

National income in Domesday England

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Abstract: The Domesday Survey provides the first comprehensive national survey of any economy. The availability of two complementary data sources allows a direct estimate of Tenant-in-Chief's lands from the Survey. By providing a means to identifying the extent of arable activity outside the demesne, as well as the extent that ploughs working on the lords estates were active in the peasant economy, I provide a transparent method of estimating the extent of non-seigniorial production. After incorporating a series of other elements valued in the Survey, and adding these to the seigniorial and non-seigniorial agricultural production estimates, we derive an estimate for the income of Domesday England in 1086. The findings are consistent with an important interpretation of the Domesday text proposed by Bridbury that is further developed conceptually. Furthermore, a 'full capacity' 1086 estimate, determined under differing assumptions concerning population, price, and climatic conditions, is compared against recent estimates for the earliest benchmark period circa 1300.

Key words: Domesday England, income, long-run economic change.

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INTRODUCTION

In 1086, for the first time in recorded history, it is possible to reconstruct and benchmark the national income of an economy. A record following the watershed in English history that accompanied the successful invasion of William the Conqueror, the Domesday Survey provides a broad set of information relating to Domesday England in 1086. No survey on the scale of Domesday was to be conducted for many centuries following its completion. The next attempt to provide a national survey, the 1279 Hundred Rolls, represented an attempt at an even more ambitious review of land holding and tenures, but was abandoned before it was completed and only a proportion of the original returns have survived.¹

Graeme Snooks and Nicholas Mayhew attempt to benchmark Domesday income and chart changes in the English economy over the long run.² To do so, both authors use Henry Clifford Darby's total of Domesday income as a measure of seigniorial income and then, based on secondary sources, make estimates of the extent of non-seigniorial income.³ Snooks makes austere assumptions to come up with a figure of £147,000, while Mayhew provides estimates that value the British economy of between £300,000 and £400,000. Mayhew then attempts to validate his estimates against a model of medieval monetarisation based on the quantity theory of money. Graeme Snooks uses aggregated data from the Domesday account to estimate income levels and then simulates economic change over time. Both these earlier novel attempts to value the Domesday economy have substantial limitations, principal of which is that they make quite *ad hoc* estimates of the extent of non-seigniorial economy.

Taking advantage of data generated by two substantial projects that render full micro-data from the Domesday Survey, this study provides a methodology to derive the full extent

¹ The classic study of the Hundred Rolls comes from Kosminsky (*Studies in the Agrarian History of England*). See also, Raban, *Second Domesday?*

² Mayhew, "Modelling Medieval Monetarisation", p.57-77 and Snooks, "Dynamic Role", p.32-54.

³ Darby's extensive compendia of regionally centred texts are referenced in his formidable *Domesday England*.

of Domesday seigniorial and non-seigniorial arable incomes. We also compile the rich information contained within the Survey to provide estimates of the pastoral economy, property holdings, mills and other important asset returns (both in monetary terms and “in kind”), being careful to contextualise this within developments in Domesday scholarship.

Having provided a micro-founded estimate of Domesday economy we then compare and contrast these with other Domesday estimates, both provided by the author under differing assumptions and in earlier work, and figures from the earliest period where a robust benchmark is possible, circa 1290/1300. Comparison across time generates additional issues that need to be addressed. As the 1290/1300 period is seen as one where England was working at full capacity we need to build a full capacity Domesday estimate so we can compare “like with like”. To do so, estimates that expand Domesday England’s geographical borders to match those of the later medieval period are provided. We also incorporate contemporary accounts and dendroclimatological data that concur that 1086 was a year with well above average rainfall, and determine the impact on agricultural production in providing an additional climate-neutral comparative estimate. The availability of a substantial resource of medieval data sources coupled with Domesday provides considerable scope to chart very long-run movements in income, and also to provide further evaluation of the Domesday text.

THE DOMESDAY BOOK AND DOMESDAY SCHOLARSHIP

The 900th anniversary of the Domesday Survey in 1986 ushered in a new era in academic research, with a renewal of scholarly interest focused on this pivotal source. In a series of papers, John McDonald and Graeme Snooks were the first to apply more sophisticated statistical methodologies, as opposed to the tabulations that were previously used to analyse

the Survey.⁴ Commentators argued that “statistical analysis, coupled with micro-economic theory will have an important role to play” (Hamshire, p265) and, from the admittedly less partisan McDonald and Snooks, that Domesday statistical studies would “bring the disciplines of history, economics and geography [together]” with the aim of generating “exciting school and tertiary education projects” (McDonald and Snooks, p147). Neither research nor teaching applications have, however, been forthcoming. Indeed, more than fifteen years following the publication of McDonald and Snooks’s work, a recent survey of the Domesday historiography points out that “the economic approach to the Domesday evidence imploded in the hands of Snooks and MacDonald; it seems that no-one dares to follow them without a secure grounding in statistics denied to most historians.” (Holt, p20). The literature, however, has provided a number of reasons why, beyond a lack of statistical acumen, this has been the case. Indeed some of the great Domesday scholars, none more so than Henry Clifford Darby, have had a strong quantitative bent, which suggests that Professor Holts’s statement, while holding a kernel of truth, is an exaggerated conception of the profession as a whole. Rather than a phobia for numbers, a series of alternative explanations exists. These explanations can be related to four facets of the Domesday research project – the quality of the translation; geographical coverage; quality of the data; and the meaning of the Domesday variables. I will deal with each of these four elements in turn and will argue that, to a greater or lesser extent, progress has been made on each of these areas that allows for the development of a more comprehensive and plausible assessment of the Domesday economy.

⁴ McDonald and Snooks, “Tax Assessment”, “Determinants”, and “Statistical Analysis” and *Domesday Economy*.

Two high-quality translations of the Survey exist – the classic Morris translations published by Phillimore and a more recent version published by Alecto.⁵ Each translation has its merits, with the Alecto being, in the author’s experience, more exacting where place and person names are concerned. However, unlike the Alecto addition, which offers a textual search engine and hence would require the researcher to re-key the data to analyse it quantitatively, the Phillimore data made available by Palmer can be readily extracted and analysed.⁶ The Palmer data-set includes the full Great, or ‘Exchequer Domesday Book’, which incorporates six of the seven Domesday circuits, and the Little Domesday Book that included Essex and the more manorially fragmented counties of Norfolk and Suffolk. This source is combined with a second, recently completed computerised version of Little Domesday Book, which combines and cross-references the Phillimore translation and the recently published Alecto translations, that has been compiled by the author. Given the ambiguity in allocating resources within manors, being able to cross-check between two independently derived data-sets is certainly a fortunate aid to this study.⁷ Certainly the ability

⁵ The Phillimore edition of the Domesday text *Domesday Book: Text and Translation* edited by John Morris et al. in 34 volumes (Chichester, 1975-1992). The data-set based on this translation generated by John Palmer and his colleagues has recently been made available as the end product of the Arts and Humanities Research Council-funded Domesday project and is located at <http://www.data-archive.ac.uk/findingdata/snDescription.asp?sn=5694>. In 1984 Alecto was invited by the Public Record Office (now The National Archives) to undertake a facsimile of the Domesday Book while it was unbound for restoration. The Alecto Great Domesday is published as *Great Domesday: Library Edition*, edited by Robert Erskine and Ann Williams (London, 1986-1992) with the *Little Domesday: Library edition*, edited by Williams in 2000. The full text was re-edited under the editorial guidance of G.H. Martin and re-published in paperback in 2001. Alecto also released a digital edition <http://addisonpublications.com/books/ddigital.html>

⁶ The relative complexity of the LDB is reflected in the fact that it makes up over a quarter of the pages constituting the Alecto Domesday Book despite accounting for only three of the 34 counties captured in the source. The county make-up of the Domesday circuits are as follows: *Circuit 1*: Berkshire, Hampshire, Kent, Surrey and Sussex; *Circuit 2*: Cornwall, Devon, Dorset, Somerset and Wiltshire; *Circuit 3*: Bedford, Buckingham, Cambridge, Hertford and Middlesex; *Circuit 4*: Leicester, Northampton, Oxford, Stafford, Warwick; *Circuit 5*: Cheshire, Gloucester, Hereford, Shropshire and Worcester; *Circuit 6*: Derby, Huntingdon, Lincoln, Nottingham, Rutland and Yorkshire; *Little Domesday Book (Circuit 7)*: Essex, Norfolk and Suffolk.

⁷ Other than its geographic coverage, the Little Domesday’s title is a misnomer as the book is considerably larger and more detailed the Great Domesday text. Little Domesday captures the Survey for one of the seven circuits of the Domesday Book. The eminent Domesday scholar V.H. Galbraith argued that local summaries were made for each group of counties (that is, for each circuit), and that these were later collated at Winchester (this view was initially expounded in 1942 but was expanded in *Making of Domesday Book*, 59-66).

to cross-check data between translations is one of the great benefits derived from a series of projects inaugurated by the 900th anniversary of the Domesday Book.⁸

In terms of geographical coverage, the weight of McDonald and Snooks's work rested on data from two counties: Essex, where a more detailed assessment was done, backed up by a less complete examination of Wiltshire.⁹ There is an appreciation that the examination of the two Domesday counties is insufficient to allow valid generalization of their findings.¹⁰ Furthermore Roffe, using both the Domesday texts themselves and the Domesday 'satellites', has provided a case that the Domesday Book was produced as part of a process, and that the scribes' recordings differed over the period during which the text was compiled.¹¹ Evidence of the exact nature of this remains contested but that there was an ongoing process of data collection appears a fair conclusion.¹² Subsequent work has also provided detailed evidence of the works of differing scribes.¹³ The localized nature of the economic landscape during the Middle Ages, with very different historical and topographical make-ups, and often radically different customs, presents a rich and complex tapestry for historical research. It is feasible to make a case for any county within a circuit, or counties between circuits, to differ. For example, Essex, the principal county examined statistically, harboured considerable historical idiosyncrasies. Essex had, of course, been a Kingdom in its own right for about three hundred

⁸ Fleming and Lowere, "MacDomesday", provide a critical review of an earlier version of the Phillimore translation of the Domesday Book that was released in 2002, containing the Great Domesday data on the Alecto translations. Folios were published in 2000 with a searchable database similar to the Phillimore translation. The recently released Domesday Explorer data set is an improvement on its earlier incarnation and the Alecto in terms of statistical amenability being available in database form.

