman with family support could easily manage the size of most peasant dairy herds, and sheep flocks were managed through family labour or hired shepherds rather than live-in female servants. When landlords leased land to peasants, pastoral specialization frequently increased, since landlords often pursued mixed farming to ensure self-sufficiency for the lordly household, whereas peasant farmers specialized in response to price signals (Dyer 2005, pp. 204-6).

The fact that so many landlords leased animals and pasture to so many peasants over long periods suggests that both parties believed that peasants would exploit those assets more productively (Campbell 1992, p. 114; Campbell 2000, pp. 146-7). The high rentals paid by peasant lessees of landlord cows, both before and after the Black Death, "testify to the potentially greater intensity and productivity of peasant as opposed to demesne husbandry" (Campbell 1992, p. 113). In sheep-raising, as well, peasants were more productive than landlords, with peasant sheep-farmers achieving lambing rates and subsequent survival quotients superior to those in demesne herds (Stone 2003, p. 21; Dodds 2008, p. 85). Overall, medievalists regard small peasant farmers as having been better practitioners of pastoral technology than large landlord estates because of lower costs of administration and management, superior local knowledge, better monitoring and supervision of animal well-being, and greater use of highly motivated family labour (Hare 1981, p. 14; Britnell 2008a, p. 29).

Peasants produced a majority of agricultural output in England – perhaps 60-80 per cent – before the Black Death, and even more thereafter (Campbell 2000, p. 56). In Worcestershire between 1273 and 1320, the landlord demesne comprised about 30 per cent of the median value of a manor, with tenants (the peasant sector in the VV model) farming the other 70 per cent of land by value (Dyer 2016, p. 65).

Peasants also produced most of the output in the pastoral sector. This was true even in sheep-raising which was by far the most land-intensive pastoral enterprise and thus most suited to large landlord operations: the best available estimate indicates that throughout the 1250-1450 period the landlord share of the national sheep flock "must have been substantially smaller than its share of the national arable area" (Campbell 2000, p. 159). In Suffolk as early as the 1280s, stocking densities of sheep were higher on peasant farms than on the landlords' demesnes and peasants supplied six times as much wool as landlords (Slavin 2015, pp. 10, 22). In the century after the Black Death, non-demesne (i.e. mainly peasant) sheep flocks "must have formed a large proportion of the total ovine population of England" (Stone 2003, p. 21). Peasants predominated in the raising of cows, as well. Stocking densities for cows were higher on peasant

holdings than on large landlord estates in Suffolk in the 1280s (Slavin 2015, p. 10, 14). After the Black Death, even more of the cow population of England moved into peasant hands, with the rents from leasing demesne dairy herds to peasants comprising the single greatest contribution to the increase in seigniorial money revenues in the period after c. 1350 (Campbell 2000, p. 435). Commercialized dairy production increased markedly after the Black Death on many peasant holdings in Suffolk in response to increased consumption per head among the lower orders of society (Bailey 2007, pp. 219-26). Commercial poultry rearing also shifted from the demesne to the peasant sector, mainly because the high costs of tending geese and chickens were more readily absorbed within peasant households in an era of labour shortages (Slavin 2010, pp. 9-15, 26).

The peasant sector also provided most of the employment. Landlords, either running their own demesnes or increasingly delegating the management of the demesnes to farmers who were holding them as leasehold farms, were certainly still an important source of employment around 1400. Many of these demesnes employed a woman (rarely more than one) as a specialist dairymaid, and many offered casual employment by the day to women, for example as harvest workers. However, there were only about 20,000 manorial demesnes c. 1400 (Campbell and Bartley 2006, pp. 314-5). Of these, more than one-fifth of them were very small, with a limited need for labour (Kosminsky 1956, p. 98).[2] By contrast, around 1400 there were about 200,000 non-aristocratic employers, i.e. peasants with middling and larger holdings (Mayhew 1995, p. 249). In various circumstances (e.g. a shortage of family labour), these peasants employed both male and female workers, either as servants living in their houses or as day workers. Peasants often had only one or two workers each, but they were ten times as numerous as the demesne holders, so in aggregate they employed more labour than did the managers of the demesnes. Peasants were also more likely than the demesnes to employ women because they needed them for domestic work, or to contribute to brewing and cheese-making, as well as for agricultural tasks (Poos 1991, pp. 184-8, 204-6).

[2] The 20,000 figure is calculated as follows. Campbell and Bartley 2006, pp. 314-15, give a figure of 14,441 vills from early-fourteenth-century tax lists. This should be rounded up to c. 15,000 to allow for two counties that were not included because they were tax-exempt. The best count of manors and vills in medieval England is provided by Kosminsky 1956, who on pp. 74, 97, reports that 784 vills contained 1,071 manors, implying that each vill had 1.32 manors. This yields a national total of 19,800 manors on the c. 15,000 vills in England. The estimate might be slightly increased by taking into account the hundreds of larger rectories which were funded from "rectory manors" with demesnes and employees. Conversely, the estimate might be reduced by omitting some hundreds of manors in the far north and south west which were mainly pastoral. The estimate might also be reduced by taking into account the fact that 65 per cent of manors were small, i.e. 500 acres or less (Kosminsky 1956, p. 98). A plausible assumption is that about one-third of these, i.e. c. 20 per cent of all manors, were so small as to provide very little employment. We are very grateful to Chris Dyer for his expert advice on these estimates.

The historical evidence thus does not support the assumption that the technology of pastoral production was available only to landlords. Pastoral production was widely undertaken by peasant families. This was already the case before the Black Death, when peasants owned dairy and beef herds, sheep flocks, pigs, and poultry, and accounted for more pastoral output than landlords. After the Black Death, the pastoral sector expanded in size and increasingly moved from landlord into peasant hands. Landlords withdrew almost completely from those sectors of pastoral production that were most commercialized and labour-intensive, notably beef-cattle-raising, dairying, poultry-rearing, and (to a lesser extent) pig-rearing. These were the very sub-sectors in which landlord enterprises would have had to hire live-in servants, because of the need for intensive tending of the livestock and poultry for short periods every day. Where landlords did continue in pastoral operations, they usually focused on large-scale sheep- and rabbit-rearing, because they possessed the land and capital to increase operations to a scale that effectively reduced unit costs. These were the least labour-intensive pastoral activities, which did not require live-in, unmarried, women servants, because they mainly involved low-level supervision for much of the year, supplemented by seasonal labour (for lambing, shearing, and culling). Peasant households, by contrast, were better suited to dairying and the raising of beef-cattle, pigs, and poultry, because the routine daily tasks of milking and tending the animals could be readily handled by married women and their resident offspring in between domestic and other farm-based activities.

3.2. Women and Pastoral Production in the Peasant Household

It might still be argued that, although peasants engaged in pastoral production, once peasant women were married they helped their peasant husbands in arable production, but did not engage in pastoral production. This is the argument of the VV model, and is crucial to their conclusion that the shift to pastoral agriculture caused women not to marry. However, the historical evidence does not support this assumption. Married women did work in the pastoral sector in medieval and early modern England, both in peasant pastoral production and as paid labourers for landlords.

The work of married women, particularly among the peasantry, is among the least visible in the historical records (Wall 1994, p. 139; Ogilvie 2003, p. 140). It is thus striking that the surviving evidence on the work of peasant wives in medieval England confirms unambiguously that they did not just engage in housework but also made a substantial contribution to the agricultural work of the peasant household. This included pastoral activities since, as Section 3.1 discussed, virtually all peasant holdings practised mixed agriculture and shifted towards more pastoral production after the Black Death. Power's classic account, for instance, states uncompromisingly that medieval peasant women "were expected, if they were married, to share in all

their husband's labours on their family holdings" and describes "the strenuous hours and weeks which a working wife was called upon to spend by her husband's side in fields and pastures" (Power 1975, p. 71). Manorial accounts and court records show that "even married women with young families did venture from their homes" (Goldberg 1991, p. 82). These sources reveal that "women participated in most aspects of agrarian life whether as family labour or paid employees"; the only jobs they are not recorded doing are ploughing and mowing, both arable tasks (Goldberg 1992b, p. xii).

