

AGRICULTURAL RENT IN THE EARLY VICTORIAN ERA

by

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# Abstract

This thesis concerns the economic and political relationship between the English tenant farmer, his landowner, and his Member of Parliament during the period between 1830 and 1865. Profound social and economic changes took place in agriculture during this time, notably the enfranchisement of the tenant farmer (1832), the Repeal of the Corn Laws (1846), and the development of the railways from 1832 onwards. The tenant farmer was an important actor in all three changes, but his role has been overlooked. This thesis brings him into focus in three chapters, each dealing with the tenant-farmer within the rural economy. Chapter 1 introduces the research project, makes a clear statement of the goals of the research, and reviews some of the recent literature. Chapter 2 deals with the ways in which agricultural rents were set in the 1830s and estimates agricultural rents from two centuries ago, using observations for nearly six hundred parishes in the southwest of England. The finding is that rents were set closely with Ricardian Rent Theory. Chapter 3 measures the impact on agricultural rents of railway development. The railways were laid from 1832 onwards, and farmers used the railways to take their stock to market. This saved large amounts of money, primarily from reduced loss of condition compared to droving to market. The social savings were approximately 1.1 per cent of GDP, a considerable sum. The chapter

shows that about one fifth of the wealth transfer resulted from cheaper transportation, while the other four-fifths resulted from productivity gains as farmers rearranged their output to take advantage of the railways. Chapter 4 measures the impact of the agricultural interest on the voting decisions of Member of Parliament during the Corn Laws crisis in 1846. This chapter shows that tenant farmers had a small but measureable influence on voting decisions.

# Table of contents

Abstract .....	ii
Table of contents .....	iv
List of tables .....	vii
List of figures .....	ix
Acknowledgements.....	x
Dedication.....	xi
Chapter 1. Introduction .....	1
Research goals .....	3
Outline of the chapters.....	4
Chapter 2. Rent-setting in early Victorian Britain.....	15
Agricultural production in the 1830s.....	20
Landowners and their tenants .....	28
The tithe system.....	33
Theory of rent setting .....	35
Data and methods.....	42
Empirical tests .....	52
Discussion .....	65
	iv

Conclusion .....	66
Chapter 3. The advent of rail and British agriculture .....	68
The development of the railways .....	76
Railways and Ricardian Rent Theory .....	80
Methods and data .....	84
Results: estimation for 1832-1865 .....	96
Valuation of the savings at the national level .....	101
Discussion .....	109
Conclusion .....	114
Chapter 4. Constituency interests and the Corn Laws Crisis of 1846 .....	117
Electoral competition .....	121
Politics in the 1840s .....	123
The politics of agricultural protection .....	136
The farmer as political activist .....	138
The structure of agricultural production .....	140
Political pressure and the MP .....	143
Statistical methodology .....	146
Analysis .....	149
Discussion and conclusion .....	162

Chapter 5. Conclusion .....	163
Bibliography .....	167
Appendix: Data Sources .....	191

## List of tables

Table 1. Tabulation by county of the parishes. ....	44
Table 2. Comparison of parish data. ....	53
Table 3. Results for pastoral test. ....	55
Table 4. Reported grain yields regression. ....	57
Table 5. Arable rent regression. ....	59
Table 6. Local R2 values by county. ....	62
Table 7. Estates and their lands. ....	89
Table 8. Rents of large estates and parishes 1836. ....	92
Table 9. Rents and access to track. ....	98
Table 10. Comparing the 31 and 21 estates. ....	101
Table 11. Social Savings 1865. ....	102
Table 12. Regional contributions. ....	107
Table 13. Contested elections by type. ....	122
Table 14. 1841 General Election Results. ....	125
Table 15. Church attendances. ....	128
Table 16. Repeal voting in 1846. ....	135
Table 17. Voting for Repeal. ....	153
Table 19. Summary statistics from by-elections. ....	157
Table 20. Conservative voting on Repeal and re-election. ....	159

Table 21. Re-election in large boroughs .....	160
Table 22. 1847 results and incumbency. ....	161



## List of figures

Figure 1. Localized wheat volumes and the region of interest.....	21
Figure 2. The parishes within the region of interest. ....	24
Figure 3. Bid-rent curve for two crops .....	37
Figure 4. Coefficient of determination by parish. ....	61
Figure 5. Holkham Hall's land and railway, 1865. ....	87
Figure 6. The 31 estates with railways in 1840 and 1865. ....	91
Figure 7. Annual rent and distance to station 1832-1870.....	93
Figure 8. Social savings as a share of GDP. ....	106
Figure 9. Anglican attendances. ....	130
Figure 10. Inter-county wheatflows. ....	142
Figure 11. Opposition predicted probabilities. ....	155

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The dissertation contains analyses based on Geographical Information Systems (GIS). To me at least, this topic is perhaps not the most straightforward. Jose Aparicio and Tom Brittnacher, both at UBC, both helped me rather more than they realize. The Corn Laws analysis requires a GIS 'shapefile' defining the physical boundaries of the political constituencies that existed at that time. Tom was instrumental in obtaining that shapefile from the University of Portsmouth, and arranging for UBC to (very kindly!) pay for it!

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Finally, UBC is a good place for the development of unlikely friendships with interesting people. Jason Barton falls into that category. Enough said.

## Dedication

This research is dedicated to the memory of my father who, in a fairer world, would have been able to go to university. I do not forget how fortunate I am.

## Chapter 1. Introduction

The central theme of this research is the changing economic and political relationship between tenant farmers, landowners and Members of Parliament in the period 1830-1865.

This was a time of great change in the countryside. Tenant farmers received the vote under the 'Chandos clause' of the 1832 Reform Bill, a new possession which they were to use with surprisingly powerful effect during the Corn Laws Crisis of the 1840s. At the same time, the structure of agricultural production was altering as the population grew larger and became wealthier. As a result, the demand for food was increasing for both volume and quality.

The advent of the railways in the 1830s provided the farmer with the first new solution since the invention of the wheel for the old problem of taking production to market. Livestock could be moved without the loss of weight, or 'condition', which results from being driven long distances along rough roads. Farmers certainly saved money by using the railways, but there was more to it than that. Cheaper and more reliable transportation allowed farmers to bring inputs, such as lime, to their farms much more cheaply, and to change their mix of outputs to maximize their comparative advantage. Landowners were not

slow to notice the cost-savings their tenants were achieving, and so rents went up, as we show below.

Productivity increased over this time, as others have noted, and by the 1840s it is possible that agriculture was as efficient as it could be, given the technology of the time. Some reformers, such as the Anti-Corn Law League, certainly thought as much. As the new tool of political economy spread, the claim that the Corn Laws were needed to ensure a domestic food supply became was analyzed and found wanting. The end of the Corn Laws as a trading regulation was in sight. Yet this was not how matters appeared to that unlikely political activist, the tenant farmer. To him, as to much of rural society, the Corn Laws were an essential part of the fabric of the countryside.