⁹ See "Determinants" and "Tax Assessment" for analyses of Essex and "Statistical Analysis" concerning Wiltshire.

¹⁰ McDonald and Snooks acknowledge that there were a number of "important similarities, and some minor differences", but were comfortable to state that they consider their findings applied to England as a whole (*Domesday Economy*, 112-3).

¹¹ Roffe, "Northern Society" provides evidence that the stylistics of the text developed over time. Tsurshima, "Domesday Interpreters", details the role of interpreters in Domesday.

¹² Roffe contends that the Domesday inquest and the writing of the text were two separate events. See Holt, "Domesday Studies", pp19-24 for an alternative view. Baxter by a detailed evidence of the wording diplomatic, or Domesday phrasing, finds evidence that textual changes occurred in the writing of the text ("Representation of Lordship").

¹³ That there were differing scribes working in circuits is well known (see Rumble, "Domesday Manuscripts").

years before being incorporated into the Kingdom of Wessex in 825 and, in addition, is unusual in the degree to which its manors had managed to resist enserfment during the century following the Conquest.¹⁴ The sustained freedom of large swathes of peasants, particularly in eastern Essex, was reflected in the area having the most violent agitators for the abolition of serfdom in the Great Revolt of 1381.¹⁵ As well as substantially differing historical experiences associated to counties, there were marked differences between counties within the Little Domesday circuit. For example, Norfolk and Suffolk suffered political volatility in the years immediately following the Conquest, which influenced the textual stylistics. Numerous minor disputes over land are recorded in the Domesday Book.¹⁶ The most serious was the Rebellion of Earls, that included Ralph de Gael, Earl of East Anglian, in 1075.¹⁷ That uprising was effectively suppressed, with land disputes being resolved without recourse to the devastation and subsequent famine that occurred following William's consolidation of power in the North of England in 1069-70.¹⁸ Certainly it would be quite possible to build compelling narratives that illustrate the differing historical contexts and factors determining any particular county, as indeed historians have done.¹⁹ The Domesday Survey is based upon, as V.A. Galbraith put it, "a congeries of widely varying regions, each with its age-long special customs and usages."²⁰

Recent research suggests that the quality of the data underlying the Domesday account is not as perfect as McDonald and Snooks maintained. The extensive nature of the scribe's task, and associated 'human recording error', is a factor that is widely appreciated.

¹⁴ Chibnall, *Anglo-Norman England*, p29.

¹⁵ Dobson, *Peasant's Revolt*, 38-41. Indeed, McDonald and Snooks, "Determinants", do emphasise the point that differences exist between circuits.

¹⁶ Fleming summarises these as appendices (*Domesday Book*, 89-518). John Palmer has a separate file that contains these entries in a more easily searchable format.

¹⁷ See Stenton, "Anglo-Saxon England", for a classic account and Marten, "Impact of the Rebellion", 132-150, for a recent analysis of the Rebellion and its consequences.

¹⁸ There have been numerous accounts of the 'harrying of the North'. An interesting debate surrounds the work of Palliser, "Harrying", pp1-23; and Palmer "Conqueror's Footprints", pp23-44.

¹⁹ The introductions to each of the Alecto translations make this point.

²⁰ Galbraith, *Domesday Book*, p17.

What was unclear until relatively recently was the existence of perjury from Domesday jurors. In an important contribution Christopher Lewis uses two Domesday satellites – *Inquisitio Comitatus Cantabrigie* [the original return made by the Jurors of the County of Cambridge, from which the Exchequer Domesday book was compiled] and the *Inquisitio Eliensis* [or Ely Inquisition] – to piece together the Domesday jurors in Cambridge and Hertfordshire. He showed that the individuals were middling tenants with intense local interests.²¹ The oral nature of the testimony raises the question of validity, particularly where information was retrospective. Information was gathered via “oaths” sworn on the relic of the saints, while vats of boiling water and bars of heated iron were on hand, in preparation for circumstances where “ordeal” was required.²² Perjury could lead to swift justice of a financial or legal sort, an uncomfortable afterlife, or denial of access to economic life associated with law-worthiness.²³ There were, therefore, strong incentives aligning jurors and Tenant-in-Chief that provide some potential for dishonesty, but while Fleming finds some evidence that rigging occurred, she concluded that in substantial cases flagrantly abusive claims were not viable.²⁴

A fourth element relates to a lack of certitude in understanding of the Domesday text. Indeed, some prominent Domesday scholars consider that all socio-economic work on the Domesday book is flawed being, as Catherine Keat-Rohan put it, derived from “a text of which the technical language is peculiar and still poorly understood.”²⁵ It is clear that an understanding of the mechanics of the Domesday source, as with any other, is an important

²¹ Lewis, “Domesday Jurors”. 17-44.

²² Fleming, *Domesday Book*, p25. More detailed information on the process of gathering data is provided in Fleming, “Oral Testimony”.

²³ Archbishop Wulfstan, *Sermo Lupi ad Anglos*.

²⁴ Recent work by Stephen Baxter provides a case in point; he shows an instance where there appears to have been a misrepresentation by a Tenant-in-Chief and member of the clergy. (“Representation of Lordship”, pp.73-102). The extent that this is an economically significant event is, however, unclear. Since the vast majority of land owners, outside the lands held by the church, were taken over by new Norman lay land holders, the potential for reinvention of one’s own past remained limited in scope.

²⁵ Keats-Rohan, “Portraits”, p.121.

first step in order to glean its secrets. However, a substantial complication with the Domesday Book is its one-off nature and the lack of a simplified compendium elucidating the meaning of terms to the twenty first century reader. This paper provides additional evidence based on analysis of relationships between variables within the Survey to assist in partially decoding the meaning of relevant variables.

The most important example of this lack of certitude, within the context of this study, relates to the *valet* [or values], variable that must necessarily form the basis of any estimate of national income. What the values referred to remains an open debate. Galbraith illustrated that a manor valued in Domesday at 20 shillings was being rented for that amount and subsequently many scholars have taken values as reflecting income a lord derived from the manor. As with many elements of the Survey, the lack of corresponding appraisal shortly after the Survey makes validation difficult. However, an important work by Du Boulay found the estates of the Arch-Bishopric of Canterbury were valued at £1,246 in 1086, and between £1,245 and £1,596 per annum in various years between 1165 and 1172.²⁶ Certainly thirteenth-century lords calculated the *valor* of their manors, and the word meant an estimate of the annual income they gained. As Christopher Dyer argues, the “Domesday Book was produced to promote the king’s interests, but in calculating the revenues of his main tenants the compilers of that great survey were giving the king useful information because at any moment, through death or forfeiture, those manors might fall into the King’s hands.” (Dyer, p198). Nicholas Mayhew argues that *valet* gave an indication of the annual manorial income enjoyed by the lord, whether in the form of rent, farms and feudal dues, and/or demesne output.²⁷ An alternative view is that only rents were contained and that “if we are to arrive at a sensible notion of what accrued to lords of manors in the eleventh century England, we must double or perhaps treble many, if not all, of the assessments to be found in Domesday

²⁶ Du Boulay, *Lordship of Canterbury*, 241-3.

²⁷ Mayhew, “Modelling Medieval Monetisation”p.60.

Book” (Bridbury, 1992, p121).²⁸ However, other than the extensive period between the examinations of a small set of manors, A.R. Bridbury’s finding would seem to sit quite poorly with McDonald and Snooks’s work which found strong links between resources and income. In addition, and Snooks found that slaves had a positive impact on values. If values represented cash payments this would make little sense since slaves by definition are unpaid. Given that both interpretations have substantially differing implications for deriving national income, it would seem reasonable to see which assumptions can be justified by the data.

CALCULATING THE COMPONENTS OF DOMESDAY INCOMES

Providing an estimate of Domesday income requires a breakdown of crops and livestock income for the seigniorial and non-seigniorial sectors. A relatively uncontentious view, also proposed by Bridbury (1990), that is critical in assessing income, is that the scope of the Domesday Survey is limited to the lands of the Tenant-in-Chief. The essential reason is that the Domesday Book was considered to be a tax document; information not pertaining to taxable income was not of interest.²⁹ The best information we have, since it comes directly from the Survey, is the incomes variable. This provides us with a figure for total income of each manor combining arable, livestock and other miscellaneous elements, such as mills. This figure comes to about £72,000. However, the implication of Bridbury’s work, which was taken on board in previous estimates by Mayhew and Snooks, is that the Domesday Book values, at least in themselves, cannot be used as a source to answer questions concerning the size of the non-seigniorial element of the British economy. Given the size of non-seigniorial economy this is a serious omission, since the aim is to provide estimates that are comparable over time, and particularly since we are aware that there were substantial shifts in the structure of land ownership and production between 1086 and the earliest

²⁸ David Roffe provided further suggestive evidence in favour of Bridbury’s hypothesis. *Decoding Domesday*, p240-50. However, as he pointed out, “the equation is not always precise” (p.246-47).

²⁹ Bridbury, “Domesday Book”, pp. 3-70.

benchmark periods of 1290 and 1300.³⁰ While we consider the Domesday Survey does indeed pertain to the seigniorial economy, and provide additional evidence that this was the case, the Survey also provides information on labour and ploughs that were employed in the non-seigniorial sector. Estimating the differential effect that seigniorial and non-seigniorial resources had on incomes thereby provides an indirect means to gauge the full extent of agricultural incomes in Domesday Britain.

In order to derive estimates of the economic size of non-seigniorial Domesday England, the study uses data from the seven circuits that constitute the Domesday Book. All manors held by the church and lay Tenant-in-Chiefs are incorporated.³¹ For the Great Domesday circuits Palmer's data-set is utilised, while for the far more complex Little Domesday Book the results from the Palmer data-set and that of one constructed by the author are examined. In doing so, I address the first two criticisms that have been levelled at earlier work: that nuances in translations of the data may undermine the findings, and the issue of geographical coverage.

The key resource variables that are rendered both in the Exchequer and the Little Domesday Book relate to the working population, followed by an account of the ploughs or plough-lands relating to the lord's demesne and to those belonging to the men.³² The population was divided into freemen (and free-women) and sokemen, villeins, cottars and bordars, and slaves. The free are the group whose definition was often made explicit in the

³⁰ A more detailed longitudinal analysis of estimates of the English economy circa Domesday and the medieval period will be contained later on. Fundamental shifts in the ownership of landholdings have been recorded and analysed elsewhere illustrating the shedding of land by the Crown between 1086 and 1129-30 (Green, *Government of England*, pp.55-94).