Married women in medieval England performed many of the same forms of work as those for which they had received wages as unmarried servants (Mendelson and Crawford 1998, p. 269). Since women were particularly productive at pastoral work when they were servants, it is unsurprising that they also specialized in animal care when they worked as married women within the peasant household enterprise. Twelfth- and thirteenth-century English peasant housewives, for instance, "took care of the family's cows, pigs and poultry as well as the crops growing in the garden" (Mate 1999, p. 16). Analyses of the seasonality of married women's work inside the peasant household suggests that "spring was an exceptionally busy time for women ... this would have been most true of pastoral regions" (Goldberg 1991, p. 81).

The peasant housewife bore main responsibility for all animals except the oxen or horses used to draw the plough. Married peasant women were responsible for the daily care of the cows and sheep which, as we have seen, many peasant households kept in large numbers. The peasant housewife fed the animals, weaned the young calves and lambs, milked the cows and ewes, made butter and cheese, and participated at calving and lambing (Hanawalt 1986a, p. xiv; Hanawalt 1986b, pp. 1, 10; Holderness 1990, p. 264; Goldberg 1991, p. 82; Graham 1992, p. 127; Mate 1999, pp. 31-2; Bardsley 2007, pp. 63, 66). In peasant households nearly everywhere in England, "wives raised pigs and poultry to provide food for the households ... milked cows and ewes and manufactured butter and cheese ... In the period after 1348 this work outside the home became even more important" (Mate 1999, p. 31-2). Court records describe peasant housewives engaging in dairying operations such as milking cows (Goldberg 1992a, p. 110). Medieval coroners' reports show peaks in peasant women's accidental deaths in the morning and at noon, resulting partly from women "working with large animals" (Hanawalt 1986b, p. 8). In a famous sermon, Bishop Hugh Latimer (born 1487), described how his farmer father "had a walk for a hundred sheep, and my mother milked thirty kine" (quoted in Du Boulay 1965, p. 451). Milking and dairying were exclusively female occupations in medieval England and continued to be so throughout the early modern period (Whittle 2005, p. 69).

Married peasant women cared for cows, sheep, and pigs during the winter when they were penned outside, sheltered in byres, or (as in some northern and western regions) housed under the same roof as the peasant family. In the other seasons of the year, peasant wives were responsible for taking the animals to pasture and herding them in the environs of the village (Hanawalt 1986b, p. 9; Bardsley 2007, p. 66). The

daily routine of the peasant housewife involved taking the cows to pasture and taking the geese to the green (Hanawalt 1986b, p. 9). Medieval law-courts record peasant women being prosecuted "for illegally trespassing with animals in the common field" (Graham 1992, p. 129). Married peasant women appeared in manor courts accused of offences relating to herding animals, as in 1331 when a married woman in Wiltshire was punished for taking her cow out of the landlord's pinfold where it had been placed (Müller 2013, p. 106). Pastoral production was sufficiently central to the responsibility of peasant wives that in 1403 a woman in Bothall bequeathed a cow apiece to two married women serving her in her final illness (Goldberg 1995, p. 179).

Surviving archival documents include a number of cases in which adult peasant women of unrecorded marital status are described as operating in the pastoral sector with their own animals, as in 1383 when a woman in Middlesex entered a man's land "with her pigs and destroyed his corn within his close, viz. beans and peas to the damage of ... 3s. 4d." (Goldberg 1995, p. 174). We cannot be sure that such women were currently married: they may have been widows or independent spinsters. However, the women in these cases are clearly working in peasant (i.e. non-landlord) pastoral production as independent adults rather than servants or offspring. Given the archival references to married peasant women doing pastoral work, it seems certain that peasant women of unknown marital status working in the pastoral sector included married women.

The peasant housewife was also involved in the purchase, washing, and shearing of the sheep in the household flock. In court records from rural communities, married peasant women are observed purchasing sheep (Goldberg 1992a, p. 110). The peasant housewife and the resident daughters of the family are described as washing and shearing the sheep owned by the peasant enterprise (Bardsley 2007, p. 66). Manorial court records describe married women as "clipping sheep in the pasture for their wool" (Hanawalt 1986b, p. 13).

Married women were also intensively involved in the marketing of pastoral goods produced by the peasant household. Thus it was the peasant housewife who sold the pastoral surplus – eggs, butter, cheese, yarn – in the local market or the neighbouring town (Goldberg 1991, p. 82; Mate 1999, pp. 31-2; Dyer 2005, p. 28, 89). Married peasant women are described as having control over the money they earned by selling these pastoral products (Hanawalt 1986b, p. 16). In the more detailed archival sources of the sixteenth and seventeenth centuries, farmers' wives are recorded engaging in specialized dairying operations, in which they would churn cream into butter on Tuesdays and Fridays ready to take it to sell at the markets customarily held on Wednesdays and Saturdays (Mendelson and Crawford 1998, p. 307). The activities of medieval peasant housewives in producing and marketing pastoral goods are regarded as having afforded them "some independence of action, and a very real degree of economic clout within the family economy" (Goldberg 1991, p. 82; see also Mate 1999, pp. 33-49).

The historical evidence does not, therefore, support the assumption that women only engaged in pastoral production if they worked for landlords. Not only did peasant households engage in a great deal of pastoral production, but peasant housewives were fully involved in this work, and their involvement almost certainly increased with the shift from arable to pastoral after the Black Death. Married peasant women performed many of the same types of work as those for which they had received wages as unmarried servants, specifically the pastoral tasks in which female productivity was high. The implications for marriage patterns are clear. Since peasant households engaged in pastoral production, and did so increasingly from 1350 onwards, women could work in the pastoral sector on the peasant family holding and did not need to work for landlords. Women did not have to remain unmarried in order to work in pastoral agriculture, even if it were the case that working for landlords required women to stay single.

3.3 Married Women's Work on Landlord Estates

The second crucial assumption in the VV theoretical model is that women who worked for a landlord had to do so as unmarried agricultural servants. This assumption is based on an inaccurate understanding of the labour force in medieval agriculture. The VV model assumes that the agricultural labour force consisted of unmarried live-in servants working for landlords and members of peasant households working for themselves. This ignores a third key group of workers: independent labourers, comprising individuals of both sexes and a range of marital statuses, including married women. In the late fourteenth century, a typical English landlord would employ between four and ten full-time farm servants, but between one dozen and two dozen labourers (Dyer 2005, p. 229). The Cheshire estate of Newton in 1498-1520 combined animal husbandry (cattle, sheep, pigs and hens) with crop growing, employing a labour force of approximately five workers at any given time, made up of resident servants, long-term non-resident labourers, and short-term day-labourers, of both sexes (Youngs 1999, pp. 146-8).

Wage-labourers were recruited from the under-employed male and female members of smallholder and cottager households lacking enough land to live wholly from farming. In such households, both the husband and the wife often had to take work as wage-labourers for landlords (Middleton 1979, pp. 159-62; Hanawalt 1986b, p. 11; Bardsley 2007, p. 63). Married peasant women frequently engaged in work that was not an integral part of the peasant household but instead involved selling their labour on the market to employers (Smith 1990b, p. 53). As a result, the work profile of women married to wage-earning men "was not so dissimilar from that of many single women" (Goldberg 1986a, p. 34).

If anything, independent labouring by married females intensified after the Black Death. Dyer describes an increase in the labour-force participation of married

females, as rising wages pulled increasing numbers of wives who had previously engaged in unpaid household work into wage-earning market employment (Dyer 2005, pp. 222-3). Bailey argues that the Black Death caused a widespread shift from servanthood by unmarried individuals to wage-labouring by married couples: both sexes married at an early age but supplemented family incomes by wives taking wage-labour where necessary (Bailey 1996, pp. 13-5). This was understandable: in conditions of labour scarcity, workers were less attracted by guaranteed servanthood contracts since they knew they could get steady work as labourers, at higher wages than servants (Bailey 1996, p. 14). It was also easier for employers and the authorities to enforce wage ceilings and mobility restrictions against servants on annual contracts than against casual day-labourers (Humphries and Weisdorf 2015, pp. 420-3). Labouring may have been particularly attractive for female workers, since female labourers' wages rose after the Black Death whereas female servants' wages stayed remarkably flat, possibly because unmarried maidservants were more vulnerable to employers' enforcement of the legal wage ceilings (Humphries and Weisdorf 2015, pp. 417, 420-3).