Tenant farmers did not write very much, and anecdotal evidence of their activities is slim. An absence of records does not mean inactivity, and as this research shows, tenant farmers took a surprisingly pro-active role, especially during the period of crisis over the Repeal of the Corn Laws in the mid-1840s. Impatient with the reluctance of landowners to take any political action, tenant farmers forced the resignation of several sitting Members of Parliament.

## **Research goals**

This research looks at the activities of tenant farmers in the early Victorian era with these two primary goals:

1. First, to determine whether agricultural rents set in accordance with Ricardian Rent Theory (RRT). This is important because tenurial arrangements were also changing, from the customary long lease to a shorter market-oriented rack rent. Simultaneously, productivity was increasing. Chapter 2 and 3 examine whether rents were set in accordance with RRT, and then discuss the finding in the framework of the co-evolution of productivity and tenurial change;
2. Second, to determine whether tenant farmer pressure groups had a measureable impact on the outcome of the Repeal of the Corn Laws Third Reading in May 1846. The traditional view of the well-known split within the Conservative Party which resulted from the Corn Laws Crisis of 1846 is that a reactionary backbench of Tory squires failed to keep up with the times. In fact, as we show below, Conservative MPs were being strongly ‘encouraged’ to vote against Repeal by tenant farmers. The goal is to quantify that encouragement, and measure its effect on voting outcomes.

## **Outline of the chapters**

The two research questions are examined and tested in three chapters, each of which has the tenant farmer as its focus. The three chapters are: the transfer of the Ricardian surplus in early Victorian Britain; the railways and agricultural rents; and the agricultural interest and Repeal of the Corn Laws. Each chapter is described in outline below.

### *Rent-setting in early Victorian Britain*

During the 18<sup>th</sup> century, the ‘yeoman’ farmer who owned the land he farmed had given way to the tenant farmer. The engrossment of open-field and common land, notably the ‘Parliamentary’ enclosures, resulted in a concentration of landownership (Turner 1980; Allen 1992; Chapman and Seeliger 2001; Clay 1968) and by the early years of the 19<sup>th</sup> century nearly 90 per cent of farmers were tenants (Offer 1991). The type of tenancy agreement that the tenant held with his landowner varied widely (Turner, Beckett and Afton 1997). Some tenants still held leases measured in ‘lives’, while others, even on the same estate, might be subject to a rack rent (Mingay 1994). The price rises of the French Wars (1792-1815) presented those tenants who were still holding long ‘customary’ leases with a windfall in which their landowners

could not share. The response of landowners was to alter their leasing arrangements as quickly as they could, and annual tenancies were the norm by the 1820s. Under annual tenancies, rents were renegotiated at least annually, and were supposedly set at market rates (Clark 2002). This arrangement made sense for both tenant and landowner, neither of whom wished to be locked into long fixed tenancies at a time of price volatility.

The analysis of agricultural rents for this period has until recently been problematic, because no central repository of agricultural accounts exists. Recently, two attempts have been made to construct a rent index. Turner, Beckett and Afton (1997) have built a rent index for the years from 1690 to 1914, using records from estates. Gregory Clark's index (2002) has more observations, but pertains to land owned by charities rather than estates. Clark's index shows higher land rental values before 1820, compared to the results of Turner, Beckett and Afton. Clark argues that this shows higher productivity before 1800, but his view is at odds with other evidence of productivity.

While both tenant and landowner might have wished to set rents to match market conditions, whether or not they were able to achieve this goal is another matter. Contemporaries who wrote on this topic, such as James Caird, thought that landowners were 'under-renting' or letting out their lands too cheaply (Caird 1851). The reasons for the alleged under-renting by the



landowner include the very human 'desire for false magnificence' as derided by Arthur Young; the wish to influence the voting behavior of his tenantry; or more charitably, a lack of information. At a time when the theory of land economics was not well known, and when knowledge of prices and conditions elsewhere travelled slowly, it is hardly surprising that many landowners took the default position of setting their rents to match those of their neighbors.

The closeness of agricultural rents to market conditions is of interest because the change in tenure from long 'customary' leases to rack rents was concurrent with an increase in agricultural productivity. During the first half of the 19<sup>th</sup> century, agricultural productivity apparently increased by perhaps 50 per cent. Robert Allen (2005), for example, finds that wheat yields increased from 20 bushels an acre in 1800 to 28 bushels an acre in 1850. Pastoral yields increased similarly. Other writers, such as Mark Overton (1996) and Liam Brunt (2004) agree. Michael Turner and his co-authors note that there was a large increase, but observe that the harvests at the end of the 18<sup>th</sup> century were poor, and so the increase was built on a low base (Turner, Beckett and Afton 2001). Conventional explanations for the increase include the greater use of fertilizers, the enclosure of open fields and common lands, and the protection provided to wheat farmers through the Corn Laws, but perhaps it was the possibility of extracting a greater share of the Ricardian surplus that drove them. It is plausible that by extracting a greater share of the Ricardian surplus, landowners forced their tenants to produce more in order to pay their

higher rents. It is therefore important to test whether rents were set according to market conditions.

Three different tests of the relationship between recorded agricultural rents, yields, and exogenous variables are undertaken. To conduct the tests, a unique database has been constructed by the author based on the 1836 Tithe Commutation Commission Files (Kain and Prince 1985). The entities of interest are nearly 600 parishes in eight counties in the southwest of England, selected because of the consistency of their data. The agricultural production information contained in the files relating to the parishes has been integrated with geospatial data so that soil, price and climatic information can be included in the observations. The first test is a Von Thunen-style ‘distance decay’ test for pastoral rents. Pastoral rents are regressed against pastoral yields, costs, and distance to London for 131 parishes in Devon.

The second and third tests make use of the hedonic model developed by Mendelsohn et al. (1994) to test for the effect on agriculture of climate change. Further work in this field is by Maddison (2000), for example, who analyses contemporary agricultural land values in England and Wales using hedonic methods. Kabubo-Mariara and Faranja (2007) use a Ricardian model to analyze the impact of climate change in Kenya. The approach taken here works in the opposite direction. The authors cited above know the land valuation and some of the exogenous variables which explain the values, and

their object is to predict changes in values based on climate change. By contrast, the goal in this chapter is to find out whether historical land values can be explained by climate and other exogenous variables.

The second test concerns the possible demand by tenants for risk compensation when negotiating for land known to be climatically 'risky'. Too much or too little rainfall in July is particularly risky for arable farmers (Brunt 2004) because of the extra expenses for harvesting a wet crop in August and the risk of fungal diseases such as rust. The risk averse farmer is expected to negotiate rents downwards in parishes with a high volatility of rainfall in July, because he prefers a certainty equivalent in his 'gamble'. The findings show that this is what happened: rents were negotiated downwards in response to yield risk. David Stead (2004) suggests that landowners developed the fixed rent contract system so that the risk inherent in agriculture was passed on to the tenant. The result found in this chapter shows that Stead's claim might still be correct, but that the tenant also demanded compensation for taking on that risk.