³¹ Manors which held burgesses were excluded, since the interest is in deriving estimates of the relative contribution of peasant agriculture. The King's resources are also excluded. The King maintained 1,069 manors that were valued (or 6.2% of the sample). The King's lands are inherently complicated due to the diverse methods by which they were measured with some being recorded as night's farms, their typically more urban nature, and the sheer complexity of the often extremely lengthy entries. As the interest here is to provide robust estimates of peasants' contributions that will feed into our estimates of Domesday income, the preference is to avoid complication.

³² Plough teams are typically assumed to comprise eight oxen (Darby, *Domesday England*, pp.125-26).

Survey's text as being 'free to go with his land'.³³ As Table 1 illustrates, free individuals were located in the Little Domesday Book and Circuits III, IV and VI with another classification of individuals who were freeman who nevertheless had to attend their lord's court. The Domesday Book also records 'sokemen' who were unfree peasants who owed their lord labour services for a finite period, but who also farmed land for themselves. Villeins, unlike the soke or freemen, did not have the right to go with their land to another lord. Villeins were the wealthiest and most numerous of unfree peasants, while bordars and cottars appear to have had quite similar status that was lower than villeins, both being small landholders, but were distributed unevenly, with bordars being found throughout Domesday England, while cottars were confined to the South-West.³⁴ The last major group, with the lowest social ranking, were slaves, who were found throughout much of the country in varying concentrations.³⁵

[Table 1 near here]

The assessment of population, while not unproblematic, has seen less major conflicts of interpretation. However, the same can most certainly not be said for ploughs or plough-lands. An element of the Great Domesday Survey is that it provides, in a large number of instances, two figures for ploughs, one being plough-lands, formulated "land for so many plough", and the second being the number of ploughs.³⁶ The controversial element of these variables, which has generated considerable discussion, is why these two figures often do not add up. Table 2 summarises the instances where ploughs and plough-lands do not equate. It can be seen that in some instances, most notably the ravaged Northern circuit, more than half

³³ Although there are isolated examples in Suffolk where freemen could not sell their land, for example in Finningham and Westthorpe, these instances are extremely rare. An early analysis of villeins is found in Lennard, "Economic Position of Domesday Bordars and Cottars", 244-264.

³⁴ Harvey, *Domesday England*, 58-64, provides a background on bordars and cottars. For an analysis of smallholders see Lennard "Economic Position of Domesday Bordars and Cottars", 197-195.

³⁵ More complete accounts are provided by Pelteret, *Slavery*, 185-240 and Moore, "Domesday Slavery", 191-220. Slaves were rarely found in Derby and Nottingham and not at all in the remainder of Circuit 6.

³⁶ The Little Domesday Book does not make the distinction between ploughs and plough-lands.

of the number of a manor's plough-lands are not equal to the number of ploughs. In the majority of cases "overstocking" predominated.

[Table 2 near here]

Attempts to explain "overstocking" have led to a split into two factions of Domesday scholars. Realists, such as Maitland and Vinogradoff, argued that plough-lands were just that – a physical measure of active land.³⁷ An alternative explanation is that the plough-land is a fiscal measure. For example, Sally Harvey argued that the plough-land data provided an assessment for a new tax to replace the geld.³⁸ Those who see plough-lands as a fiscal measure have countered that the realist interpretation does not account for the phenomenon of "overstocking". Fiscalists consider that having more than required would make no sense since plough teams were expensive assets to maintain. An alternative view, proposed by Bridbury, is that there is no reason to assume that freemen and villeins did not plough elsewhere. In essence, Bridbury argues that what the plough-land data are showing is service capacity. If it is the case, as is widely considered, that the Domesday text relates exclusively to the Tenant-in-Chief's holdings, this would imply that the men's ploughs were being utilised elsewhere in what was sometimes termed *inland*, as opposed to lands for which tenants owned service. The Survey data provide reasons to consider the capacity argument as correct. First, where waste is recorded, and hence where there was by definition no capacity to plough, there should be no ploughs or plough-lands.³⁹ This was uniformly the case. Second, there are 693 cases where the Survey explicitly states that additional ploughs "are

³⁷ Maitland, *Domesday Book and Beyond*, 482-513 and Vinogradoff, *English Society*, 153-74.

³⁸ Harvey "Taxation", pp.49-64.

³⁹ While waste land was most common in areas that had been affected by war, waste lands were not always visited by physical destruction, but were often land that did not generate income (Palmer, "War and Domesday Waste", p256-75).

possible”. In 680 cases (97.6%) when the number of ploughs is added to ‘possible plough’, these equate to plough-lands.⁴⁰

The Anglo-Saxon Chronicler stated that the Survey did not exclude “one ox nor one cow nor one pig was there left out and not put down in his record.” (*Anglo-Saxon Chronicle*, p.162). Unfortunately, this was not the case. Seigniorial arable land exploitation is documented in the Survey in only two circuits, Little Domesday and Circuit II, where information on non-working livestock in the form of sheep, pigs, goats and cattle is provided.⁴¹ Livestock farming developed considerably during the medieval age, with pastoral products being estimated at amounting to 70% of total agricultural output by 1450.⁴² However, this reflected a steady growth in livestock, with arable land accounting for 55% in 1300 having been falling by 0.23% relative to the pastoral sector between 1250 and 1300.⁴³ It appears unlikely that non-working animals generated more than 30% of Domesday incomes, but certainly we would want to generate as precise an estimate as is feasible rather than taking the proportion as an informed ‘guestimate’.

The historical account provides implications in relation to the income. If income is related purely to Tenant-in-Chief holdings then we should expect to find that different resources will have differing impacts on Tenant-in-Chief’s lands. Non-free persons, by virtue of the fact that they had substantive obligations to the Tenant-in-Chief, should have a positive impact on values. Conversely, for free individuals, who predominantly worked their own holdings, we should expect to find that they made a less substantial impact on Tenant-in-Chief’s incomes. Similarly, ploughs used exclusively in the lord’s service should be expected

⁴⁰ The full list of instances is available from the author’s website.

⁴¹ The data have been tabulated by H.C. Darby in *Domesday England*, p.164. As Darby shows, there are small numbers of other livestock such as donkeys and mules; records show 60 and three respectively (*Domesday England*, p164). Additionally, chickens appear on only one occasion, in Wiltshire, involving 480 chickens and 1,600 eggs (Phillimore ref.: WIL 24p, 1).

⁴² Broadberry *et al.* “English Agriculture”, p.31.

⁴³ *Ibid*, p.31.

to play a greater role in explaining manorial incomes. More importantly, an appreciation of the differential return to ploughs is of wider significance in that it also provides an insight into unrecorded production.

In order to evaluate the extent of the seigniorial and non-seigniorial economies we need to provide an estimate of how assets employed exclusively on the demesne differed from those that were also used in the peasant sector. To analyse the data I take a similar approach to that applied by McDonald and Snooks by utilising a Box-Cox transformed model. Since the nature of the relationship between resources and values was non-linear in their work, it can reasonably be assumed that this is the case for other counties. To estimate the relationship between the values and resources, I adopt a more general Box-Cox model – the theta model. The model provides maximum likelihood estimates and is of the form,⁴⁴

$$y_j^{(\theta)} = \beta_1 x_{1j}^{(\lambda)} + \beta_2 x_{2j}^{(\lambda)} + \dots + \beta_k x_{kj}^{(\lambda)} + \gamma_1 z_{ij} + \gamma_2 z_{2j} + \dots + \gamma_k z_{kj} \quad (1)$$

where the dependent variable, values, is subjected to a Box-Cox transformation with parameter, θ , the independent resource variables, x_1, x_2, \dots, x_k , are made up of the five labour types discussed above – slaves, bordars, cottars, villeins, and freemen⁴⁵ – ploughs belonging to the lord and to the ‘men’, and in the case of Little Domesday and Circuit II are estimated livestock is also included – and which are scaled by λ .⁴⁶ Finally, the seven circuits and 34 county fixed-effects are binary (and therefore cannot be transformed), and are represented in Equation 1 by z_1, z_2, \dots, z_k . Whether or not the circuit and county variables are of statistical importance is of great interest, as these variables capture differences at the circuit and county,

⁴⁴ Davidson and MacKinnon provide a good general discussion of the transformation (*Estimation and Inference* pp.480-88).

⁴⁵ The Palmer data-set does not distinguish between sokemen and freemen; therefore neither does the analysis.

⁴⁶ McDonald and Snooks aggregated differing labour groups and ploughs held by peasants and the Lord, weighting them equally, which is counterintuitive and not in line with the findings presented here (“Determinants”, p.555).

and therefore capture a vast array of cross-county differences in history and economic structure that has provided the foundation of a large body of Domesday scholarship.⁴⁷

The results are provided in Table 3.⁴⁸ The first column provides the results for Domesday England with the following columns containing the circuit-by-circuit finding.⁴⁹ The results provide strong support for the hypotheses of differential returns to peasant resources posited above. The Box-Cox functional form tests show that the relationship between the variables is between linear ($\lambda = 1$) and log linear ($\lambda = 0$) forms, and hence units do not have a straightforward interpretation as marginal effects. As we are interested in using the differential effects of seigniorial and non-seigniorial resources what really matters is that the coefficients are in the same units so that we can interpret the *relative* magnitude of each coefficient.

[Table 3 near here]

Taking the most critical asset, ploughs, the coefficients suggest that plough dedicated to the lords' lands is about 56% higher than that provided by the peasants (the coefficient on lord's ploughs, 0.28, divided by the coefficient peasant ploughs of 0.12). In addition, those who were free have well-defined impact values that were about half that of non-free individuals. Interestingly, slaves, who devoted themselves to the lord's lands, do not appear to have provided land lords with a greater net income than those who were 'more free' – i.e. bordars, cottars and villeins. A third important finding is that, in the two circuits where livestock were recorded, the coefficient is about ten times lower than lords ploughs (0.26 compared to 0.02). The core findings are robustly maintained – non-free labour raises valets

⁴⁷ The set of county-by-county introductions that are provided for each of the county studies of the Alecto Domesday series offers an excellent set of summaries of local histories and a rich set of associated references (Great Domesday and Little Domesday county volumes).

⁴⁸ The specification provided is more parsimonious than the one applied in McDonald and Snooks's work, reflecting the lack of detailed information on livestock and other resources outside the Little Domesday text.