Females – including married women – certainly made up a non-trivial proportion of English labourers in the period after the Black Death. In Somerset in 1358-60, females comprised 26 per cent of those described as "labourers" who were punished for charging wages higher than the legal wage-ceiling (Penn 1987, pp. 506). In Essex in 1352, 1,559 female labourers were prosecuted for such violations, and over fifteen per cent of these women were explicitly described as married (Poos 1991, p. 226). On the Essex demesne of Porter's Hall in 1483-4, approximately one-third of all person-days worked by labourers were worked by females; of the sixteen named female labourers, six were explicitly described as married (Poos 1991, pp. 214, 217). On the Cheshire estate of Newton in 1498-1520, 14 of 45 female day-labourers (31 per cent) were specifically recorded as married women and a number of others shared surnames with male workers (Youngs 1999, pp. 157-8).

Marriage may even have helped women get work as labourers. For one thing, married females were not subjected to the social and legal pressures placed on unmarried ones to enter into dependent annual servanthood contracts. For another, wives often obtained access to employment through husbands, worked alongside them, or were recruited by them to work for the same employer (Penn 1987, pp. 6-11; (Youngs 1999, pp. 157-8; Humphries and Weisdorf 2015, pp. 411-2).

Documentation of the precise tasks carried out by married female labourers is extremely rare, even after 1500 when archival sources become more plentiful. Unsurprisingly, however, the few surviving references show that the work of married female labourers included the normal pastoral tasks in which females engaged as unmarried servants and as peasant housewives (Mendelson and Crawford 1998, pp. 273-4). In 1483-4, a married woman was paid wages for doing twelve days' milking at Porter's Hall in Essex (Poos 1991, p. 217). In a Devon village in 1598, a married

woman was being paid to shear sheep; in a Somerset village in 1603, a work gang shearing sheep for wages consisted of 3 men and 2 married women (one working independently of her husband); in another Devon village in 1634 two married women aged 53 and 54 were working as hired labourers and "deposed that they had together sheared 50-60 sheep in each of the last three years for one Westcott of Holcombe Burnell".[3] In 1698, a married woman was working for Sir Daniel Fleming as a labourer, "salveing and tobaccoing of sheep" (Humphries and Weisdorf 2015, pp. 411). Availability of archival sources means that most examples explicitly stating that married female labourers worked in pastoral activities come from the period after c. 1480, but there is no reason to believe that the many married female labourers recorded in earlier medieval documents did not also earn their wages doing pastoral tasks, especially given the evidence discussed earlier showing that married women carried out pastoral work within the peasant household.

A second pattern was for married women to be employed by landlords to do pastoral work at a higher level of responsibility. In the thirteenth century, the De Lacy estate in Lancashire ensured the management of its pastoral enterprises by hiring married vaccary keepers who organized the labour force to care for the livestock using their entire households: men, wives, children, and hired herdsmen. The wives and other female family members were responsible for the milking, the butter-churning, the cheese-making, the other dairy work, and the marketing of the produce. When the herds were moved seasonally, the wives and daughters of the vaccary keepers remained at the home farm to tend the milk-cows and calves and do the specialized cheese-making. So fully involved were the vaccary keepers' wives in this paid pastoral work for landlords that in the 1290s three of the De Lacy vaccaries were operated by women, probably widows who had hitherto been running them with their husbands and were holding the tenancies until sons could take over (Atkin 1994, p. 16). Similar family-based pastoral employment of married women in the pastoral sector is recorded in other contexts, as on the Sussex manor of Alciston which in the fifteenth century employed married male shepherds and dairymen who carried out their paid employment with the aid of their wives and other family members (Mate 1999, p. 32). In 1509 the East Suffolk manor of Sibton Abbey employed a married woman called Katherine Dowe to manage the demesne dairy. With the help of three maidservants, she was responsible for caring for 63 cows, milking them, manufacturing the butter and cheese, and caring for the pigs and poultry (Whittle 2005, pp. 69-70).

The historical evidence does not, therefore, support the assumption that working for a landlord in pastoral production required a woman to remain unmarried.

[3] Devon quarter sessions 1598 (Devon Heritage Centre, QS/4/Box5); Somerset church court deposition 1603 (Somerset Archives, Church Court Depositions D/D/Cd/36); Devon church court deposition 1634 (Devon Heritage Centre, Chanter 866). We are very grateful to Jane Whittle for her generosity in providing these references.

On the contrary, many land-poor and landless rural households could not survive unless both the husband and the wife went out to work, often as wage-labourers for landlords. Females in general, and married women in particular, made up a quantitatively significant share of the agricultural labourers employed by landlords and better-off farmers. Although the precise tasks performed by such married female labourers are only rarely recorded, they clearly included pastoral as well as arable work. Married women also worked for landlords in positions of greater responsibility, both as partners in familial teams of vaccary keepers and as individual managers of demesne dairy operations.

The key assumptions in VV's theoretical model are thus not consistent with the historical evidence. Can it nonetheless be argued that this does not matter because all models have to make simplifying assumptions? The answer is no, because not all simplifying assumptions are acceptable. An acceptable simplifying assumption is one which abstracts from non-essential complications without being crucial for the results of the model. If an acceptable simplifying assumption were to be relaxed, the analysis would have to take account of additional details, but the results of the model would still hold. This does not apply to VV's key assumptions: relaxing them would completely change the results of the model. VV's theoretical results are entirely driven by two critical assumptions which are inconsistent with the historical evidence.

4. Is There Evidence of a Causal Relationship between Pastoral Agriculture and Lower Fertility?

Can it instead be argued that it does not matter that the VV theoretical model is driven by inaccurate assumptions, because the empirical evidence supports its predictions? The answer is no. Careful examination shows that the evidence advanced to support the predictions of the VV model does not in fact do so.

The central argument of VV is that there was a causal relationship between pastoral agriculture and lower fertility. They provide three major pieces of evidence to support this claim. First, they argue there was a positive causal link between the extent of pastoral agriculture in English counties in 1290 and the proportion of unmarried females in these counties in 1381 (VV, Table 3). Second, they argue there was a positive causal link between pastoralism before the Black Death and female age at first marriage (henceforth FAFM) several hundred years later, as well as a positive association between the shift to pastoral agriculture after the Black Death and FAFM several hundred years later (VV, Table 4). Finally, they argue that there was a positive causal relationship between a measure of pastoralism in the early modern period and FAFM in the early modern period (VV, Table 5). Does the evidence show that these causal relationships in fact prevailed in medieval and early modern England?

4.1 Pastoralism and the Proportion of Unmarried Females in 1381

First, did pastoralism in 1290 cause female celibacy in 1381? VV (Table 3) report several regressions showing a relationship between an approximate measure of the proportion of pastoral land in a county in 1290 and a proxy for the proportion of unmarried women in a county in 1381. This proxy is the proportional decrease in the number of taxpayers between the 1377 and 1381 poll tax returns. It is needed because little information about the number of unmarried women is available from the 1377 returns and the information about the number of unmarried women reported in the 1381 returns is not accurate due to a trebling of the tax between 1377 and 1381. This caused huge evasion which is thought to have involved "suppress[ing] the existence of ... unmarried female dependents, widowed mothers and aunts, sisters, young daughters, &c." (Oman 1906, p. 28). However, if the drop in recorded taxpayers between 1377 and 1381 indeed resulted from concealment of unmarried women, then the proportion of unmarried women in a county can be proxied by the proportional fall in taxpayer numbers.

The proportion of pastoral land in a county in 1290 (henceforth denoted as *Pastoral 1290*) is calculated as one minus the proportion of arable land in 1290 (Broadberry et al. 2015; VV 2013, p. 2253). This is only an approximation of the actual proportion of pastoral land, since non-arable land also included woodland, unfarmable moorlands and mountains, ornamental parks, surface water, communications, and settlements. In their online appendix, VV provide reasons for regarding the proportion of non-arable land as a reasonably accurate indicator of the proportion of pastoral land, but it unavoidably measures the share of pastoral land in 1290 with some degree of error.