The third test concerns the auctioning of agricultural leases. We know that some leases were auctioned in Devon and also possibly Cornwall (Turner, Beckett and Afton 1997; Vancouver 1813; Tanner 1848). The auction method is the closest realization of the theoretical 'equilibration' of rents with land qualities proposed by Ricardian rent theory. If rents outside Devon and

Cornwall were significantly lower than the rents for comparable land in Devon and Cornwall, then it is plausible that rents outside Devon and Cornwall were not being set competitively.

The findings are that rents in the southwest of England were being set competitively and according to Ricardian rent theory. The chapter ends with a claim that this finding can be extended to the rest of England, and as a result landowners were receiving a consistent share of the Ricardian surplus...

### *The development of the railways and agricultural rents*

The third chapter continues the discussion of agricultural rent and the transfer of the Ricardian surplus. The railways were constructed from 1832 onwards, with the main network complete by about 1870 (Turnock 1998; Cain 1991). The railways were a new technology whose routing was entirely independent of agriculture. The accessibility of railways to a farmer was in the form of a natural experiment: by chance some farmers had access to the railways, while others did not. Those farmers who did have access made considerable use of the railways for the transport of stock, saving considerable sums compared to the ancient alternative of droving to market by road (Hawke 1970). The question of interest is whether agricultural rents rose with

accessibility to railway track, as Ricardian Rent Theory would suggest. The farmer who uses the railway is saving money, and so in a competitive rental market these savings should theoretically be transferred to the landowner (Alonso 1964; Kellerman 1989).

To test the theory, records of the annual rents per acre for 31 estates have been collected for the period 1832-1865. The records come from the work of Turner, Beckett and Afton (1997). The estates are distributed quasi-randomly around England. The annual observations for each estate have been integrated with price data from Gregory Clark (2004), elevation and climate data. Using old railway maps, a measure, calculated annually, of the availability of railway track to each estate has been obtained. The measure of access to railway track is the total number of kilometers of track within 40 kilometers of the estate... Using a panel-data formulation of the Ricardian model (Massetti and Mendelsohn 2012) the results show that rents did indeed increase with the availability of railway track.

The increase in rent represents a saving in cost which the tenant is transferring to the landowner. Using the 31 estates as a sample, it is possible to calculate the savings of agricultural freight by rail at the national level. The savings are calculated as the amount of money saved divided by the GDP. As a proportion of GDP for 1865, the savings were of the order of 1.1 per cent, rather more than the amount found by Gary Hawke (1970) using cost-benefit

methods. A further step is to split the social savings into those due to reduction in cost of transport, and those due to more efficient farming as a result of access to railway track. The split shows that the wealth creation from production changes are approximately five times the savings from transport alone, vindicating those agricultural historians, such as Orwin and Whetham (1964) who claimed that the railways made profound changes to rural economic life.

### *The agricultural interest and Repeal of the Corn Laws*

The fourth chapter is more ‘political’ in nature and is concerned with the valiant but ultimately unsuccessful attempt by tenant farmers to retain agricultural protection, specifically the tariff protection provided by the Corn Laws. Tenant farmers had received the franchise through the Chandos Clause of the 1832 Reform Act, and were in most cases willing to follow the lead of their landowners when voting (Gash 1953). In some rural constituencies, tenant farmers made up 30 per cent of the electorate, an influential percentage (Crosby 1977). During the Corn Laws Crisis in the 1840s over the removal of agricultural protection from domestic wheat markets, tenant farmers became rather less supine because their own interests were being directly threatened. In response to the threat, they mobilized and formed their own rural

protectionist societies to protest Sir Robert Peel's decision to repeal the Corn Laws (Adelman 1989; Crosby 1977). In these actions they were far ahead of their landowners, the class from which they would usually expect leadership. As the fourth chapter shows, tenant farmers managed to force a number of sitting free-trading Members of Parliament to resign their seats, and protectionists were elected in their stead (Ramsden 1998).

The Repeal of the Corn Laws in 1846 has attracted a large volume of research, for two main reasons. First, as McLean and Bustani (1999) point out, none of the mainstream theories of political action can explain why a Parliament of landowners, whose median member was a landowner, and at least to some extent dependent on agricultural rents, should have voted for Repeal. Second, Repeal represents Britain's move towards free trade, a step beyond mercantilist attitudes. Researchers are divided into those who favor a public choice approach (such as Cheryl Schonhardt-Bailey) and those who allow Sir Robert Peel a greater role (such as Ian McLean and Jonathan McKeown). Cheryl Schonhardt-Bailey has made many contributions to the debate, developing interesting variables and techniques for her statistical analyses. For example, she develops an index of constituency economic diversification (Schonhardt-Bailey 1994). Elsewhere, she uses content analysis to quantify statements in the newspapers of the time. McLean develops a 'heresthetic' approach, and wishes to show that Peel was a politician able to craft a coalition in remarkable circumstances (1999). Jonathan McKeown

(1989) describes the various approaches taken by others in careful detail before making his own statistical analysis. In the end, his conclusion is closer to that of McLean than Schonhardt-Bailey, in that individuals had a role to play which was at least as important as constituency interests.

In this chapter, we develop a measure of the dependency of each political constituency on the flows of wheat, both positive (a wheat-exporting constituency) and negative (a wheat-importing constituency). Previous analyses have included wheat, but only for the acreage grown within the county. The measure we develop is qualitatively different because it is based on production and consumption, and not acreage grown. In addition, the wheat-flow measure can be observed at the constituency level with the use of GIS.

A roll-call analysis of voting on both the Third Reading of Repeal in May 1846 and the Villiers Motion of the preceding year, using the wheat-flow and other variables, reveals the sharp shift in sentiment among Members of Parliament (MPs) over the removal of protection. The analysis shows that for Repeal, MPs voted closely in accordance with the interests of their constituencies. The greater the constituency's dependency on wheat exports, then the greater the probability that its MP would vote against Repeal. The opposite is also true. MPs from constituencies which had to import wheat, or whose agriculture was based on pastoral production, were more likely to vote for Repeal. This is a qualitatively different result from that obtained from the



analysis of the Villiers' vote of the preceding year, where constituency interests were not so strong. It is evident that over the intervening year, Conservative support for the continuation of protection weakened as some MPs, notably those who had served in the government, decided to vote for Repeal. As we show, those MPs who voted against Repeal were the subject of pressure from tenant protection societies in their constituencies. The argument is that the sharply increased pressure from tenant farmers on one hand, and a desire to support the government on the other hand, caused the fracture within the Conservative Party to occur where it did. In summary, had the tenant farmers taken no action, then the number of 'Peelites' would have been rather more.