⁴⁹ The results of estimates that exclude ecclesiastical holdings are very similar, but suggest that the ratio of peasant to landlord ploughs was slightly lower, and hence that peasants who were linked to ecclesiastical manors contributed more to those manors (on average 5% more). These results are also available on request.

while free labour does not, and ploughs that work exclusively on the lord's land provide a greater reward than those used by peasants. However, it has been emphasised in Domesday scholarship that differences in circuits reflect marked local and regional differences.⁵⁰

Having estimates of ploughs used in the peasant economy (surplus and the extent that ploughs *were not* being used on the lords' land), the extent that freemen were producing (half the produce of non-free labour), and the extent that pastoral production impacted on Domesday incomes, we are in a position to build an estimate of Domesday income. However, the estimate of peasant plough activity is in relation to lords' ploughs, which makes up a *component* of valets, not valets themselves. Therefore, in order to derive an estimate on peasant crop, we first need to determine the proportion of *valets* generated outside the arable sector. In other words, we need to remove non-agricultural components from the seigniorial estimate, and then use the relative estimates to provide an estimate of the peasant economy.

BUILDING A DOMESDAY INCOME ESTIMATE

Calculating Seigniorial Income

Table 4 summarises the calculation of total income detailed below.⁵¹ The Domesday Book provides information on further forms of income-generating resources in the form of mills, fisheries, beehives and property amongst other things. In some cases these resources are valued independently in monetary terms. More rarely, however, resources are valued as payment-in-kind. Fortunately, in the majority of instances resources that were valued in this way were also given valuations in monetary terms, thereby allowing an assessment of their

⁵⁰ The emphasis from Domesday scholars that quantitative work was insensitive to regional differences has been a likely cause of the lack of development in cliometric Domesday scholarship. Given this paper's focus on developing a robust estimate for national income, examining these regional differences is outside its scope. However, the results suggest that more detailed regional study is warranted.

⁵¹ Darby maintains a figure for rural income that is 0.08% higher at £71,573 (Darby, *Domesday England*, p359).

contribution to the Domesday economy. We are therefore able to deduct these factors included in the Survey's calculations.

[Table 4 near here]

Mills, as one of the “greatest economic achievements” of the four centuries before 1086, were by far the dominant ‘other income’ producer outside houses.⁵² Several thousand mills were recorded in the Survey, of which around three-quarters were separately valued. Other resources were far less common. For example, only 45 vineyards are recorded (with no consistently recorded measure of output), salt houses (439, of which 140 were valued), fisheries (668, of which 230 were valued)⁵³, and 313 beehives (1,559 hives are recorded).⁵⁴

Table 5 summarises the distribution and valuation of ‘other’ major non-crop or livestock resources in each circuit in the form of mills, fisheries, salt houses and property. For each resource, the number of manors where mills were recorded, the average (mean) number, and the total number where each resource was located is provided. The next three columns record the number of manors with observed values, the proportion of the total and the average valuation. In total, values of mills amount to a not insubstantial £1,702.1s.2d. Analogous calculations for salt houses and fisheries value these resources at £107.1s.2d. and £56.2s.5d. respectively. There are a number of other payment forms that further complicate the

⁵² Quote from Clapham, *Concise Economic History*, p.59. See John Langdon, *Mills*, and John Holt, *Mills*, for a comparison of mills in Domesday England and circa 1300.

⁵³ In a minority of cases fisheries were sometimes measured in eels or alternatively in stitches, the medieval stick of eels comprising 25 (Darby, p279). There is no money measure provided for these items. Providing a monetary equivalent is also problematic as occasionally the size of the eel is emphasised [“1,502 large eels” appear in (SHR, 4,1,21)]. All in all, 273,272.5 eels (made up of 272,460 eels and 32.51 sticks of eels, where there are 25 eels to a stick) are reported. Furthermore in a minority of cases other varieties of fish are cited: herring (79,560), salmon (1,156) and 1,000 lamprey (a jawless fish). With the exception of herring (valued at 2s.6d per 1,000 - Harvey, “Domesday England” p57), no specific value is provided for these fish in Domesday and in the two instances where fish are mentioned in the absence of other resources, allowing their values to be directly determined, they provide no contribution to the value of the manor (CAM 5,56 and 18,9). However, the majority of produce was included in valuations with payment in kind or customary produced representing a minority of payment. For example, only 26,748 eels were used as payment in kind.

⁵⁴ Salt was valued at 1d per amber, 110 ambers or 9s.2d. (DB I, 28a) while honey was valued at 1s per sester (DB I, 69a). Both these instances were previously recorded by Harvey (“Domesday England” p57). Each of these resources was recorded across England with the exception of beehives, which were only recorded in Little Domesday on around 12% of manors.

calculation, but sum up to £2,290.13s.10d., including revenues from fisheries but not those of mills and salt houses listed above. An additional element incorporated into Domesday is a record of property, made up of *mansurae*, *mansiones*, *hagae* and *domus* that comes to £1,532.⁵⁵ Hence, the total contribution of these ‘other’ major resources to seigniorial income comes to £4,472, leaving £66,529 to be accounted for by arable and livestock.

Livestock was by far the most important element outside arable land. This key item is difficult to gauge with accuracy as only two Circuits of the Survey, Little Domesday and Circuit II of the Exchequer Domesday, provide detailed information on non-working animals. Another further difficulty is that there is no work analogous to John Langdon’s rigorous study of draught animals that would enable robust link to be established between the admittedly thin, twelfth- and thirteenth-century sources, and those prior to 1290/1300. In estimating livestock levels we face three problems. First, what was the value of livestock to the demesne in Little Domesday and Circuit II of Domesday England? Second, how can we generalise the findings in order to calculate seigniorial livestock income? And third, how do we then estimate from this the extent of peasant livestock?

If we assume that a livestock unit in Little Domesday and Circuit II is worth the same in other locations of England, we have an estimate of the first element of the puzzle from Table 3. To answer the second question we need to provide a means to estimate the extent that animals were farmed. Conversions of seigniorial densities and numbers into corresponding national densities and numbers are determined as follows. Following Robert Allen, it is assumed that, due to their high unit capital value, the density of cattle is a third lower on the non-demesne lands.⁵⁶ Second, pigs, which were largely maintained by the

⁵⁵ This figure is taken from Snooks and is low. As was mentioned the Domesday Book provides income information on urban holdings and their worth. A more detailed discussion of this problematic element is made in the following section, which compares the Domesday income estimates with those available for the thirteenth century.

⁵⁶ Allen, “English and Welsh Agriculture”.

peasantry, are assumed to be stocked at double the density by non-seigniorial producers.⁵⁷ Third, following Harvey, we assume that only one-third of the population of sheep were accounted for by peasant producers.⁵⁸ In order to convert livestock into common comparable units, feed requirements were used: sheep (0.1); pigs (0.1); goats (0.1); and cattle (1.1).⁵⁹

[Table 5 near here]

As Table 5 shows, these assumptions lead to an estimate of 84,156 livestock units on the demesne. At a ratio of roughly 10 to 1 these livestock make up £6,474 leaving a residual return of £60,056 from arable. In order to complete the seigniorial component we need to add livestock outside the two circuits where it was not recorded. To do so we require a weighting scheme that captures the fact that many of the counties in the two circuits have historically had relatively higher stocking ratios than elsewhere. In the absence of robust data in the Domesday era⁶⁰ we use average weights taken between 1250 and 1350 to provide ideal

⁵⁷ Wrigley, “Transition”.

⁵⁸ Harvey, “Domesday England”, p.125. Sawyer, “Wealth of England”, (esp. pp.162-4) and Bridberry “Before the Black Death” (esp pp.398) have emphasised that livestock had an important role to play in the Domesday economy. It is unclear whether or not Harvey's ‘third’ would be additional to the total. I have assumed, conservatively, that it is included in the total.

⁵⁹ These ratios come from Campbell (*English Seigniorial Agriculture*, p.104-107).

⁶⁰ A promising alternative approach suggested by Harvey, “Domesday England”, pp.124-26 to extrapolate on circuit size is to use information on grazing land to calculate livestock numbers indirectly. The Survey provides detailed information on the extent of meadow, and to a far lesser extent, pasture. The availability of meadow and pasture is clearly requisite to farm animals and the Survey indicates that meadow not actively being used is rare, which is not surprising since meadow was a valuable commodity in a period where artificial grasses were not available. In principle what distinguished pasture from meadow was that meadow could be mowed while pasture could not. Meadow was land bordering a stream liable to flood, producing hay, and afterwards used for grazing. Because hay was required in quantity to keep livestock through the winter, the most valuable grassland was almost invariably the most highly valued (Campbell, 67-89 for definitions and more detail relating to the *Inquisitus Post Mortum* database). Of the 11,819 cases where meadow is recorded there are 47 instances where the meadow unit is “just meadow” and in no case is there any indication of land area [specifically; Circuit I - (Kent - P3; P19; Sussex - 12,42). Circuit II - (Wiltshire - 68,1). Circuit III - (Bedford - 3,2; Cambridge - 1,21; 26,37; 26,9; 32,29). Circuit IV - (Northampton - 1,8; Oxford - 6,3). Circuit V - (Cheshire - 1,25; Gloucester - 1,10; 1,12; 1,47; 1,57; 1,7; 12,1; 12,2; 12,6; 15,1; 3,7 (four instances); 59,1; 60,1; 7,1; 70,2; Hereford - 10,27; 10,9; 14,2; 14,3; 19,10; 19,9; 24,2; 7,1; 7,3; 7,4; 8,2; 8,5; 43,1; Worcester - 2,16; 2,17; 23,14). Circuit VI - (Nottingham - B1; Yorkshire - 6N2)]. Unfortunately, the recording of meadow proves a poor proxy to livestock with a low correlation between the two variables in the Little Domesday and Circuit II (0.17), implying that there was ten times more meadow in Circuit III. A further alternative correlate would be pasture. The variable is problematic, however. Keen provides an analysis of pasture in “Dorset Domesday” (pp.11-13) and illustrates that there is gross overstocking. For example, Cerne Abbey’s manor of Little Puddle suggested a ratio of 9.4 beasts per acre. More pragmatically, pasture was only consistently recorded on Circuit II, and as we want to extrapolate outside this circuit, this is not helpful.

“typical” stocking densities.⁶¹ These imply that there were about four times more animals outside Circuit II and the Little Domesday counties. Adding seigniorial non-working animals that were located outside Circuit II and Little Domesday gives a total of £98,838.