To deal with the endogeneity of *Pastoral 1290* created by the measurement error and the likelihood that their regressions omit explanatory variables with which it is correlated, VV use an instrumental variable (henceforth IV) for *Pastoral 1290*. The IV on which they focus is the log of the number of days when grass can grow in different counties (henceforth ln(*daysgrass)*). VV Table 3 equation (4) reports a regression of the proportion of unmarried women in 1381 (proxied by the decrease in taxpayers 1377-81) on *Pastoral 1290* using ln(*daysgrass)* as an IV. The resulting point estimate of the causal effect of *Pastoral 1290* is both statistically and economically significant, corresponding to an elasticity of 1.59 (here and throughout the paper, all reported elasticities are calculated at sample mean values). VV show that the estimate of the causal effect of *Pastoral 1290* on the drop in the number of taxpayers 1377-81 is very similar if the general crop suitability of a county is used as a second IV for *Pastoral 1290* (VV 2013, Appendix, Table B.5).

There is, however, a problem with VV's IV estimate of the effect of *Pastoral 1290* on the drop in taxpayer numbers 1377-81: both IVs used are correlated with a variable omitted from the IV regression that VV estimated. Thus both IVs are invalid.

Table A1 in the Appendix to this paper shows that both ln*(daysgrass)* and general crop suitability are correlated with the log of county population density in 1290 (henceforth ln*(popdensity)*). Table 1 shows the results of estimating a regression model in which ln*(popdensity)* is added to VV's IV specification. Equation (1.1) uses ln*(daysgrass)* as an IV, equation (1.2) uses general crop suitability, and equation (1.3) uses both variables together. The estimated effect of ln*(popdensity)* is both statistically and economically significant in all three equations: the elasticity of the drop in taxpayer numbers 1377-81 with respect to population density in the three equations varies between 1.4 and 1.6. The omission of ln*(popdensity)* from the IV regression estimated by VV therefore means that the IV estimates they report for the effect of *Pastoral 1290* on the drop in taxpayer numbers 1377-81 are inconsistent, because the IVs are correlated with ln*(popdensity)*.

The first-stage F statistics for all three equations in Table 1 show that there are serious weak-instrument problems.[4] The critical value at which the Montiel Olea-Pflueger statistic rejects the null hypothesis that the LIML estimator has a bias no larger than 30 per cent of the worst case is 12.04 for equations (1.1) and (1.2), and 8.38 for equation (1.3). The finite-sample bias of IV estimation is particularly serious when the IVs are weak, so to obtain the results in Table 1 we use Fuller's modified LIML estimator with parameter $a = 1$, which is a recommended estimator in the case of weak instruments.[5] The Stock-Yogo critical value for the maximal bias of the Fuller estimator to be 30 per cent of that of the OLS estimator is 12.71 for equations (1.1) and (1.2), and 7.49 for equation (1.3). The critical values for the maximal absolute bias of the Fuller estimator to be 30 per cent are 12.76 and 6.97 respectively. Thus in these equations the point estimates of the effect of *Pastoral 1290* on the drop in taxpayer numbers 1377-81 are likely to be substantially biased.

Table 1 reports both standard (based on the asymptotic distribution of the IV estimator) and weak-instrument-robust confidence intervals for the effect of *Pastoral 1290*. The asymptotic distribution of the IV estimator is likely to be a poor approximation of the actual sampling distribution when the IVs are weak. The weak-instrument-robust 95 per cent confidence intervals show that it is essentially impossible

[4] Table 1 reports both the Kleibergen-Paap (2006) and Montiel Olea-Pflueger (2013) first-stage F statistics. The former is typically used as an ad hoc procedure for adjusting the Stock-Yogo (2005) tests which apply to the case of iid errors, although there is no formal justification for it. The latter is a formal test that allows for non-iid errors. In some cases it is equal to the former. The Stata command *ivreg2* (Baum et al. 2010), which was used for all the estimates in this paper, reports the Kleibergen-Paap F statistic. The Montiel Olea-Pflueger F statistics were calculated using the Stata command *weakivtest* (Pflueger and Wang 2015).

[5] Hahn et al. (2004). An alternative recommended estimator is Fuller's modified LIML estimator with parameter $a = 4$. The conclusions drawn from Table 1 are unchanged if this estimator is used.

Table 1: Instrumental Variable Estimates of the Effect of the Share of Pastoral Land in 1290 on the Drop in Taxpayer Numbers 1377-81

	Dependent variable: Drop in taxpayer numbers 1377-1381		
Regressors	(1.1)	(1.2)	(1.3)
Pastoral 1290	2.23	2.40	2.44
95 per cent standard confidence interval	[0.66, 3.79]	[0.94, 3.86]	[1.20, 3.68]
95 per cent weak-instrument-robust confidence interval	[-500, 500]	[-500, 0.353] U [1.090, 500]	[-500, 500]
90 per cent weak-instrument-robust confidence interval	[-500, -20.961] U [0.257, 500]	[-500, -3.308] U [1.538, 500]	[-500, 500]
ln(*popdensity*)	0.47	0.52	0.53
95 per cent confidence interval	[0.02, 0.92]	[0.07, 0.96]	[0.14, 0.91]
Kleibergen-Paap *F* statistic	3.50	4.97	4.18
Montiel Olea-Pflueger *F* statistic	3.50	4.97	4.81
Observations	38	38	38
R^2	0.277	0.200	0.179

Notes: The weak-instrument-robust confidence intervals were obtained using the Stata *weakiv* command of Finlay et al. (2013). For equations (1.1) and (1.2) these are based on the Anderson-Rubin test, and for equation (1.3) on the conditional likelihood ratio test. The range of values for the coefficient of *Pastoral* 1290 assumed for the calculation of these confidence intervals was [-500, 500].

to reject any null hypothesis about the coefficient of *Pastoral 1290*. The only values for this coefficient between -500 and 500 that can be so rejected are those from 0.353 to 1.090 in the case of equation (1.2). The weak-instrument-robust 90 per cent confidence intervals show that it is possible to reject the null hypothesis that the coefficient of *Pastoral 1290* is zero at 0.10 level in equations (1.1) and (1.2), but even with this larger size of test it is not possible to reject the null hypotheses that this coefficient is equal to most values between -500 and 500.

Once ln*(popdensity)* is included in the IV regressions, as it must be in order to obtain consistent estimates, the IVs are so weak that the resulting estimates of the causal effect of *Pastoral 1290* on the drop in taxpayer numbers 1377-81 are almost completely uninformative. There is an economically and statistically significant positive association between these two variables controlling for ln*(popdensity)*, as equation (2) in Table 3 of VV shows. But it is almost certain that this association does not reflect a causal relationship, given that the share of pastoral land in 1290 is measured with error and other variables influencing the drop in taxpayers are omitted from the regression. Any causal link that might exist between pastoral agriculture and the proportion of unmarried females cannot be detected from these data.

4.2 Pastoralism and Female Age at First Marriage

What about the causal link between pastoral agriculture and women's marriage age? In Tables 4 and 5 of their paper, VV analyse the relationship between various measures of pastoralism and FAFM in England between 1600 and 1837. The dependent variable is derived from the Cambridge Group for the History of Population and Social Structure parish-level estimates of FAFM, which are available for each of a maximum of 26 parishes at five different periods (1625, 1675, 1725, 1775 and 1819).[6] VV matched the 26 parishes to the 15 counties which constitute their units of observation for the regressors, so the dependent variable is the mean FAFM in the parishes located in a particular county, which is observed at five different periods. Although FAFM varies across periods, almost all the regressors in VV's Tables 4 and 5 take the same value in all five periods. The single exception is the share of parishes with a spring marriage pattern, as will be explained shortly.

In Table 4 of VV, there are two regressors of primary interest. One is *Pastoral 1290*, which measures the extent of pastoral agriculture in a county before the Black Death. For the reasons mentioned in the preceding section, it almost certainly measures pastoralism with some error. The other main regressor is the county-level number of deserted medieval villages (DMVs) per 100,000 acres. This is interpreted as measuring the shift from arable to pastoral production after the Black Death.[7] Again, this variable almost certainly measures the arable-pastoral shift with error.

At best, the regressions in VV's Table 4 can show that there was some relationship between FAFM in the period c. 1600 – c. 1837 and the two measures of pastoral agriculture some centuries earlier. Even if the evidence for the existence of such a relationship was unambiguous, it could not provide unambiguous support for the VV theory, because there are other mechanisms that could underlie such a relationship. As we will see, however, the evidence for the existence of the relationship is far from unambiguous.