## Chapter 2. Rent-setting in early Victorian Britain

During the first half of the century, both pastoral and arable output increased by nearly fifty per cent, a large rise by any standards (Turner, Beckett and Afton 2001; Allen 2005). An output increase within a closed system would normally lead to a decline in commodity prices, but in Britain the higher output was more than matched by increased consumption. As a result, the value of agricultural production grew from £75.5 million in 1801 to £106.5 million by 1851 (Deane and Cole 1980; Kelly and O'Grada 2012 for an interesting discussion of calories per capita). The two parts of the relationship between agricultural production and tenurial change have been examined separately in recent work. Explanations for the rise in agricultural production in the first half of the 19<sup>th</sup> century are contained in recent work by Robert Allen (2005), Stephen Broadberry et al. (2011), reviewed in Kelly and O'Grada (2012), Turner, Beckett and Afton (2001), and Allen (1982). On the rents side, two separate indices are now available. Gregory Clark has compiled a rent index using rents and prices of land held by charities, and Michael Turner and his co-authors do the same using records from large estates (Clark 2002; Turner, Beckett, and Afton 1997). Despite this work, there has been no attempt, as far as the author is aware, to test whether early Victorian landowners were receiving at least a consistent share of the surplus. If they

were, this would go some way towards explaining the growth in productivity from an institutional perspective.

Writers in the 18<sup>th</sup> century certainly doubted that landowners were extracting the Ricardian surplus. Describing Somerset in 1796 for the Board of Agriculture, John Billingsley wrote that, “Some gentlemen, from the best of motives, have been in the habit of letting their estates at the old rents, though the price of articles of produce has, in the course of thirty years, advanced one third at least. ... I have invariably found lands so occupied in a much worse state than those of neighboring farmers moderately motivated”. Arthur Young derided landowners for preferring ‘an extra-low bow and scrape’ to an additional five shillings an acre per annum. More recent writers have also suggested that landowners failed to extract the maximum rent possible because they rather enjoyed being the landlord equivalent of Lady Bountiful. Gordon Mingay notes that the greatest landowners “thought it below their dignity to see the highest return the land could be made to produce” because “works of charity were incumbent on their elevated social position and income” (Mingay 1994, p. 29).

Even as Billingsley and Young were writing, the institutional arrangements of land tenure were changing, quickening under the pressure of the price rises brought about by the French Wars. As we show below, tenure shifted from long ‘customary’ leases to shorter arrangements based on rack

rents, supposedly set to market conditions. As a first step in examining the possible co-evolution between tenure change and the productivity increases desired by contemporary writers, this chapter tests whether early Victorian agricultural rents were set according to Ricardian rent theory (RRT). According to RRT, the Ricardian surplus is transferred to the landowner as rent, leaving the tenant with at least enough to service his capital and sustain his family and himself.

This chapter makes several contributions. We estimate land rents set almost two centuries ago as part of a test for the transfer of the Ricardian surplus, in the tradition of Allen (1982 and 1992) and O'Rourke (1997). Here we use GIS methods to construct a spatial dataset which includes hedonic characteristics. We incorporate historical agricultural data into observations for spatial land characteristics, such as climate and soil information (Knowles 2002). The spatial dataset allows the use of novel data analysis techniques to estimate market rents using three separate approaches.

To test whether observed rents diverged from the 'correct' rents predicted by Ricardian Rent Theory (RRT), we use a sample of nearly six hundred parishes in the southwest of England. The sample is taken from the 1836 Tithe Commutation files, a source that is well-known but which has not previously used in this fashion (Cox and Dittmer 1965; Kain and Prince 1985)<sup>1</sup>. Three

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<sup>1</sup> See Appendix: Data Sources on page 191 paragraph 1 for a full description

tests are used to ascertain whether rents were set in accordance with Ricardian rent theory (RRT).

The first test is a Von Thunen-style 'distance decay' test for pastoral rents. Devon exported livestock eastwards towards the London market, and the tithe files for Devon are unusual in providing both pastoral rents and pasture yields. Pasture yields are presented in shillings in the tithe files. It is not clear how the Assistant Tithe Commissioner who recorded the yields in money terms arrived at these figures. A regression of pastoral rents on yields, costs, and distance to the final market in London should produce an estimate with a high coefficient of determination if pastoral rents were set according to RRT.

The second test is for the level of compensation demanded by tenant farmers for taking on risky land. Farmers lack capital, and are therefore expected to demand a risk premium for taking on a tenancy in an area known for climatic risk. If the rent had already been adjusted downwards to incorporate yield risk, then the variables reflecting yield risks will be statistically significant factors in predicting arable rents.

The third test involves the leasing out of agricultural land by auction. Open bidding by prospective tenants for agricultural land was, according to documentary evidence, customary in Devon, and the auction process should, according to theory, transfer the Ricardian surplus to the landowner. If rents

outside Devon were not being set according to RRT, then they will be lower than those for Devon.

The findings from the three tests show that rents were set closely to their hedonic properties, including the reduction of rents in response to yield risk. There is some evidence that landowners who auctioned agricultural leases retained more of the surplus, but this is not conclusive. In any case, it is possible that prospective tenants bid high in the expectation of higher prices to come. However, the observed rents used in the analysis refer to the period 1829-35, which was a time of agricultural depression. Prospective tenants are unlikely to have bid high into a falling market because they could not have predicted the upturn which occurred at the end of the decade. In this chapter, agricultural production is first described in order to set the scene for the three tests. An outline of the changing business relationship between landowners and their tenants follows, in particular the transition from the customary lease to the fixed-rent lease, set at a 'rack rate'. Data from the 1836 Tithe Commutation Files forms the core of the dataset used in the three tests, and so tithes and their history are reviewed. An outline of agricultural location theory introduces a section on the methods used for the three tests. The three tests are conducted, and then discussed especially with reference to the implications for productivity. A conclusion ends the chapter.

## Agricultural production in the 1830s

A well-known map drawn by James Caird in 1851 shows Britain divided vertically into a grain-growing east and a pastoral west (Caird 1851). The eastern counties, whose fertile soil and relatively flat terrain provided high yields of grain, produced more wheat than they consumed. By contrast, the livestock areas in the west were deficient in wheat, and so brought in wheat from surplus counties. Transport costs meant that the local price of wheat depended on distance from the wheat-surplus counties in the east.

From records published in the *London Gazette*, it is possible to determine the volume and prices of wheat and barley sold at market towns<sup>2</sup>. Figure 1 shows a surface constructed from the volumes of wheat sold on 29 September 1829 based on the records for 64 market towns. The market towns are indicated on the figure. The greatest volume was in the eastern counties, as millers and corn factors bought wheat at wholesale to be moved west for sale at a more retail level. The high volume around the port of Liverpool in the north-west is due to the importation of wheat from Ireland, then part of the United Kingdom.

The area of interest in this chapter is the southwest, indicated in the right-hand panel of figure 1. The volume of wheat sold in the southwest was

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<sup>2</sup> Details of the *London Gazette* are in the Appendix: Data Sources on page 191 paragraph 5.

small because the region was primarily involved in the raising and exporting of livestock eastward towards London. Unfortunately there was no market town on the extreme western tip of Cornwall and so it is not possible to calculate grain prices and volumes for this small area.