Calculating Non-seigniorial income

To calculate the most important element of non-seigniorial income, arable, we take the figure for seigniorial arable and multiply this by the estimated proportion of time ploughs belonging to the peasants were employed off-demense. Taking this figure and then weighting it by the number of peasant ploughs relative to those operated on behalf of the lord (i.e. $4.11/1.34$, hence 3.065), gives an arable production figure of £103,827. By doing this we are assuming that peasants obtained the same return on their own land. David Stone has provided solid evidence that peasants worked more intensively on their own land, and this is consistent with later evidence examined.⁶² Therefore the assumption that peasants worked equally hard can be viewed as a lower bound estimate. Multiplying out the number of ploughs used exclusively on peasant land coupled with the “surplus ploughs”, detailed in Table 2, combined with information on the extent of peasant plough utilisation derived in Table 3, gives us a figure of £34,760.1s. As should be expected in an economy where freedom was a relative concept, the vast majority of peasant ploughing activity was derived from ploughs active in both the demesne and peasant sector, which amounted to a much larger proportion of output.

To this we add non-peasant live stock. In the absence of direct information in the Survey we use weighting for the latter medieval period by Bruce Campbell to calculate the number of livestock. The weighting used is that, relative to Tenant-in-Chief’s lands, peasants

⁶¹ The data come from work by Broadberry, Campbell, and Bas van Leeuwen and I am grateful to Bas van Leeuwen for providing them. It should be noted that these are preliminary estimates but it is not anticipated that there will be substantial changes.

⁶² Stone, “Productivity of Hired and Customary Labour”, 640-656.

owned one-third of sheep, twice as many pigs and two-thirds the number of cattle.⁶³ We apply these weightings to the livestock number provided in Table 5, which gives a figure of 55,936 livestock units. Then, as with the seigniorial holding, we multiply by roughly four to encompass those livestock living outside Circuits II or recorded in the Little Domesday Book to come to a pastoral total of almost £70,000. Adding arable and pastoral components together provides a figure of £212,761.

As Table 5 illustrates, there are a large proportion of mills and ‘other’ resources which are not valued, and which were therefore not included in the income figure. Multiplying the average valuation of each asset, and the number of unvalued mills, fisheries, salt houses and burgesses, allows us to put value on these assets, as shown in Table 6. In addition, while it is possible to obtain estimates for urban income for what properties are located in the Survey, it is well known that the Survey was incomplete in its coverage. Some places which may well have possessed urban characteristics were omitted, while the urban nature of some of the places listed, particularly where the number of recorded buildings was low, may have been questionable.⁶⁴ To calculate the value of urban holdings we have information on the number of houses and their valuation in certain cases. There are 88 instances where the number of properties listed (made up of *mansurae*, *mansiones*, *hagae* and *domus*) is recorded *and* valued, amounting to £1,533, with an average value of £0.155. There are, however, also six instances where a valuation is listed but with no properties, at a total value of about £84, and 43 instances where a total of properties are recorded, some 5,983 in all, but where no associated valuations are provided. The average values are used to estimate the value of the unvalued properties (5,983 multiplied by £0.155) to arrive at an overall urban total of £2,529. Keene points out that London dominated the urban landscape, estimating that the city housed 20,000 people in 1100. Combined with Christopher Dyer’s estimates of 4.5 to

⁶³ Campbell, *English Seigniorial Agriculture*, 104-107.

⁶⁴ Darby, *Domesday England*, pp309-13 and Ballard, *Domesday Boroughs*, are the key sources.

5 people per household, this implies between 4,000 and 4,440 houses in London, which at the average value of £0.155 gives a valuation of between £619 and £687.⁶⁵ Appendix 2 contains the full set of these data broken down by Circuit and county, with the London entry assuming 4.75 people per household (i.e. the average of Dyer's two estimates).⁶⁶

[Table 6 near here]

Finally, as noted above, in a small minority of cases, the Domesday Survey also provides a number of observations that do not include monetary information but, rather, are valued in the form of customary exchange and payment-in-kind.⁶⁷ Since there is information on the value of three of the more important elements of these payments-in-kind – honey (1s per sester), Farms of the One Night (£100) and hawks (£10) – their value can be added to our overall estimate.⁶⁸ The total of these ‘unvalued items’ comes to £6,885. There are, however, a number of observations that have a component of payment-in-kind whose valuation is unclear. The majority of customary items were paid by means of livestock, crop, or aforementioned fish,⁶⁹ but also, there is a set of miscellaneous and diffuse items such as “100 loaves with ale to pray for king's soul” (GLS, 61,2) and a “packload of flour from nuns” (KEN, 7,11). These have not been valued due to the lack of any information to derive an estimate from. It is not plausible that these items could make a substantive impact on the aggregated Domesday estimate.

⁶⁵ Keane “London”, p196 and Dyer, *Making a Living*, p94.

⁶⁶ These data have been constructed by the author from the primary source in consultation with Alan Dyer's summary (“Rankings”, p752-73).

⁶⁷ A more complete breakdown of miscellaneous items is provided in Appendix Table I.

⁶⁸ Data on honey and hawk values are provided in the Domesday text. More work has been done of Farms of the One Night with the most recent contribution coming from Grassi, “Lands and Revenues”. Using circuit income as a weighting for differences in consumption between circuits implies that there were 1,705 beehives [the weighting being Little Domesday Book (18.4%); Circuit I (16.2%); Circuit II (20.4%); Circuit III (8.6%); Circuit IV (13%); Circuit V (9.9%); Circuit VI (13.6%)]. Alternative weighting schemes were also considered using meadow and pasture as weight but both provided highly unrealistic distributional potential.

⁶⁹ The majority of animals and their attendants were pigs (979.5) and pigmen (211), with 18 sheep, ten lambs and on one manor ‘rams’. Arable was made up of corn and wheat. These are small numbers of livestock and amounts of arable so their omission leads to a trivial underestimation of income. A larger number of observations of in-kind payment related to fish, but the impact on values is also unlikely to be great (see footnote 53).

As the Domesday record is clearly incomplete where urban holdings are concerned, providing a concrete number that captures urban income involves a degree of speculation. Considerable alternative evidence exists in the form of archaeological data and information relating to specific towns. However, archaeological evidence is derived from partial extraction of a given town and, while critical to our understanding of the topography and economic activities of medieval towns, the partial nature of archaeology does not facilitate concrete estimates.⁷⁰ Holt considers that 10% of the population was living in towns by 1086, which is below the proportion of income reported in Table 6.⁷¹ Taking the running total of £318,484, multiplying this by 10%, and deducting those properties recorded (£1,533 plus £1,648) provides an estimate of £342,472.

COMPARISON OF ESTIMATES

How does this estimate compare to earlier estimates from other scholars? Four sets of estimates, three explicit and one implied, have been made from Domesday. The lowest is that of Snooks, of £137,000. Snooks used the Domesday values to calculate his total, assuming that not all recorded income is included in the market economy and that the subsistence economy made up 60% of output.⁷² Nicholas Mayhew takes the seigniorial total from Darby, expands this for omissions to £100,000, and he then takes assumes that the peasant sector made up at least two-thirds of the economy in order to provide a figure of £300,000 as a lower bound total. Mayhew also examines a scenario where the peasant sector makes up three quarters of the economy hence providing an upper bound estimate of £400,000. Both

⁷⁰ *The Cambridge Urban History of Britain (Vol I)* provides a valuable source concerning each of the points raised here. Palliser, Slater and Dennison review material on topography (in *The Cambridge Urban History of Britain (Vol I)* p.153-186, while Holt provides a discussion on information concerning Canterbury, Gloucester and Winchcombe, and St Oswald (p83), and with Derek Keene provides a more detailed discussion pertaining to London (pp187-216).

⁷¹ Holt, "Society and Population" in *The Cambridge Urban History of Britain (Vol I)*, p.84.

⁷² Snooks, 'Dynamic Role', Table 3.1, p.33.

estimates are essentially *ad hoc* as both authors are quite rightly aware that they are making approximate estimates. In Mayhew's defence he then takes a methodologically interesting approach by using the degree of monetarisation of the economy comparing his estimate using the money-multiplier identity.⁷³ The problem Mayhew then has is that he needs to justify the further elements of the identity. Typically, monetary economists use the identity to estimate the velocity of money, as this is difficult to observe in any period. In addition, the extent of credit needs to be accounted for, and while Mayhew makes a solid effort to address these issues he is aware that he is on shaky ground. Such a method of calculating GDP has not been commonly applied to periods where GDP can be derived via outputs or inputs. The third set of estimates, based on land area and extraction ratios, are closer to Mayhew's £300,000 estimate (Campbell, 2000).⁷⁴ Finally, a fourth estimate is implied in Bridbury's claim that only cash renders were included. As cash made up only a fraction of income, this would imply Domesday England was wealthier than at any point in the late medieval period, which is implausible. Of the available candidates the estimate of this paper is thus well above that of Snooks and is closer to Mayhew and Campbell's estimates.

The degree to which any estimate can be valid is difficult to assess in isolation. To be able to compare national income over time we need estimates of population, price movements, climatic conditions, and of benchmark GDP, preferably for benchmark periods that are not far apart. Unfortunately, the nearest feasible benchmarking date is not until after 1250. Previous studies have concentrated on 1300 as a comparator year and in order to place the findings in perspective I will follow suit, but also provide an alternative date of 1290 in order to assess the robustness of the estimates.

As was noted earlier, there are a large number of instances where no values were recorded in Northern England and in the West. The likely cause of this is that extracting

⁷³ Mayhew, 'Modelling Medieval', Table 4.5, p.72.