In Table 5 of VV, the regressor of primary interest is the county-level share of parishes with a spring marriage pattern in the period c.1560 – c. 1820. Kussmaul (1990) argues that marriage seasonality shows whether a parish was pastoral or arable. If marriage frequency was high in spring but low in autumn, she suggests, a parish was pastoral rather than arable, since pastoral servants would typically marry after the lambing season while arable workers would marry after the harvest season. So VV measure pastoralism by calculating the county-level share of parishes with a spring marriage pattern (henceforth *Pastoral Marriage*) using Kussmaul's data for 542

[6] FAFM was available for 19 of the 26 villages in 1625, 21 in 1675, 26 in 1725, 24 in 1775 and 22 in 1819.

[7] Broadberry et al. (2015), ch. 2 section 3, discuss the use of the density of DMVs as an indicator of the switch from arable to pastoral production following the Black Death.

English parishes from 1561 to 1820. *Pastoral Marriage* for 1625 is based on Kussmaul's data for the period 1561-1640; for 1675 and 1725 it is based on Kussmaul's data for 1661-1740; and for 1775 and 1819 it is based on Kussmaul's data for 1741-1820. This variable therefore takes three different values in the five periods. Once again, even if a clear positive relationship existed between *Pastoral Marriage* and FAFM, it would provide only limited support for the VV theory about the Black Death, since the degree of pastoralism in a county in 1561-1820 was not necessarily the same as it was in 1350-1400.

An immediate problem with VV's Table 5 is that equation (3) is estimated using *Pastoral 1290* as an IV for *Pastoral Marriage*. Given the VV claim that *Pastoral 1290* has a causal effect on FAFM, it cannot be a valid IV for *Pastoral Marriage* in a regression model of FAFM, since it cannot satisfy the required exclusion restriction. VV's results in which *Pastoral 1290* is used as an IV must therefore be disregarded, as they are based on an IV that is clearly invalid.

VV argue that all three measures of pastoralism – *Pastoral 1290*, the density of DMVs, and *Pastoral Marriage* – influence FAFM. But they do not explain why they omit *Pastoral Marriage* as a regressor in their Table 4 regressions, or why they omit *Pastoral 1290* and the density of DMVs in their Table 5 regressions. Since all three measures are expected to influence FAFM, omitting any of them is likely to result in biased estimates of the effects of the others unless there exist IVs to allow for the omitted variables. If VV are correct in arguing that all three pastoralism variables influence FAFM, the OLS estimates reported in their Tables 4 and 5 must suffer from omitted variable problems.

In Table 2, therefore, we report the results of OLS estimation of regression models of FAFM which include all three pastoralism variables. Regional dummy variables and ln*(popdensity)* are also included as regressors. Since the only regressor that varies across the five periods is *Pastoral Marriage*, there is very little to be gained by pooling the periods. We therefore estimate the regressions separately for each of the five periods. We follow VV by assuming that the regression errors are clustered at the county level, although this creates some complications. The standard cluster-robust variance estimate assumes that the number of clusters tends to infinity, but in this case there are only 15 counties. Monte Carlo simulations by Cameron et al. (2008) suggest that with a small number of clusters the best method of estimating the cluster-robust variance matrix is a version of the wild cluster bootstrap. In Tables 2 and 3 we therefore report 95 per cent confidence intervals for the parameters of interest obtained from such a bootstrapping procedure, using the Stata *boottest* command of Roodman (2015).[8]

[8] The random weights applied to the residuals in each bootstrap replication underlying the results in Table 2 were drawn from the distribution proposed by Webb (2014), rather than the two-point wild bootstrap analysed by Cameron et al.

Table 2: OLS Estimates of the Association between Female Age at First Marriage and Pastoralism

	Period				
	1625	1675	1725	1775	1819
Regressors	(2.1)	(2.2)	(2.3)	(2.4)	(2.5)
Pastoral 1290	10.62	24.82	23.72	11.13	4.658
	[-5.3, 15.67] U [17.91, 47.76]	[1.25, 52.16]	[14.96, 31.76]	[9.20, 16.52]	[-9.38, 15.62]
DMV	9.21	17.24	23.03	15.20	6.894
	[-15.07, 16.52]	[-24.62, 45.11]	[11.28, 33.34]	[9.43, 18.1]	[-3.35, 11.08]
Pastoral Marriage	-3.02	-7.23	-1.86	-1.83	5.66
	[-6.15, 7.36]	[-29.21, 15.9]	[-4.51, 2.49]	[-4.79, 2.98]	[0.10, 12.27]
ln(*popdensity*)	2.33	5.10	4.80	1.89	1.02
	[-5.02, 4.15]	[-3.54, 13.37]	[2.48, 7.52]	[0.77, 3.23]	[-2.62, 2.6]
Regional dummy variables	Yes	Yes	Yes	Yes	Yes
p values for regional dummy variables	0.296	0.440	0.116	0.068	0.082
Elasticity:					
a) *Pastoral* 1290	0.224	0.544	0.533	0.270	0.115
b) *DMV*	0.031	0.057	0.066	0.048	0.024
c) *Pastoral Marriage*	-0.013	-0.039	-0.011	-0.008	0.025
d) ln(*popdensity*)	0.417	0.902	0.836	0.345	0.192
Observations	19	21	26	24	22
R^2	0.490	0.772	0.806	0.681	0.840

Notes: Figures in brackets are 95 per cent confidence intervals obtained from the wild cluster bootstrap as described in the main text.

In Table 2, the p values for the test of the null hypothesis that the coefficients of the regional dummy variables are all zero provide very weak evidence that regional influences are associated with FAFM. There is, however, some evidence that FAFM is associated with ln*(popdensity)* in some periods.

The associations between FAFM and the pastoralism variables in Table 2 do not provide unambiguous support for the VV argument. The association between FAFM and *Pastoral Marriage* is negative in all periods except the last one, where it is positive. Even if the fact that the 95 per cent confidence intervals include zero for all periods except 1819 is ignored, the economic significance of this association, as measured by the elasticity corresponding to the point estimate, is very small indeed. Nevertheless, it is unclear how VV's theory can be consistent with a situation in which, if there is an association at all, it is one in which a county with higher pastoral marriage seasonality is associated with a very slightly lower female marriage age.

Table 2 shows a clear positive association between the county-level density of DMVs and FAFM in 1725 and 1775. In the other periods, the point estimate is positive, but poorly determined. However, the economic significance of this association is always very small: the largest elasticity corresponding to the five point estimates is a mere 0.066 in 1725.

It is only for *Pastoral 1290* that there is any clear evidence of an association with FAFM that is of both economic and statistical significance. In 1675, 1725 and 1775 the confidence intervals exclude zero. The elasticity corresponding to the point estimate is a little larger than 0.5 in 1675 and 1725, and roughly half this size in 1775. The point estimate of the association in 1625 is similar to that in 1775, but is poorly determined, while the association in 1819 is small and poorly determined. The fact that the association between *Pastoral 1290* and FAFM is clearer and larger in 1675 and 1725 than in 1625 is not easy to reconcile with the VV theory. It suggests that this association is being driven by influences that operated in the late seventeenth and early eighteenth century, but not earlier. This casts doubt on the idea that it has anything to do with the Black Death, a point discussed more fully below.

Of course, the causal effects of pastoralism on FAFM are likely to differ from the associations reported in Table 2 for a number of reasons. *Pastoral 1290* measures the share of pastoral land in 1290 with error, the density of DMVs measures the shift from arable to pastoral agriculture after the Black Death with error, and *Pastoral Marriage* measures the extent to which counties engaged in pastoral agriculture in the early modern period with error. In addition, the regressions in Table 2 almost certainly omit variables that influenced FAFM, at least some of which are likely to be correlated with the pastoralism measures. To identify the causal effects of pastoralism, IV estimation is necessary, although the small number of observations available means that the potential advantage of IV over OLS – consistency – may well be outweighed by increased variance. As we have already noted, however, all the regressors used by VV in their analysis of the causal effects of pastoralism on FAFM except one –

Pastoral Marriage – take the same values in all five periods. The same is true of the two IVs. Thus, by using IV estimation with a small number of observations, we are simply following the VV procedure.