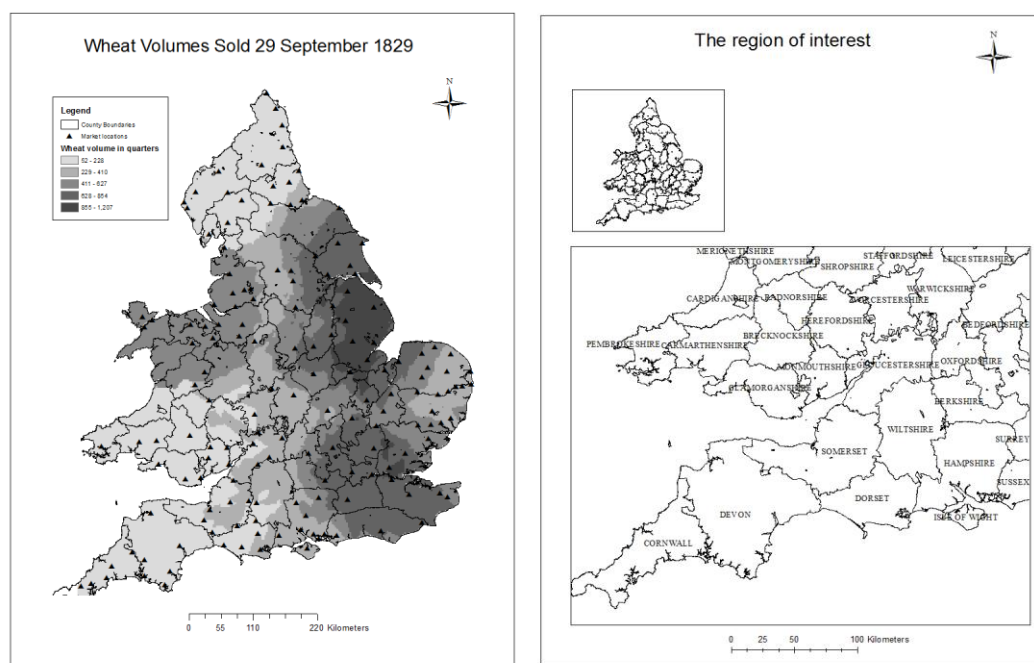


Figure 1. Localized wheat volumes and the region of interest.

(Source: London Gazette, 29 September 1829. See Appendix: Data Sources page 191 paragraph 5)

A similar surface-creation process was used to calculate farm-gate prices for wheat and barley, and these are used in the Empirical Section below. Wheat was cheapest where it was mostly grown, in the east of England. The most



expensive wheat was in the industrializing midlands and in some regions of the livestock-producing southwest, where local wheat production fell well below demand. In the southwest, the climate and terrain favored pastoral production, and only a small amount of wheat was grown. As a result, wheat prices were higher in the southwest than in the eastern counties.

A different technique, based on estimates of yield, acreage and population, is used in Chapter 4 to show the flow of wheat within Britain. The results are very similar.

### *Dominance of the London market*

Early Victorian London contained 14 per cent of the British population, and its market power set the reference prices for agricultural commodities. London's wealth attracted a flow of livestock, driven by road towards London (Blackman 1975; Haldane 1952; Hallas 1986) from the livestock breeding areas in the southwest, Wales, and Scotland. Beef from Scotland was prized in London, where steak-houses specializing in Scottish beef remain to this day. One reason for the preference was that Scottish beef animals were raised for consumption, and did no draught work during their lives. Their meat was, apparently, more palatable (Trow-Smith 1967).

## *The southwest*

Our particular region of interest consists of those eight counties in the southwest of England for which suitable data are available from the 1836 Tithe Commutation Commission Files<sup>3</sup>. These are Cornwall, Devon, Dorset, Somerset, Wiltshire, Gloucestershire, Herefordshire and Shropshire. The observations which we analyze below are based on data collected for nearly six hundred parishes within the eight counties. The distribution of the parishes within their counties is shown in figure 2 below.

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<sup>3</sup> Source referenced in full in the Appendix: Data Sources on page 191 paragraph 1

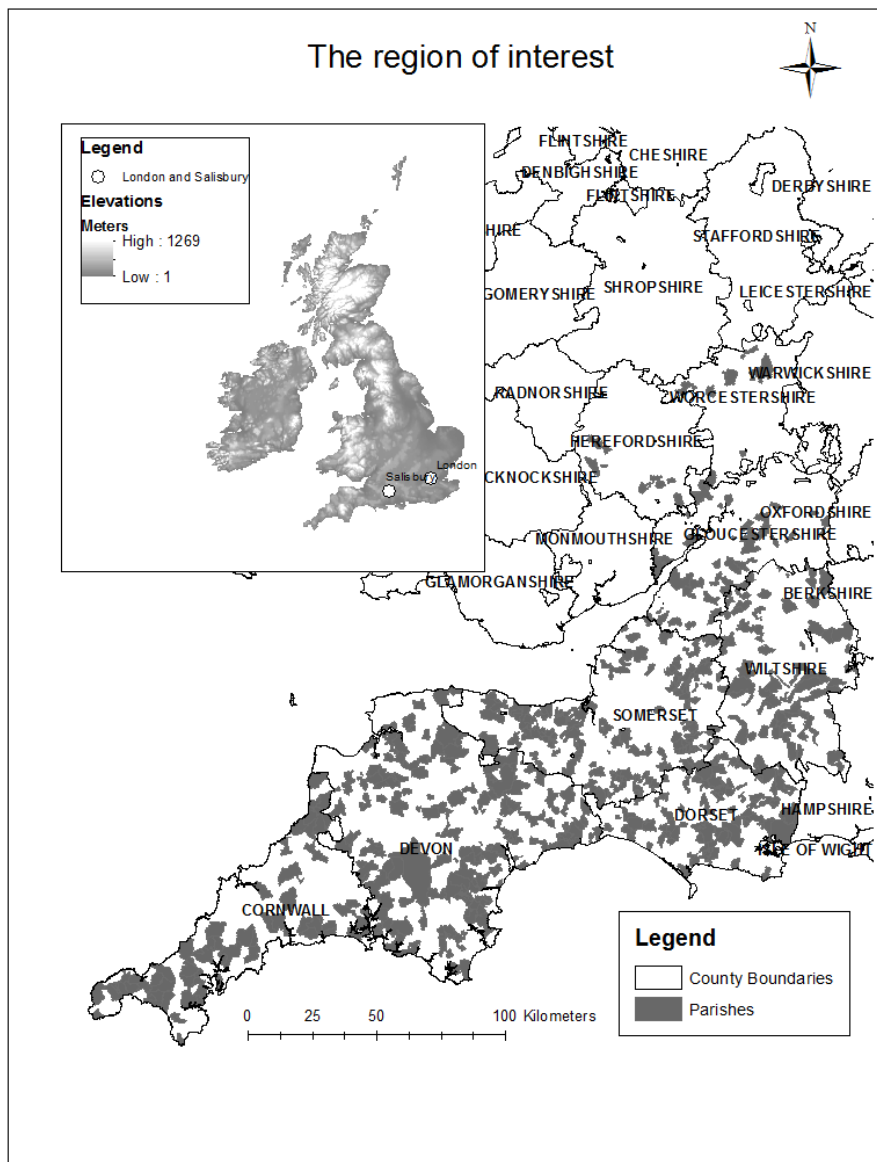


Figure 2. The parishes within the region of interest.