⁷⁴ Campbell, *English Seigniorial Agriculture*, p.407.

income from the North counties, which had suffered extensively the laying waste of lands as part of the “harrying” of the North, was not feasible. By 1250 the Northern and Western counties were considerably more secure than in 1086. The boundaries recorded in Domesday differ from those for England in latter periods since they excluded the four additional northern counties of Cumberland, Westmorland, Northumberland and Durham and the account of the county of Lancaster is incomplete. Darby estimated that the rural workforce of Lancashire was 1,800 and that the four counties came to 5,000. Taking mean earnings for Domesday England as being similar to that of the Northern counties provides a figure of £3,034. As this represents a seigniorial estimate, which accounted for one third of total income according to the estimates of this study, we adjust this figure accordingly to obtain an admittedly tentative estimate of £9,133.6s.5d. Table 7 details that on these lands were 2,533 lord’s ploughs, and 18,025 men’s ploughs. Those ploughs amounted to 9% of the total number of lord’s ploughs, 22% of the total number of peasants’ ploughs recorded in the Survey. By far the greatest proportion were recorded in the North, where 9,513 of the total 16,092 ploughs recorded in Circuit VI had no value associated to them. The Western counties bordering Wales, Circuit V, also have a relatively high proportion of values missing. Much of this land was laid waste as a result of the “harrying of the North” and conflicts with the Welsh kingdoms. Taking the product of average value of ploughs and the number of unincorporated ploughs provides an estimate of £4,257.4s.1d. for lord’s ploughs and a further £16,039.7s.5d. relating to men’s ploughs, and hence a total of £20,297.11s.5d. Adding that figure to the “full capacity” estimate leads us to a counterfactual Domesday economy valued at £360,281.

[Table 7 near here]

Table 8 incorporates estimates of population, price, and climatic conditions for this and earlier studies calculating GDP per capita estimates. Population figures vary widely. A

recent estimate by Gregory Clark suggests a population of about 6 million, while Campbell is less sanguine and provides perhaps the most robust evidence to date. Campbell's estimate reconciles well with available data, the most compelling of which are from the lay subsidies (1290 and 1327/32), and points to a figure closer to 4 million, with the most recent estimate being 4.25mn.⁷⁵ What emerges starkly from Table 8 is that these more recent figures are considerably lower than those used by Mayhew and Snooks.⁷⁶

[Table 8 near here]

The availability of the Winchester pipe rolls allows the tracking of prices from 1165/6,⁷⁷ However, it is only from 1208 that data sources become richer.⁷⁸ Prior to 1165/6, there is very little information on prices, but what does exist suggests that prices were stable.⁷⁹ There is considerable debate on the nature and extent of price rises, particularly between 1180 and 1220.⁸⁰ The price data, compiled by Farmer, show that wheat price averaged between 1165/66-1070/71 and 1295-1305 rose 3.28 fold while livestock prices increasing 3.57 fold.⁸¹ In the absence of direct information on the price movements of mills and 'other' resources, the average price rise of wheat and livestock is applied to those resources.

An important element for accurate comparison between agrarian economies over time is climate. This is particularly the case since we are comparing two specific years of data over

⁷⁵ Clark, "Microbes and Markets"; Campbell, "Benchmarking", Table 14, p.68; Broadberry *et al.*, "English Agricultural Output", pp.33-34.

⁷⁶ Mayhew, "Modelling Medieval Monetisation", p.57-77 and Snooks, "Dynamic Role", p.32-54.

⁷⁷ Harvey provides the best evidence of price movements between Domesday and c. 1300, but as noted by Mayhew, "Modelling Medieval Monetisation", the relatively thin nature of the data means that these figures are not accurate. Both Mayhew and Snooks use quite similar price deflation between 1086 and c. 1300, of a factor of 4 and 4.066 respectively, and quite similar population estimates.

⁷⁸ Clark, "Price History", pp.41-125.

⁷⁹ For livestock price commentary see Farmer, "Prices and Wages", p717.

⁸⁰ A lack of consensus as to the extent of any price rises at some periods over the comparison period, in particular 1180-1220, has not prevented the development of an extensive literature on the causes of potential rises over the period (Latimer, "English Inflation", provides a recent contribution to the debate).

⁸¹ Data come from Farmer, "Prices and Wages" Appendix A: 'Sale price of major grains' (p787-794) and Appendix B: 'Purchase price of livestock' pp.799-805 which averages indices for oxen, affers, cows, weathers, ewes and pigs. Five-year averages are taken so as to obtain a more 'typical year'.

a long period. Contemporary evidence from the *Anglo-Saxon Chronicle* for 1086 tells us that it was “a very severe year in England; corn and crops were checked, and there was such great misfortune that the weather as cannot easily be conceived – there were such big thunderstorms and such lightening that many people were killed and it kept on getting worse and worse amount the people. May God Almighty make things better when it is his will”.⁸² While the *Chronicle* provides a *prima facie* case that climate was potentially an important factor, a more precise gauge of the relative weather conditions is necessary in order to be able to derive a robust income estimate. Recent work on climate change has generated a series of long-run climatic data series based on the use of ice core reading and dendroclimatology, which are reliable methods for examining climatic conditions over extensive time horizons. Ice core readings taken from the Greenland Ice Core Project (GRIP) do not suggest that there was anything special in either 1084 or 1087.⁸³ A central finding in the dendroclimatological literature, however, is that temperatures across global regions are weakly correlated. Therefore, changes in the estimated temperature, even across Northern Europe, may poorly explain weather conditions and crop yields.⁸⁴ Indeed, recent work by Bruce Campbell, Morgan Kelly, and Cormac O’Gráda found little evidence that Northern European weather conditions correlate with crop yields, but that Dutch climatic data correlate well.⁸⁵ Using Irish tree ring and Dutch climatic data, they find a robust relationship between climate and yields. An examination of Swedish and European Alpine data series for 1086 suggests broadly similar tree ring growth to the Irish series and also with oak ring data from central England.

⁸² *Anglo-Saxon Chronicle*, p162. The *Annals of the Four Masters*, which are not contemporary and are thus less reliable, speak about a cattle murrain in Ireland already in 1085 which also suggests adverse effects on crops in 1086. The author thanks Kathleen Pribyl for pointing this out.

⁸³ Data and references from the GRIP project are found at <http://www.esf.org/activities/research-networking-programmes/life-earth-and-environmental-sciences-lesc/completed-esf-research-networking-programmes-in-life-earth-and-environmental-sciences/greenland-icecore-project-grip.html>. Data from the Dye 3 is provided by the National Climatic Data Centre.

(http://www.ncdc.noaa.gov/paleo/icecore/greenland/gisp/dye3/dye3_data.html).

⁸⁴ See Jones and Mann, “Climate over Past Millennia”, for a review that stresses the extent of local differences within European climates.

⁸⁵ Dutch weather data comes from Engelen, Buisman and IJnsen, “A Millennium of Weather”.

However, in contrast, conditions in 1300 were cooler than average in both Ireland and Central England.⁸⁶

Campbell *et al.*'s research on the climate-yield relationship suggests that a one-degree rise in temperature increased average yields by 7%, while a one standard deviation increase in oak ring thickness was associated to an 11.5% fall in output, as wet conditions are conducive to oak growth but not to crop production.⁸⁷ In the absence of yield information in Domesday England – by which we could directly assess the relationship between crop yields and weather conditions – the best we can do is to use these coefficients in relation to Domesday weather conditions. The data suggest that the summer temperature was quite a lot cooler in 1086, over one-and-a-half standard deviations, while the tree ring data suggest that 1086 was a wet year, 0.73 standard deviations wetter. Taken together these factors imply that crop production was slightly below 20% lower than the norm. In contrast, in 1300 England, rainfall as indicated by the oak rings, was slightly wetter than the norm and output 4% higher than the norm. These findings suggest that, in order to compare the economy under 'normal conditions', we need to inflate the crop returns by 16%, which adds another £18,678.9 worth of 'counterfactual wheat'.

How robust are these findings? Other than Snooks and Mayhew's estimates, two further comparative estimates are provided in Table 7. It is difficult to comment on Snooks's estimate as it was generated by a simulation model which is left unspecified providing a figure of £4.066 million. Mayhew provides a figure of £5 million based on earlier work by Dyer (1989), who constructs a breakdown of living standards across English society in 1300. A more recent figure, provided by Campbell (2007), estimates a value of £3.6 million in

⁸⁶ The Swedish data were derived by Grudd and are detailed in "Torneträsk tree-ring" while the Alpine series are from Büntgen, Frank, Nievergelt, Esper "Summer Temperature". These data, along with data from Central England, were provided by Dan Miles and Rob Wilson, for which I am grateful.

⁸⁷ These results are adjusted for attenuation bias by Campbell *et al.*

1290. Given this is the most recent estimate available it is adopted here.⁸⁸ Table 8 shows that the implied growth rate, after correcting for climatic conditions, is 0.112%, substantially lower than Snooks, and marginally (0.050%) lower than Mayhew's comparative result. To further contextualise the finding we also provide a further estimate based on Clark's alternative population estimate, while the second is based on an earlier benchmarking date of 1290. The incorporation of Clark's population count implies that there was a fall in per capita income, which is an implausible result. While 1300 is a convenient comparative date, since it has been used in previous work, 1290 is perhaps a more natural comparative year since, as Campbell argues, "across much of Europe, long-established processes of economic and demographic expansion and commercial integration attained their secular climax".⁸⁹ In addition, prices can be quite volatile and can impact on the robustness of the findings.

CONCLUSIONS

The Domesday Survey is the key to unlocking the earliest potential benchmarking of income for a nation. Using an explicit and transparent methodology, this paper provides estimates of Domesday England that are plausibly comparable with later benchmarks under differing population, price, and climatic assumptions. In doing so, it responds to four criticisms of earlier work as well as is feasible. Specifically, the use of data derived from the two recognised Domesday translations for the more complex Little Domesday set as a cross-check addresses potential criticism related to the quality of the translation; the entire Survey is analysed to ensure as wide a geographical coverage as is possible; there is an acknowledgment of the potential for error and participant manipulation within the Survey;

⁸⁸ There is currently a substantial project providing estimates for 1300 by Broadberry, Campbell and Van Leeuwen. These data will provide a more robust inter-temporal comparison and will shortly be available in early 2009.

⁸⁹ There are of course data sources between Domesday and the 1290s but these are too fragmentary to be able to sustain a plausible comparison (see Campbell, "Benchmarking" for further information and justification of this as the pivotal comparative period).

and, being keenly aware that there is still debate and controversy concerning scope and meaning of variables, I take a cautious approach, using relationships within the Survey to examine the validity of differing interpretations that are implied by the testimony. The findings largely support the interpretation provided in Bridbury (1990), which we further developed conceptually before operationalising with the data. Given the lack of uniform agreement on the meaning of important elements within the Survey, any estimate must necessarily make a number of assumptions. By being explicit about how the estimates are derived and highlighting limitations, it is hoped that this research widens the future scholarly agenda on the Domesday Survey and Domesday England. The availability of a substantial resource of medieval data sources coupled with the Survey provides considerable scope to chart very long-run movements in income, and also to provide further evaluation of the Domesday text. Moving away from comparisons based on aggregation of micro-data sources, as has been done here, towards explicit linking and mapping analysis of manorial returns, such as the manorial data and taxation returns (for example the Lay subsidies and poll tax), will provide scope for a burgeoning literature that can inform and be informed by the Domesday Survey.