VV's dataset contains two possible IVs – ln*(daysgrass)* and general crop suitability – for the three pastoralism variables. We follow VV in not treating the density of DMVs as an endogenous variable despite the likelihood that it measures the post-Black-Death shift from arable to pastoral agriculture with error. Assuming this to be justified, in principle it would be possible to obtain IV estimates of the effect of *Pastoral 1290* and *Pastoral Marriage* on FAFM using the two available IVs. In practice, however, this is not possible, because general crop suitability does not satisfy the relevance condition – that it be sufficiently closely correlated with the endogenous variable – for either *Pastoral 1290* or *Pastoral Marriage*. This emerges from the first-stage regressions of the two endogenous variables on general crop suitability together with the density of DMVs, ln*(popdensity)*, and regional dummies, for each of the five periods. The first-stage F statistic is 11.97 in one case, but in the other nine cases it never exceeds 2.66. So the only relevant IV available is ln*(daysgrass)*.

In these circumstances, it is possible to use ln*(daysgrass)* as an IV in order to obtain a consistent estimate of the effect of one of the two endogenous variables while omitting the other endogenous variable provided that, conditional on the other regressors, the omitted endogenous variable is not correlated with ln*(daysgrass)*. Table A2 of our Appendix shows that these conditions are clearly satisfied in all periods except 1625 when *Pastoral 1290* is the included endogenous variable and *Pastoral Marriage* the omitted one. But when *Pastoral Marriage* is the included endogenous variable and *Pastoral 1290* the omitted one, the conditions required for ln*(daysgrass)* to give a consistent estimate of the effect of *Pastoral Marriage* are not satisfied.

We therefore proceed by estimating regression models of FAFM which include *Pastoral 1290* but omit *Pastoral Marriage*. The regressions, reported in Table 3, also include the density of DMVs, ln*(popdensity)*, and regional dummy variables,. The models are estimated separately for each of the periods 1625, 1675, 1725, 1775, and 1819. The IV estimates in Table 3 are obtained using Fuller's modified LIML estimator with parameter $a = 1$, since the first-stage F statistics suggests that ln*(daysgrass)* is a weak instrument for equation (3.5).[9] In equations (3.1) – (3.4), however, the first-stage F statistics suggest that weak-instrument bias is not a serious problem. As in Table 2,

[9] The IV estimates in Table 4 are similar if either Fuller's estimator with parameter $a = 4$ or two-stage least squares are used instead. The Stock-Yogo critical values for the Fuller estimator to have maximal bias of 30 per cent of that of the OLS estimator and to have maximal absolute bias of 30 per cent are 12.71 and 12.76 respectively: the corresponding values for 5 per cent bias are 24.09 and 23.81. The critical values for the Montiel Olea-Pflueger F statistic to reject the null hypothesis that the LIML estimator has bias equal to 5, 10 and 30 per cent of the worst-case bias are respectively 37.42, 23.11 and 12.04.

Table 3: Instrumental Variable and OLS Estimates of the Effect of *Pastoral 1290* on Female Age at First Marriage

	IV estimates					OLS estimates				
	Period					Period				
	1625	1675	1725	1775	1819	1625	1675	1725	1775	1819
Regressors	(3.1)	(3.2)	(3.3)	(3.4)	(3.5)	(3.6)	(3.7)	(3.8)	(3.9)	(3.10)
Pastoral 1290	4.29	3.05	18.52	10.04	8.12	5.17	6.22	18.77	10.24	4.22
95 per cent standard confidence interval	[-19.78, 23.39]	[-7.22, 16.17]	[12.85, 28.72]	[6.91, 17.14]	[-7.42, 500]	[-17.75, 19.98]	[-10.9, 36.84]	[9.96, 21.7]	[6.33, 16.04]	[-15.99, 16.52]
95 per cent weak-instrument-robust confidence interval	[-15.21, 29.3]	[-3.24, 7.60]	[10.13, 27.71]	[4.82, 17.01]	[-4.29, 27.89]					
DMV	6.03	1.86	19.55	14.31	9.35	6.64	4.05	19.71	14.44	7.38
95 per cent confidence interval	[-16.33, 30.37]	[-46.93, 25.73]	[10.23, 26.96]	[6.52, 18.33]	[2.93, 19.13]	[-18.18, 30.32]	[-57.5, 26.6]	[3.28, 25.11]	[4.16, 17.98]	[-0.13, 24.57]
ln(*popdensity*)	1.12	0.19	3.61	1.63	1.61	1.23	0.59	3.64	1.65	0.98
95 per cent confidence interval	[-3.59, 5.88]	[-4.08, 10.85]	[1.75, 8.38]	[-0.06, 4.16]	[-3.30, 5.17]	[-5.87, 5.97]	[-8.72, 13.92]	[-0.19, 9.21]	[-0.94, 4.2]	[-4.48, 4.43]
Regional dummy variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap *F* statistic	24.03	26.04	29.48	30.74	11.31					
Montiel Olea-Pflueger *F* statistic	24.67	26.71	30.37	31.73	11.70					
Cluster-robust Hausman test *p* value	0.865	0.925	0.988	0.968	0.758					
Elasticity:										
a) *Pastoral* 1290	0.090	0.067	0.416	0.244	0.201	0.109	0.136	0.422	0.249	0.104
b) *DMV*	0.020	0.006	0.056	0.045	0.032	0.022	0.014	0.056	0.046	0.026
Observations	19	21	26	24	22	19	21	26	24	22
R^2	0.449	0.555	0.789	0.665	0.709	0.449	0.557	0.789	0.665	0.715

Notes: Confidence intervals obtained from the wild cluster bootstrap as described in the main text. The upper bound of the range of values for the coefficient of *Pastoral 1290* assumed for the calculation of the standard confidence interval in equation (3.5) was 500.

the regression errors in Table 3 are assumed to be clustered at the county level and the cluster-robust variance matrices are estimated by the wild cluster bootstrap. Because of the small sample sizes, Table 3 also reports weak-instrument-robust confidence intervals for *Pastoral 1290*, as these do not depend on the asymptotic distribution of the IV estimator.

In both 1625 and 1675, the IV point estimates of the causal effect of *Pastoral 1290* on FAFM are very small and very poorly determined. Table 3 reports, for the IV estimates, the p value of the cluster-robust Hausman test of the null hypothesis that there is no difference between the IV and OLS estimates of the coefficient of *Pastoral 1290*. It is unsurprising, given the imprecision of the IV estimates for 1625 and 1675, that this null hypothesis cannot be rejected, even though the point estimate in equation (3.7) is double that in equation (3.2). However, the conclusions reached on the basis of the OLS estimates for the first two periods hardly differ from those implied by the IV estimates. The elasticities corresponding to both the IV and the OLS point estimates of the effects of *Pastoral 1290* and the density of DMVs are small – miniscule in the case of the latter – and not statistically significantly different from zero. The lack of precision in the IV estimates means that there is some unavoidable doubt about regarding the causal effects as being the ones given by the OLS estimates. However, in the absence of better IVs, there is no alternative to doing so.

The estimated effect of the density of DMVs on FAFM is economically insignificant in both 1625 and 1675: the elasticities corresponding to the point estimates are essentially zero, and the point estimates themselves are very poorly determined. The estimated associations between the density of DMVs and FAFM in 1625 and 1675 reported in Table 2 are small, but the estimates in Table 3 are even smaller.

In the eighteenth century, however, the estimated effect of *Pastoral 1290* is considerably larger. The IV and OLS estimates for both periods are very similar and clearly positive. The cluster-robust Hausman test shows that there is no difference between the IV and OLS estimates, so the latter can be interpreted as causal effects. They show that there was a statistically significant influence of *Pastoral 1290* on FAFM in both periods. The point estimate for 1725 corresponds to an elasticity of about 0.4, while that for 1775 corresponds to an elasticity of 0.25. These effects of *Pastoral 1290* are substantially larger than those estimated for the seventeenth century. The causal effect in 1725 is somewhat smaller than the corresponding association reported in Table 2, while the causal effect in 1775 is similar to the association in Table 2.