(Source: 1836 Tithe Commission Files; GIS of Ancient Parishes. The two sources are fully described and sourced in the Appendix: Data Sources on page 191, paragraphs 1 and 2.)

The southwest was primarily a livestock breeding area, and both meat and wool were exported by an intricate system of local markets. Before the railway reached the southwest in the 1840s, cattle and sheep were driven east towards London, changing hands along the way at enormous livestock fairs held in Salisbury and other historic locations en-route. Dairy products such as cheese were also an important commodity, and cheese from Wiltshire sold for a good price in London. The share of arable cultivation increased with movement east towards London, accompanied by an increase in farm size. Below we describe the relevant agricultural characteristics for Cornwall, Devon, Dorset and Wiltshire, the counties with greatest representation in the sample.

Land ownership in Cornwall, the westernmost county, was dominated by the Duchy of Cornwall, which owned more than 12,000 acres. No Cornish land was enclosed under the ‘parliamentary enclosures’ which were proceeding at the time (Turner, Beckett and Afton 2001) and the remaining farms were small. It is probable that the west of England had been enclosed for several centuries (Gray 1915). Economic development seems to have been slow until the 19<sup>th</sup> century, a report from as late as 1789 describing Cornish villages as being built entirely of mud (Armstrong and Huzel 1989). Despite their distance from centers of agricultural innovation, poor soils, and a windy and wet climate, Cornish farmers adopted arable techniques suitable for their own particular conditions, particularly when these increased livestock yields. Turnips, an innovation from the light soils found in Norfolk, were grown in Cornwall’s

sandy soils as winter -feed for livestock. Cornish farmers also adopted the 'pig and potato' combination, in which the potato was the main crop, but pigs were fed on the scraps and waste production. Potato production grew to such an extent that by 1846, more than 12,000 bushels a year were being sent to markets in the east (Brown and Beecham 1989). There was demand for non-agricultural labor, which raised on-farm wage rates as well as allowing Cornish farmers to supplement their agricultural income by working off the land when necessary (Orwin and Whetham 1964). Both mining and fishing work was available; central Cornwall has deposits of lead, copper, zinc and tin, and a high ratio of coastline to total area. As a result, agricultural wage rates in Cornwall were slightly higher than those in Devon (John 1989).

Devon, the county to the east of Cornwall, was noted for its small fields and length of hedges. In 1844, an area of less than forty thousand acres in south Devon was divided into nearly eight thousand fields. Devon specialized in livestock, perhaps because of a lack of an alternative. Cattle-breeding was of primary importance in the north of the county, most of the production being sold on to markets to the east. Graziers in the adjoining county to the east, Somerset, were the main customers. A chain of selling and droving of cattle had developed by the 19<sup>th</sup> century, Devon being an important point of origin for the droving links to final markets in London. Cattle-breeding developed to such an extent that fodder for winter feeding was in short supply. As a result, pasture and meadow rents began to rise.

By the 19<sup>th</sup> century Devon had also become an important maker of woolen cloth in England. Dartmoor, the large heathland at a relatively high altitude in the southwest of the county, was used for sheep pasturage, and flocks as large as 2,000 were summered there. Aside from livestock, Devon produced crops such as grains, apples, hops and timber. Wheat was the most important grain, but yields were low at only 75 per cent of the national average. Soil and climate no doubt explain some of the poor performance, but backward agricultural practice may also have been to blame. Devon farmers were still using a rotation in which three grains crops were sown in succession, without the intervention of a fallow crop (Thirsk 1989).

Dorset, to the east of Devon, was an important county for the raising of sheep for their wool. The variety of sheep known as the 'Dorset Horn' came, at least nominally, from this county. The fleece was close and heavy, and the breed is considered one of the best of the old horned varieties (Trow-Smith 1967). Arable farmers were aware of the value of sheep manure, and in 1790 arable farmers were reported to be paying flockmasters considerable sums to have flocks folded on their land. As in Cornwall, Dorset cottagers practiced 'pig and potato' husbandry. Dorset butter was supposedly of high quality, and was sent to markets in the east.

Wiltshire, to the north-east of Dorset and hence closer to London, is an interesting mixture of arable and pastoral farming. The soil in the county

divides into chalk and clay, and agricultural production was arable on the chalk and dairy on the clay. The division was so fine that farmers within the county exhibited exactly opposing attitudes towards the threat of loss of protection from removal of the Corn Laws in 1846 (Randall and Newman 1995). Average farm size also defined the division between 'chalk and cheese'. Pastoral farms were, as in counties to the west of Wiltshire, small. By comparison, arable farms were much larger, some of 1,000 acres or more (Prince 1989). Arable production, especially wheat, was a greater component of agricultural output in Wiltshire, compared with the counties to the west. As a result, Wiltshire was at least self-sufficient in wheat and possibly a net exporter.

## **Landowners and their tenants**

By the end of the 18<sup>th</sup> century, the yeoman, cultivating his own land, had largely disappeared as a result of 'enclosure' or the engrossment of land into large estates, thousands of acres in size (Allen 1992; Turner 1980). A small number of customary leaseholders remained, and the result was a confused patchwork of tenurial systems. As Gregory Clark writes, "land was held on a bewildering variety of tenures --- customary leases well below market values, leases for 'lives' where the current rent has little relation to current market conditions, renewable leases with low annual rents but large entry fines and so

on” (Clark 2002). Contemporaries blamed landowners for the lack of tenurial rigor, as we noted in the Introduction.

As prices rose during the French Wars, those landowners who could do so adjusted their leasing arrangements, replacing the customary lease with an annual tenancy based on a rack rent. Rack rents called for the payment of a rent, usually paid at least annually, which theoretically might change from year to year (Mingay 1994). Everywhere landowners shifted into rack renting as price rises reduced the share of the Ricardian surplus enjoyed by the landowner (Turner, Beckett and Afton 1997). By the 1830s, about ninety per cent of Victorian farmers were tenants, paying a fixed contractual rent to their landowner (Offer 1991).

Some landowners provided leases, while others let out their land to tenants ‘at will’ (Habakkuk 1994). Despite the apparent insecurity, it was not unusual for tenants to remain on the same farm for many years, as Susanna Wade Martins (1980) shows in her study of the famous Holkham Hall in Norfolk. This might in part have been because there was a convention that the rent of a sitting tenant was not raised during his tenancy (Habakkuk 1994). Certainly the transaction costs involved in a move were high for both sides. Tenants had invested time and money in working their land, which they knew intimately, while the landowner faced the cost of negotiating a new lease with a fresh tenant (Stead 2004).