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TABLE 1
DOMESDAY (MEANS)

		Domesday	Little	Domesday Circuits					
		Britain	Domesday	Circuit I	Circuit II	Circuit III	Circuit IV	Circuit V	Circuit VI
<i>Income</i>	Values	£4.3s.8d.	£3.7s.5d.	£5.16s.6d.	£4.9s.11d.	£4.2s.11d.	£4.8s.2d.	£3.18s.9d.	£3.18s.9d.
<i>Population</i>	Slaves	1.88	0.90	2.40	3.27	1.59	1.55	5.39	0.02
	Bordars	5.37	5.88	6.51	6.17	3.20	5.53	7.27	3.31
	Cottars	0.28		1.00	0.34	1.05	0.20	0.04	0.01
	Villiens	7.43	2.91	10.83	7.27	5.42	10.26	10.73	8.24
	Freemen	2.14	3.18	0.01	0.00	0.13	3.93	0.03	4.70
<i>Ploughs</i>	Lords' Ploughs	1.34	0.90	1.56	1.60	1.14	1.45	2.24	1.06
	Mens' Ploughs	4.11	2.32	4.58	3.63	2.56	4.86	8.92	3.92
No. Obs		17,195	3,918	1,982	3,252	1,479	2,090	1,797	2,677

Notes: Data sources being Palmer for Great Domesday and the author for Little Domesday. The county make-up of the Domesday circuits is as follows: *Circuit 1:* Berkshire, Hampshire, Kent, Surrey and Sussex; *Circuit 2:* Cornwall, Devonshire, Dorset, Somerset and Wiltshire; *Circuit 3:* Bedfordshire, Buckingham, Cambridgeshire, Hertford and Middlesex; *Circuit 4:* Leicestershire, Northamptonshire, Oxfordshire, Staffordshire, Warwick; *Circuit 5:* Cheshire, Gloucestershire, Herefordshire, Shropshire and Worcester; *Circuit 6:* Derbyshire, Huntingdonshire, Lincolnshire, Nottingham, Rutland and Yorkshire; *Circuit 7:* Essex, Norfolk and Suffolk. Values represent mean manorial 'valets' whose meaning is examined in the text.

TABLE 2
DIFFERENCE BETWEEN PLOUGHS AND PLOUGH TEAM

Domesday	LDB	Domesday Circuits							TOTAL
		Circuit I	Circuit II	Circuit III	Circuit IV	Circuit V	Circuit VI		
less than	-	463	222	30	353	53	1,053	2,174	
more than	-	580	1,987	598	921	583	1,283	5,952	
	-	1,043	2,209	628	1,274	636	2,336	8,126	
total	3,954	1,963	3,214	1,451	2,067	1,817	2,727	14,078	
less (%)	n/a	24	7	2	17	3	39	15	
more (%)	n/a	30	62	41	45	32	47	42	
TOTAL	n/a	53	69	43	62	35	86	58	

Notes: 1. Calculations based on the difference between 'plough-lands' and the total number of 'plough-teams' (peasant plus demesne). Hence 'less' refers to circumstances where there are less ploughs than plough-lands while 'more' refers to instances where there are more ploughs than plough-lands. 2. Little Domesday Book is abbreviated as LDB.

TABLE 3
DETERMINANTS OF VALUES
(Box Cox estimates – Theta model)

		Domesday Britain	LDB	Domesday Circuits					
				Circuit I	Circuit II	Circuit III	Circuit IV	Circuit V	Circuit VI
Labour	Slaves	0.09 (227.42)***	0.08 (71.164)***	0.10 (62.545)***	0.13 (197.871)***	0.09 (30.796)***	0.07 (44.043)***	0.04 (11.216)***	0.10 (8.562)***
	Bordars	0.09 (858.89)***	0.13 (262.143)***	0.15 (202.772)***	0.08 (152.329)***	0.12 (109.515)***	0.05 (34.466)***	0.03 (6.626)***	0.04 (34.226)***
	Cottagers	0.10 (150.47)***		0.16 (136.595)***	0.04 (5.603)***	0.08 (36.498)***	0.15 (19.092)***	0.08 (2.099)***	0.09 (4.097)***
	Villiens	0.10 (533.70)***	0.07 (74.258)***	0.17 (129.092)***	0.12 (161.346)***	0.17 (154.437)***	0.09 (62.151)***	0.08 (31.256)***	0.11 (157.800)***
	Free	0.05 (91.83)***	0.04 (25.348)***			0.05 (0.94)	0.04 (20.477)***		0.05 (50.455)***
	Capital	Lords' Ploughs	0.28 (1469.83)***	0.23 (244.428)***	0.30 (173.607)***	0.18 (219.948)***	0.22 (48.648)***	0.26 (187.104)***	0.36 (234.901)***
	Men's Ploughs	0.12 (1002.82)***	0.18 (305.091)***	0.06 (6.172)***	0.13 (51.541)***	0.18 (48.041)***	0.16 (73.804)***	0.12 (31.596)***	0.17 (139.153)***
	Livestock		0.03 (78.76)***		0.03 (72.311)***				
	Circuit Fixed Effects	YES							
	County Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
	λ	0.50 (84.06)***	0.40 (31.11)***	0.51 (29.55)***	0.54 (38.30)***	0.53 (26.04)***	0.55 (28.69)***	0.54 (23.07)***	0.46 (36.70)***
	θ	0.15 (36.38)***	0.19 (21.79)***	0.23 (14.63)***	0.09 (9.00)***	0.28 (18.02)***	0.17 (12.27)***	-0.01 (0.43) ¹	0.09 (7.84)***
	N	16,126	3,664	1,862	3,054	1,444	1,965	1,678	2,459
	Log Likelihood	-16230.4	-3391.5	-1880.4	-2770.3	-1433.8	-1963.2	-1524.2	-2553.9

*** indicates significant at the 1% level.

** indicates significance at the 5% level.

Notes: 1. Independent variable significance is determined by χ^2 tests (where $P > \chi^2$). 2. Function form parameter significance tests (i.e. for λ and θ) are reported as z-statistics. 3. The 'Domesday England' includes circuit and county fixed effects. 4. Data includes all manors with lay and church ownership. 5. Little Domesday Book is abbreviated as LDB. *Sources:* See Table 1.

TABLE 4
ESTIMATING DOMESDAY AGRICULTURAL INCOME

Seigniorial	Recorded amount	£71,002	
	Non-working animals	£6,474	
	less Mills	£1,702	
	non-arable income Fisheries	£107	
	Salthouses	£57	
	Other payments	£1,074	
	Property	£1,533	
	Arable	£60,056	
			£71,002
		Non-working animals (unrecorded)	£27,836
	TOTAL		£98,838
Non-Seigniorial	Ploughs (partial demesne)	£103,827	
	Ploughs (non-demesne)	£34,760	
	Non-working animals	£69,920	
			£208,506
plus non-arable value	Mills	£1,873	
	Fisheries	£431	
	Salthouses	£650	
	Farm of One Night & hawks	£1,915	
	Honey	£370	
	Proprerty	£1,648	
			£6,885
		£314,229	
	Proprerty (unrecorded)	£28,243	
TOTAL			£342,472

Notes: **Seigniorial** – Recorded amount is the total income reported in the Survey. The derivation of non-working animals is detailed in the text. Mills, fisheries, and salthouses values are derived in Table 5. Property values recorded in Domesday are explained in the text. Appendix II provides a breakdown by location of properties. ‘Other payments’ is made up of a set of valued items. Arable and pasture is calculated as the total recorded income less non-arable income as detailed in the text. **Non-Seigniorial** – Ploughs (non-demesne) is calculated from the total number of “surplus” ploughs multiplied by the mean return to ploughs on the landlord’s demesne. Hence, $[\text{value}/(\text{lord's plough} + \text{peasant plough}(1 - \text{estimate of return to peasant plough}))]$ where the mean values and ploughs are taken from Table 1 and the ‘estimated return to peasant plough’ is derived from Table 3. Peasant ploughs used both on the Lord’s lands and privately (derived from Table 3). Freemen working off-demesne (i.e. $\text{values}/(\text{freemen} * 2)$). Non-working animals are calculated as seigniorial animal values were, but using the peasant livestock estimate (see Table 6). Non-arable incomes, with the exception of ‘Farm of One Night and hawks’ are derived by multiplying out unvalued resources using the mean (circuit weighted and excluding instances where “surplus” ploughs were recorded to avoid double counting) values of those resources. Appendix II extrapolates to provide values for properties using mean property values and gives a breakdown by location of properties. ‘Farm of One Night’ was taken at £100, as argued by Grassi in “Lands and Revenues”, while hawks were explicitly valued at £10. Unrecorded properties are calculated by assuming 10% of the Domesday economy was urban and deducting those properties that were recorded with or without valuation in the Survey.

TABLE 5
'OTHER' RESOURCES

Mills				Fisheries			
Circuit	Total Number	Proportion Valued (%)	Average Valuation	Circuit	Total Number	Proportion Valued (%)	Average Valuation
LDB	1,111	0.62	7s.8d.	LDB	-	-	-
I	1,227	95.53	10s.5d.	I	378	46	9s.1d
II	1,350	97.12	12s.6d.	II	43	43	7s.2d.
III	499	97.38	13s.11d.	III	85	23	12s.8d.
IV	1,067	96.80	8s.11d.	IV	38	42	12s.11d.
V	1,233	85.06	7s.2d.	V	209	15	10s.8d.
VI	1,151	95.35	8s.9d.	VI	401	65	6s.3d.
Total/mean	7,637	78.23	9s.4d.	Total/mean	1,155	34	9s.4d.

Salthouses			
Circuit	Total Number	Proportion Valued (%)	Average Valuation
LDB	-	-	-
I	498	46	11s.1d.
II	127	43	7s.2d.
III	1	23	2s.8d.
IV	5	42	3s.11d.
V	790	15	19s.8d.
VI	323	65	6s.3d.
Total/mean	1,744	34	8s.4d.

Note: 1. Little Domesday Book is abbreviated as LDB.