For both 1725 and 1775, Table 3 shows that the effect of the density of DMVs is clearly positive, but its economic significance continues to be small. The point estimate in Table 3 is somewhat smaller than the corresponding association reported in Table 2, while the point estimate in 1775 is similar to the association in Table 2.

For 1819, the IV and OLS point estimates for *Pastoral 1290* differ, though the imprecision of the IV estimate is such that it is completely uninformative and the cluster-robust Hausman test does not reject the null hypothesis of no difference between it and the OLS estimate. The IV point estimate of the effect of *Pastoral 1290* is larger than the OLS one, but neither are well-determined. The low first-stage F statistics for equation (3.5) means that the IV point estimate is likely to be biased, and this, together with the imprecision of the IV estimate, means that the OLS estimate is the most compelling indication of the causal effect of *Pastoral 1290* in 1819. This effect is similar to the corresponding association reported in Table 2: it is of limited economic significance as well as being poorly determined.

For 1819, the IV point estimate of the density of DMVs is clearly positive and the OLS point estimate is almost so (its p value is 0.058). The two point estimates do not differ very much and their economic significance is very small. These point estimates are similar to the association for 1819 shown in Table 2.

In summary, Table 3 shows that there was a causal effect of *Pastoral 1290* on FAFM in the eighteenth century, but not in the seventeenth century and not in 1819. To interpret the Table 3 estimates for the density of DMVs as causal effects, this variable must be viewed as an exogenous regressor, which is not a compelling assumption. Given that assumption, however, the estimates in Table 3 show that there was essentially no effect of the density of DMVs on FAFM in the seventeenth century, and a positive but very small effect in 1725, 1775, and 1819.

The absence of any evidence that *Pastoral 1290* and the density of DMVs had an effect on FAFM in the seventeenth century is a major problem for VV's conclusion that data on FAFM in early modern England support their theory. Their argument is that the Black Death contributed to the emergence of fertility restriction because of the abundance of land relative to labour after the mid-fourteenth century and the consequent shift from arable to pastoral farming. If this was the case, why is there no evidence of any positive relationship between pastoralism and FAFM in the seventeenth century? Even though there is evidence of such a relationship in the eighteenth century, it is difficult to see how the Black Death could have had this effect in the eighteenth century without having had a similar effect in the seventeenth. Furthermore, if a positive relationship between pastoralism and FAFM underlies the emergence of fertility restriction in England, how can the evidence that this relationship existed in the eighteenth century, but not the seventeenth, be reconciled with the fall in FAFM which occurred in England in the course of the eighteenth century? According to the best available estimates, FAFM declined from 26.3 in 1710-19 (its peak over the period 1610-1837) to 24.0 in 1790-99 and 23.1 in 1830-37 (Wrigley et al. 1997, Table 5.3, p. 134). The combination in the eighteenth century of a fall in FAFM and the emergence of a positive relationship between pastoralism and FAFM indicates that VV's theory that the Black Death led to fertility restriction cannot be right. It is far more plausible that some other factor, probably dating from later than

the Black Death, lay behind the positive relationship between pastoralism and FAFM that emerged in the eighteenth century.

There are, in fact, three developments in the English economy in the post-1650 period which can explain why a positive causal relationship between *Pastoral 1290* and FAFM emerged in the eighteenth century.[10] In all three cases, the explanation assumes that women have more labour supply choices than they are allowed in the VV model: in particular, they have the options of working in industry or withdrawing from the labour force altogether (e.g. specializing in childcare and housework), in addition to working in pastoral or in arable agriculture.

The first development in the English economy that can explain the emergence of a causal link between *Pastoral 1290* and FAFM during the eighteenth century is the increasing regional specialization of agriculture from the second half of the seventeenth century onwards (Overton 1996, pp. 103-5, 131). The adoption of new crops and techniques in the late seventeenth century accelerated regional specialization since regions suited to growing the new crops specialized more strongly in arable production while regions unsuited to the new husbandry shifted more intensely to pastoral production (Coward and Gaunt 2017, p. 516). Regional specialization made those regions that had a greater percentage of pastoral land in 1290 more intensely pastoral in the eighteenth century, as formerly mixed farms converted to sheep-raising, cattle-raising, or specialized dairying. This eighteenth-century intensification of the specialization of already pastoral regions in purely pastoral production was likely to have created an even more intense demand for female labour, with the result that females in those regions enjoyed better labour market opportunities, motivating them to remain in the labour force to a later age and hence to marry later.

The second relevant development in the English economy was a technological change in arable production. From the seventeenth century onwards, there was a gradual shift from the widespread practice of using sickles to harvest grain to greater use of scythes (Roberts 1979, pp. 16-8; Snell 1985; Overton 1996, p. 188). Wielding the scythe required greater upper-body strength than using the sickle, so the shift to scythe-based harvesting reduced female relative to male productivity in arable agriculture, causing women's relative wages in reaping gradually to decline between the late sixteenth century and c. 1725 (Roberts 1979, pp. 18-9). Although the shift from sickle to scythe varied both regionally and according to crop mix (Sharpe 1999, pp. 170-1), across the country as a whole this change in arable technology caused female labour productivity gradually to decline in arable regions while remaining unaffected in pastoral regions. Controlling for other variables, this would have reduced female labour force participation in arable regions, making marriage a more attractive option for

[10] Although there is evidence that the density of DMVs had a positive effect on FAFM in the eighteenth century, it was so small that we focus our explanation of the temporal change in the relationship between pastoralism and FAFM on *Pastoral* 1290.

women, thereby reducing their mean age at first marriage. However, since the technological shift did not affect women's labour productivity in pastoral regions, it would have left female labour force participation in pastoral regions unchanged and hence would have had no effect on FAFM in those regions. This would have increased the difference in FAFM between arable regions (where female marriage age was now lower) and pastoral regions (where it was unchanged). As a result, one might expect to observe a positive relationship to emerge in the eighteenth century between pastoral regions and FAFM, since arable regions were experiencing a decline in female labour productivity and thus greater incentives for women to marry.

By the early nineteenth century, the positive causal relationship between *Pastoral 1290* and FAFM observed in the eighteenth century disappears almost completely. This can be explained by a third development in the English economy, the first phase of the Industrial Revolution, which was accompanied by rapid urbanization. Industrialization and urbanization gave women alternative sources of employment in the secondary and tertiary sectors, weakening the relationship between pastoralism and FAFM.

The relationship between *Pastoralism 1290* and FAFM, which is observable only in the eighteenth century in VV's data, can thus be explained in terms of agricultural developments specific to the post-1650 period. There is no need to invoke factors associated with the Black Death to explain why such a relationship existed in the eighteenth century, and any attempt to do so would be highly implausible given the absence of such a relationship in the seventeenth century.

5. Conclusion

What can we conclude about the claim that the Black Death created the EMP, thereby freeing western Europe from Malthusian limits on growth? Careful examination of the evidence reveals pervasive problems with this argument, affecting the basic premise, the empirical analysis, and the underlying theoretical assumptions.

There is no definitive evidence that the EMP originated in the aftermath of the Black Death. The evidence on medieval English demography is so sparse and fragile that scholars disagree fundamentally about women's marriage age and lifetime celibacy rates before the 1540s when family reconstitution data become available. Many reputable historians regard the EMP as long pre-dating the Black Death, and many others argue that it cannot have emerged until after 1500. Even those who conjecture that the Black Death changed marriage behaviour disagree fundamentally, with some arguing that it encouraged earlier and more universal marriage through rising incomes while others argue that it motivated later and less universal marriage through rising female employment, albeit mainly in towns. The unresolved controversy about medieval English marriage behaviour does not mean that VV's basic premise is necessarily wrong, but an explanation of the origin of the EMP that is crucially

dependent on the EMP emerging soon after the Black Death requires more convincing support for this premise than VV provide.

There is also no evidence of a causal relationship between pastoralism and later female marriage in the aftermath of the Black Death – or, indeed, at any period before the eighteenth century. To identify causal relationships using instrumental variables, it is necessary to ensure that the instrument used is not correlated with variables omitted from the regression. Once this key step is taken, VV's evidence on the relationship between pastoralism and the drop in taxpayer numbers between 1377 and 1381 becomes completely uninformative about causation. Their evidence on the relationship between pastoralism and female marriage age in the period 1600-1837 is more informative, but displays a temporal pattern that cannot be reconciled with the claim that the Black Death led to the appearance of the EMP, since evidence of a causal link is missing for the seventeenth century and only emerges in the eighteenth, four centuries after the plague-induced shift in factor proportions.