Although leases were shorter, the problem of how to set the rents remained. The default was to observe neighboring rents, as described by Cooke and Griffiths in 1850: “Practically, rent is in England usually fixed by comparison with the adjoining land, or by the common rate of the neighborhood”. Some of the more substantial landowners sought advice from their staff on rents and abatements, and as the management of estates became more professional, full-time agents and bailiffs began to be employed. The Duke of Northumberland engaged a surveyor and valuer, and any tenant could have his farm revalued and a new rent fixed (Thompson 1963).

The competition for land that underlies Ricardian rent theory requires that prospective tenants ‘bid away’ the Ricardian surplus that they expect a particular parcel of land to provide, leaving the winning tenant with only ‘normal profits’. This mechanism requires that there be at least two prospective tenants, and that the landowner leases the land to the highest bidder. It is not clear whether either of these two conditions was met in the first half of the nineteenth century, perhaps because the most desirable tenants, those with capital and experience, were in short supply. Records of the offers made by tenants are rare, and those that do survive indicate that they were kept only because the number of prospective tenants was unusually high (Stead 2005).

Under the fixed contract system under which most land was now held, the tenant has taken on the risk inherent in farming, while the landowner

enjoys a fixed rental income. The tenant might be expected to adopt a risk management strategy, such as diversifying his output to spread the risk, storing output, running rent arrears with his landowner, or negotiating a risk premium into his rent. There is plenty of evidence for this amongst peasant-farming populations, as Moscardi and de Janvry (1977) show. Present-day solutions to this problem, such as hedging or crop insurance, had not yet been developed in Britain in the 1830s. Insurance against damage from hailstorms began in 1842, shortly after our time-period, and seems to have been taken up mostly by wealthy arable farms in the eastern counties (Stead 2004). The theoretical section below discusses the possibility that a tenant demanded compensation for yield risk.

The rent-setting method that most closely replicates the Ricardian mechanism is an auction in which bidders have knowledge of the bids of their competitors. Some agricultural land was leased out in this way, certainly in Devon and perhaps also Cornwall (Turner, Beckett and Afton 1997). The auction process in Devon is described in detail by Vancouver in 1813 in a report for the Board of Agriculture (Vancouver 1813). The auction, called by Vancouver a ‘survey’, was held in a public house, and the bidding was open. Vancouver notes that “no preference beyond that which arises from the highest offer” was shown. Some years after Vancouver’s description of auctions in Devon, Henry Tanner wrote a prize essay for the Royal Agricultural Society of England on farming in the county. In his section on the management of landed

property, Tanner writes that covenants which restrict farming operations hinder progress but that “a still greater evil” is the practice of “letting land to the highest bidder” (Tanner 1848, p. 487). Both Vancouver and Tanner make a point of observing that the land was let to the highest bidder, which implies that in Devon the bulk of the Ricardian surplus was likely being transferred to the landowner. In the ‘auction test’ below, rents of land let out at auction are compared with those apparently not let out by the auction process. If rents for auctioned land are significantly higher than those set elsewhere, then this indicates that the non-auctioning landowners were leaving their tenants with more of the Ricardian surplus than their auctioning counterparts.

Ricardian rent theory assumes that landowners wish only to gain the maximum rental income for their land. It is possible that some prudent landowners are willing to give up some of their share of the Ricardian surplus in exchange for a higher standard of cultivation. Covenants specifying the type of cultivation that a tenant could undertake were common, but it appears that they were not uniformly enforced. Some landowners wrote detailed covenants into their leases and then failed to enforce them, while others allowed experienced farmers more leeway. Unfortunately, the tithe files are silent on covenants, and it is not possible to quantify their effect on rents.

It is however possible to include the landowner side of the rent negotiations by considering the effects of enclosure, especially during the

‘Parliamentary’ period of 1793-1815. During those years, the number of Acts which enabled enclosures to take place reached high levels as agriculture attempted to produce more output during the French Wars (Turner 1980). At the time, enclosure of common and ‘waste’ land was seen as a way to increase productivity, and also to earn a greater income from the high wartime prices. Enclosure was expensive and therefore landowners are likely to charge a higher rent to recoup their expenditures. Higher rents on enclosed lands are likely to lead to higher rents nearby, even on unenclosed land, as the smaller landowners emulate landowners on larger estates. As we will discuss below, we include the percentage of the county whose common and waste land was enclosed during the period 1793-1815 in the estimation of arable rents.

## **The tithe system**

Farmers were required to pay both their fixed rent and an annual tithe of ten per cent of their production of major crops, such as livestock and grain, to the beneficial owner of the tithe (Kain and Prince 1985; Baker 1993; Evans 1976). The beneficial owner was frequently a local clergyman, and farmers resented their obligation to pay the tithe, especially during the agriculturally depressed and anti-clerical atmosphere of the 1830s (Evans 1976). Resentment against the tithes was high because of the high rate of

absenteeism among the clergy, who would often live in the town and ride out only on Sundays to their parishes. Interestingly, disputes were particularly bitter when the farmer was a Methodist (Evans 1975; Porter 1989).

As tensions grew between farmer and tithe-owner, the government encouraged landowners and tithe-owners to commute the tithe to a corn-rent. The commutation was based on the price of wheat during the period 1829-1835, the 'years of average' (Baker 1993). A Tithe Commutation Commission was established to survey land on which tithes were still payable, and to value the tithes. The commissioners who were sent out to do the survey work were apparently skilled and fair, and there seems to have been very little objection to the tithe valuations which resulted (Evans 1976; Kain 1984). The wealth of agricultural production data contained by the tithe commission's files is available as a result of the detailed work of Roger Kain and Hugh Prince (Kain and Prince 1985).

Although the tithe commission reported on parishes over all of England, the coverage of the west and southwest was particularly thorough. This is partly because the movement to 'enclose' or engross parcels of land into large estates was weak in the west and southwest, perhaps because of the remoteness of the region from political power in London. The process of enclosure nearly always included the extinguishing of tithes, usually in exchange for land. The slow progress of the enclosure movement in the west and southwest meant that tithes were still paid in many parishes, requiring the

attention of the tithe commissioners. The land whose rent and production data is used in the estimations below was therefore still titheable.

An interesting possible consequence of the commutation of tithes is that in some areas the replacement of the tithe by a corn-rent may have led to an increase in the amount of arable production. According to James Caird (1851), tithe commutation had encouraged pastoral farmers in Wiltshire to move into arable production, but the greater capital requirements for arable farming had caused some problems (Beckett 1989). Here Caird is suggesting that the burden of the tithe had previously discouraged farmers from planting wheat, and that even after paying the corn-rent, arable production was more profitable than livestock farming. The working capital difficulty that Caird mentions comes about because the grain harvest was sold only once a year, in contrast to the almost continuous sales of livestock. Caird's example, limited though it is, does suggest that tenant farmers were sensitive to changing market conditions and were flexible enough to change their output accordingly.