TABLE 6
LIVESTOCK

	Circuit	Number	Weighted
Sheep	LDB	140,684	14,068
	II	144,373	14,437
	Total	285,057	28,506
Pigs	LDB	33,177	3,318
	II	13,317	1,332
	Total	46,494	4,649
Goats	LDB	9,768	977
	II	13,743	1,374
	Total	23,511	2,351
Cattle (incl. Cows)	LDB	10,358	11,394
	II	33,869	37,256
	Total	44,227	48,649
		399,289	84,156

Notes: 1. Little Domesday Book is abbreviated as LDB. 2. Weights are as follows: Sheep (0.1); Pigs (0.1); Goats (0.1); Cattle (1.1). Peasant weighting relative to Tenant-in-Chief's lands: Sheep (1/3rd); Pigs (times 2); Goats (times 2); Cattle (1 less 1/3rd) [Campbell, *English Seigniorial Agriculture*, 104-107].

TABLE 7
UNVALUED PLOUGHS

	Domesday	Little	Domesday Circuits					
	Britain	Domesday	Circuit I	Circuit II	Circuit III	Circuit IV	Circuit V	Circuit VI
<i>Totals</i>								
Lords' Ploughs	26,908	4,029	3,299	5,350	1,786	3,358	4,758	4,327
Men's Ploughs	82,536	10,420	9,704	12,162	4,008	11,241	18,909	16,092
<i>Proportions</i>								
Lords' Ploughs	9	5	3	2	4	11	19	18
Men's Ploughs	22	9	4	3	4	11	28	59

Notes: See text.

TABLE 7
**COMPARATIVE ESTIMATES DOMESDAY AGRICULTURAL INCOME WITH
LATER BENCHMARKS**

Author	Year	GDP (mn)	Population (000s)	Income per capita	Price deflator	Real Income per capita	Implied Growth rate
Snooks	1086	0.137	1,531	0.089			
Mayhew I		0.300	2,250	0.133			
Mayhew II		0.400	2,250	0.178			
<i>This study</i>		0.367	1,684	0.218			
Climate change		0.370	1,531	0.241			
Snooks	1300	4.066	5,750	0.707	4.00	0.177	0.231
Mayhew		5.000	6,000	0.833	4.00	0.208	0.168
Campbell	1290	3.600	4,250	0.847	3.78	0.323	0.153
Climate change		3.600	4,250	0.847	3.43	0.323	0.118
Clark popn est.		3.600	6,000	0.600	3.43	0.175	-0.115

Notes: 1. Snooks and Mayhew estimates come from *A Commercialising Economy* pages 27-54 and 55-77 respectively. The population estimate for 'this study' 1086 uses Bribury's assumptions detailed in "Domesday Valuation", p124-25; 2. Derivation of the climate change counterfactual is detailed in the text; 3. The population estimate and income levels are taken from Campbell, "Benchmarking"; 4. 'Clark popn est.' or Clark's population estimate, comes from "Microbes and Markets"; 5. The earlier benchmark uses price data from 1290 assuming GDP remained unchanged. Price deflation is calculated using data from Farmer "Prices and Wages" and is weighted by wheat and livestock prices, within residual resources being deflated by the mean of wheat and livestock prices.

APPENDIX TABLE 1.
DISTRIBUTION OF PAYMENTS ‘IN-KIND’ BY CATEGORY

Form of payment-in-kind	Total number
Animals and their Attendants	42
Crops	19
Fish	179
Woodland	8
Hawks	9
Farm of One Night	20
Honey	16
House	13
Miscellaneous	117
Salt	25
Tributes	3
Totals	451

Notes: Categories were derived by the author. Footnote 60 details the constituent population of animals, attendants and crops while footnote 53 does the same for fish. Hawks, Farm of One Night and honey have associated prices and hence their value has been incorporated into the calculation.

APPENDIX TABLE 2.
VALUES AND NUMBERS OF DOMESDAY PROPERTIES

Circuit	County	Town	Value	No.	Circuit	County	Town	Value	No.
<i>INCLUDE BOTH PROPERTIES AND VALUES</i>					<i>EXCLUDE PROPERTIES</i>				
I	Berkshire	Reading	4	28	II	Wiltshire	Cricklade	5	32
I		Wallingford	62	383	II	Wiltshire	Salisbury	6	39
I		Windsor	2	95	II	Wiltshire	Wiltshire	16	106
I	Kent	Canterbury	51	383	III	Bedfordshire	Bedford	5	32
I		Dover	40	31	V	Worcestershire	Worcester	23	150
I		Fordwich	11	73	V	Gloucestershire	Winchcombe	28	181
I		Rochester	8	97	TOTAL			£84	541
I	Surrey	Guildford	30	75	<i>EXCLUDE VALUES</i>				
I	Sussex	Lewes	8	458	I	Hampshire	Southampton	8	54
I		Pevensey	27	51	I		Winchester	5	31
I		Rye	8	64	I	Kent	Romney	8	50
II	Devonshire	Barnstable	3	26	I		Sandwich	64	415
II		Lynford	3	69	I		Hythe	36	231
II		Totnes	8	110	I	Sussex	Chichester	24	158
II	Dorset	Dorchester	1	88	I		Hastings	4	24
II	Somerset	Axbridge	1	32	II	Cornwall	Bodmin	11	68
II		Bath	18	154	II	Devonshire	Exeter	46	300
II		Ilchester	1	107	II		Okenhampton	1	4
II		Langport	1	34	II	Dorset	Bridport	15	100
II	Wiltshire	Bradford-Upon Avon	18	33	II		Shaftesbury	34	217
II		Malmesbury	27	84	II		Wareham	21	135
II		Tilshead	3	66	II		Wimborne Minister	3	22
II		Wilton	50	30	II	Somerset	Milborne Port	9	56
III	Cambridgeshire	Cambridge	14	281	II		Milverton	0	1
IV	Leicestershire	Leicester	43	226	II		Taunton	10	64
IV	Northamptonshire	Northampton	31	235	II	Wiltshire	Bedwyn	4	25
IV	Nottinghamshire	Nottingham	47	227	II		Calne	11	70
IV	Oxfordshire	Oxford	28	70	II		Warminster	5	30
IV	Staffordshire	Stafford	60	968	III	Buckinghamshire	Buckingham	4	26
IV	Warwick	Warwick	7	112	IV	Staffordshire	Tutbury	6	42
LDB	Essex	Colchester	184	353	IV	Leicestershire	Lough	0	80
LDB		Maldon	83	409	IV	Nottinghamshire	Newark	9	56
LDB	Norfolk	Norwich	16	183	V	Cheshire	Penwortham	1	6
LDB		Trentford	97	1175	V		Rhuddlan	4	26
LDB		Yarmouth	70	720	V	Hertfordshire	St Albans	7	46
LDB	Suffolk	Dunwich	70	720	V		Ashwell	2	14
LDB		Ipswich	59	242	V	Worcestershire	Droitwich	10	64
V	Cheshire	Chester	20	210	V	Lincolnshire	Grantham	29	188
V	Gloucestershire	Gloucester	70	282	VI		Lincoln	137	889
V		Tewkesbury	60	22	VI		Steyningin	19	123
V	Herefordshire	Berkhamsted	1	13	VI		Torksey	16	102
V		Hereford	4	52	VI	Yorkshire	Clifford	2	16
V		Hertford	60	103	VI		Dadsley	5	31
V		Stanstead Abbots	20	54	VI		Pocklington	2	15
V	Shropshire	Shrewsbury	1	7	VI		Tanshelf	9	60
V	Worcestershire	Pershore	40	276	VI		York	243	1571
VI	Derbyshire	Derby	2	28	VI	Suffolk	Beccles	4	26
VI	Huntingdonshire	Huntingdon	30	259	LDB		Bury of St Edmunds	53	342
VI	Lincolnshire	Stamford	30	427	LDB		Clare	7	43
VI	Lincolnshire	Stamford	74	407	LDB		Eye	4	25
					LDB		Sudbury	21	138
TOTAL			1,598	10,603	LDB				
		London*	£651	4,211	TOTAL			913	5,983
TOTAL			£3,693	24,524	GRAND TOTAL			£2,595	17,126

Notes: See text.

APPENDIX: THE LIKELIHOOD FUNCTION FOR THE THETA MODEL

The unconcentrated log likelihood function can be written as,

$$\ln L = \left(\frac{-N}{2} \right) \left\{ \ln(2\pi + \ln(\sigma^2)) \right\} + (\theta - 1) \sum_{i=1}^N \ln(y_i) - \left(\frac{1}{2\sigma^2} \right) SSR \quad (A1)$$

where

$$SSR = \sum_{i=1}^N (y_i^{(\theta)} - \beta_1 x_{1j}^{(\lambda)} + \beta_2 x_{2j}^{(\lambda)} + \dots + \beta_k x_{kj}^{(\lambda)} + \gamma_1 z_{ij} + \gamma_2 z_{2j} + \dots + \gamma_k z_{kj}) \quad (A2)$$

Using matrix notion,

$$SSR = (Y^{(\theta)} - X^{(\lambda)} b' - Zg')' (Y^{(\theta)} - X^{(\lambda)} b' - Zg')$$

Where $Y^{(\theta)}$ is a $N \times 1$ vector of data that is transformed element wise. $X^{(\lambda)}$ is an $N \times k$ matrix of data that is transformed element wise. Z is an $N \times l$ matrix of untransformed data, b is a $1 \times k$ vector of coefficients, and g is a $1 \times l$ vector of coefficients. Where $W_\lambda = (X^{(\lambda)} Z)$ is the

horizontal concatenation of $X^{(\lambda)}$ and Z , and $d' = \begin{pmatrix} b' \\ g' \end{pmatrix}$ is the horizontal concatenation of the

coefficients gives $SSR = (Y^{(\theta)} - W_\lambda d')' (Y^{(\theta)} - W_\lambda d')$. For given values of λ and θ the solutions for d' and σ^2 are

$$\hat{d}' = (W_\lambda' W_\lambda)^{-1} W_\lambda' Y^{(\theta)}$$

and

$$\hat{\sigma}^{2\theta} = \frac{1}{N} (Y^{(\theta)} - W_\lambda \hat{d}')' (Y^{(\theta)} - W_\lambda \hat{d}')$$

Substituting into (A1) provides the concentrated log likelihood function.

$$\ln L = \left(\frac{-N}{2} \right) \left\{ \ln(2\pi + 1 + \ln(\sigma^2)) \right\} + (\theta - 1) \sum_{i=1}^N \ln(y_i) \quad (A3)$$