Perhaps the most fundamental problem is that the claim that the shift to pastoralism after the Black Death entailed later female marriage is entirely driven by assumptions that are inconsistent with the historical evidence. The VV theoretical model is critically dependent on two assumptions: first, that women could only work in the pastoral sector if they worked for landlords; and second, that in order to work for landlords, women had to remain unmarried. The historical evidence makes it quite clear that these assumptions do not apply to medieval England: peasant households engaged strongly in pastoral production, with peasant housewives as key pastoral workers; and women who worked for landlords included married female wage-labourers and dairy managers. Since the VV argument is set wholly in the context of medieval and early modern England, it must be rejected.

When and how pre-industrial people managed to calibrate their fertility to the productive capacities of the economy, thereby freeing themselves of Malthusian shackles on growth, is an important question for economists, historians and demographers. The idea that it was suddenly triggered by a calamitous medieval epidemic and a consequent shift in factor proportions is attractively simple, but empirically untenable. Answering this question will require more careful research into the economic, institutional and cultural origins of demographic decision-making.

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Appendix

This Appendix analyses the relationship between the two instruments and the variables included as regressors in the IV regression models in Tables 1 and 3 of the main text.

Table A1 addresses the question of which regressors need to be included in the model of the drop in taxpayer numbers 1377-81, the dependent variable in Table 1, for the IVs to be valid. It shows the results of OLS regressions of the two IVs – ln*(daysgrass*) and general crop suitability – on ln(*popdensity)* and seven regional dummy variables. When the regional dummies are excluded, as they are in equation (4) of VV's Table 3, the coefficient of ln*(popdensity)* is statistically significant in both equations (A1.1) and (A1.3). The size of this association is also economically significant: the two point estimates in (A1.1) and (A1.3) correspond to elasticities with respect to population density at sample mean values of -0.39 and 0.87 respectively. When the dummy variables are included, the coefficient of ln*(popdensity)* in equation (A1.2) is not statistically significant at conventional levels (the p value is 0.111), although the elasticity (at sample means) with respect to population density is non-trivial, at -0.21. In equation (A1.4), this coefficient is neither statistically nor economically significant: the implied elasticity is -0.04. The regional dummy variables are significantly correlated with both IVs: the null hypothesis that their coefficients are all zero is strongly rejected for both equations (1.2) and (1.4). The implication of the results in Table A1 together with those in Table 1 of the main text is that neither ln*(daysgrass)* nor general crop suitability are valid instruments for the IV regression estimated in VV Table 3.

Table A1: The Relationship between the Instrumental Variables and Various County Characteristics

	Dependent variable			
	ln(*daysgrass*)		General crop suitability	
Regressors	(1.1)	(1.2)	(1.3)	(1.4)
ln(*popdensity*)	-0.132***	-0.070	0.290**	-0.013
	(0.041)	(0.043)	(0.138)	(0.269)
Regional dummy variables	No	Yes	No	Yes
p value for regional dummy variables		0.000		0.000
Observations	38	38	38	38
R^2	0.285	0.863	0.240	0.535

Notes: Figures in parentheses are heteroscedasticity-robust standard errors. ** and *** denote significance at the 0.05 and 0.01 levels respectively.

Table A2: The Relationship between ln*(daysgrass)* and the Measures of Pastoralism

	Dependent variable: ln*(daysgrass)*				
	Period				
Regressors	1625 (A2.1)	1675 (A2.2)	1725 (A2.3)	1775 (A2.4)	1819 (A2.5)
Pastoral 1290	0.99	0.99	0.95	0.98	0.83
	[0.19, 1.33]	[0.27, 1.26]	[0.36, 1.28]	[0.45, 1.28]	[-0.71, 1.20]
DMV	0.86	0.85	0.79	0.80	0.75
	[-0.29, 1.28]	[0.19, 1.26]	[-0.001, 1.23]	[0.02, 1.26]	[-0.19, 1.24]
ln*(popdensity)*	-0.05	-0.05	-0.06	-0.06	-0.10
	[-0.36, 0.10]	[-0.35, 0.09]	[-0.37, 0.09]	[-0.38, 0.09]	[-0.53, 0.04]
Regional dummy variables	Yes	Yes	Yes	Yes	Yes
p value for regional dummy variables	0.134	0.003	0.006	0.002	0.004
Elasticity wrt *Pastoral 1290*	0.101	0.105	0.103	0.108	0.091
Observations	19	21	26	24	22
R^2	0.98	0.98	0.99	0.99	0.99
	Dependent variable: ln*(daysgrass)*				
	Period				
Regressors	1625 (A2.6)	1675 (A2.7)	1725 (A2.8)	1775 (A2.9)	1819 (A2.10)
Pastoral Marriage	0.26	0.14	0.14	0.07	-0.01
	[-0.50, 0.87]	[-0.65, 1.46]	[-0.09, 0.77]	[-0.64, 1.07]	[-1.00, 0.86]
DMV	0.27	0.16	0.17	0.18	0.33
	[-0.77, 1.05]	[-1.15, 3.11]	[-1.03, 1.99]	[-1.25, 1.88]	[-0.80, 1.71]
ln*(popdensity)*	-0.21	-0.21	-0.21	-0.18	-0.23
	[-0.59, 0.31]	[-0.86, 0.33]	[-0.72, 0.25]	[-0.71, 0.28]	[-0.89, 0.56]
Regional dummy variables	Yes	Yes	Yes	Yes	Yes
p value for regional dummy variables	0.027	0.292	0.301	0.189	0.061
Elasticity wrt *Pastoral Marriage*	0.005	0.004	0.004	0.001	-0.0002
Observations	19	21	26	24	22
R^2	0.97	0.96	0.98	0.96	0.98

Notes: Figures in brackets are 95 per cent confidence intervals obtained from the wild cluster bootstrap.

Table A2 addresses the question of whether it is possible to use ln*(daysgrass)* as an IV in order to obtain a consistent estimate of the effect of one of *Pastoral 1290* or *Pastoral Marriage* on FAFM, the dependent variable in Table 3, while omitting the other. It shows the results of estimating two different regressions for each of the five periods for which FAFM data are available. In both sets of regressions, ln*(daysgrass)* is the dependent variable and the density of DMVs, ln*(popdensity)*, and regional dummy

variables are included as regressors. The only difference between the two sets of regressions is whether *Pastoral 1290* or *Pastoral Marriage* is included as a regressor. The regressions in Table A2 that include *Pastoral 1290* are the ones that show whether the omission of this variable makes ln*(daysgrass)* an invalid IV for *Pastoral Marriage* in a regression explaining FAFM. Similarly, the regressions in Table A2 that include *Pastoral Marriage* are the ones that show whether the omission of this variable makes ln*(daysgrass)* an invalid IV for *Pastoral 1290* in a regression explaining FAFM. The regressions in Table A2 are estimated by OLS. As in Tables 2 and 3 of the main text, the regression errors in Table A2 are clustered at the county level and the cluster-robust variance matrix is estimated using the wild cluster bootstrap.

In the upper panel of Table A2, the 95 per cent confidence interval for the coefficient of *Pastoral 1290* excludes zero in all periods except 1819. The economic significance of this association is small: the point estimates correspond to an elasticity at sample mean values of about 0.1. But there is clearly an association between ln*(daysgrass)* and *Pastoral 1290* conditional on the other regressors. This means that ln*(daysgrass)* is not a valid instrument for *Pastoral Marriage* in a regression explaining FAFM that includes these other regressors while omitting *Pastoral 1290*.

In the lower panel of Table A2, the 95 per cent confidence intervals for the coefficient of *Pastoral Marriage* all include zero. Furthermore, the size of this association is always tiny. Thus there is no evidence of an association between *Pastoral Marriage* and ln*(daysgrass)*, conditional on the density of DMVs, ln*(popdensity)*, and the regional dummies. Omitting *Pastoral Marriage* from a regression explaining FAFM will not, therefore, make ln*(daysgrass)* an invalid IV for *Pastoral 1290*, provided that these other variables are included as regressors.