## **Theory of rent setting**

The aim of this chapter is to test whether rents in the southwest of England were set in accordance with Ricardian rent theory (RRT). The three tests comprise a 'distance decay' test for pastoral rents; a risk compensation

test, in which the tenant is expected to demand a risk premium in the form of a lower rent for taking on risky arable land; and a test for differences between auctioned leases and those set by other means. The work of J.H. Von Thunen and David Ricardo forms the core of agricultural location theory, and a description of their work begins the section.

### *Agricultural location theory*

The two names historically associated with the early development of agricultural location theory are those of David Ricardo and J.H. Von Thunen, both of whom were writing at the beginning of the 19<sup>th</sup> century. Von Thunen uses observations from his own farm to develop both a ‘distance’ theory and an ‘intensification’ theory (Kellerman 1989). In his distance theory, Von Thunen holds land quality constant on a ‘featureless plain’. If all land is equally fertile, then the only difference between parcels of land will be the cost of bringing production to market. At the market, the transportation cost will be zero, and therefore the farmer’s profits will be greatest. By contrast, at some point the distance from the market is so great that all receipts from sales of production are consumed by transportation charges. This is the margin of cultivation, where the farmer is indifferent between cultivating for the market and for his own consumption.

Figure 3 represents two crops, a and b. The price at the market, O, is given by the intercepts a and b. As the distance to market increases, transport costs rise and the surplus decreases. The points b1 and a1 are the limits for profitable cultivation of each crop. The cross-over between crops is represented by c. At point c, a and b would provide exactly the same surplus. The bid-rent curve is represented by the line from intercept b to the cross-over point, and then the line from the cross-over point to a1.

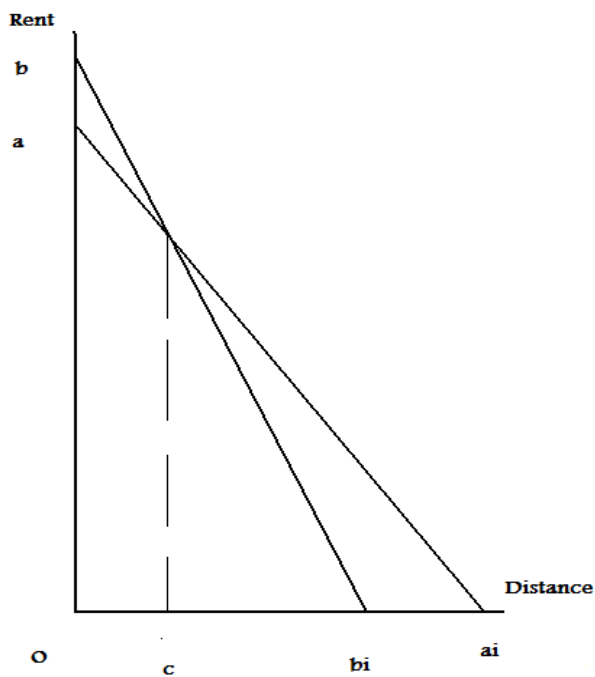


Figure 3. Bid-rent curve for two crops



Figure 3 shows, on the vertical axis, the relative value of parcels of farmland by distance from the market. Distance is represented on the horizontal axis. The figure indicates the rent that a parcel of land would attract in a perfectly competitive situation, where land is in fixed supply and there are several prospective tenants. A rent which is to the left of the curve leaves the tenant with a surplus, while paying a rent to the right of the curve means a loss to the tenant. Landowner and tenant negotiate from opposite positions, both attempting to retain surplus for themselves. The result is that rents are set along the curve. The landowner retains the surplus, while the tenant is left with ‘transfer earnings’ or just enough to subsist.

David Ricardo’s contribution was to see that any one parcel of land possesses its own hedonic qualities, such fertility, and that more productive land should therefore attract a higher rent. It follows that a change in the productivity of a particular parcel of land will affect its rent. For example, when land in West Lancashire was drained over the years 1650-1850, the rent increased because productivity improved as a result of the drainage (Gritt 2008).

More recently, Dunn has combined the yield of a parcel of land with its distance to market (Dunn 1954; Kellerman 1989). Dunn’s equation, with rent as a function of yield, cultivation costs and distance to market is

$$r_{ij} = y_i(p_i - c_i) - y_i f_i d_j \dots (1)$$

where  $i$  is a crop,  $j$  is a point,  $y$  is yield per acre,  $p$  is market price per unit of product,  $c$  is production cost per unit of product,  $f$  is transport cost per unit of product and  $d$  is the distance from point  $j$  to market. We expect the following results when the rent is being set in accordance with Dunn's equation:

$$\frac{\partial r}{\partial y} > 0, \frac{\partial r}{\partial c} < 0, \frac{\partial r}{\partial d} < 0$$

Below, we use Dunn's equation to test whether pastoral rents were set according to the theory described above. The method is first described in the methods section, and then tested in the empirical section.

### *Incorporation of a risk premium*

In equation 1 above, the rent is calculated based on a particular yield. This assumption is unrealistic because clearly the farmer can never be sure what the yield will be. A possible risk management strategy is to demand a risk premium in the form of a reduced rent to compensate for the riskiness of the land. The discussion of agricultural location theory is now extended to include a risk premium.

To simplify the presentation, the farm is located at the market. There are therefore no transportation costs, and the price is the farm-gate price. In this

discussion, the focus is on variations in yield as a result of weather and price risk is therefore not considered. The farm-gate price is assumed to be independent of the yield of any one farm.

Assume that the farmer produces only one output, and that the price for this output is fixed, and so we are dealing with yield uncertainty only. His net profit is given by  $\pi = \varepsilon y(p - c) - r$  where  $p$  is the price he expects to receive,  $y$  is the yield, and  $r$  is the rent he pays. The yield distribution is represented by  $\varepsilon$ , which has a mean of one and a finite variance. The farmer cannot know the size of  $\varepsilon$  for any particular harvest year, but he will be acquainted with its long-run variance.

Assuming that the farmer behaves in a way consistent with the expected utility hypothesis, then the farmer will maximize  $EU(\pi) = EU(p\varepsilon y - r)$ . However, given his lack of capital, we suggest that the farmer is risk averse. If he is risk averse, then  $U(E(\pi)) \succ E(U(\pi))$ .

Because he cannot achieve  $U(E(\pi))$  he requires some compensation for taking on the gamble which is implied by the variance of  $\varepsilon$ . The compensation that he requires is exactly enough to maintain his utility at  $E(U(\pi))$ . The farmer obtains that compensation by a reduction in rent because a reduction in rent increases his expected utility. The size of the compensation is the risk premium, or the amount of rent reduction that the farmer requires in exchange for taking on the risk yield.

In money terms, the amount of risk premium is equivalent to the difference between the expected yield multiplied by the commodity price less the compensation yield multiplied by the commodity price. The compensated yield is the certainty equivalent  $CE(y)$ . The meaning of the certainty equivalent is this. If the farmer was offered the same land but with no risk, then he would be prepared to pay a rent based on the certainty equivalent.

Continuing with the assumption that the farmer is risk averse, then it follows that observed rents will be negotiated downwards to accommodate the farmer's risk preferences. We test this proposition in the empirical section by including variables in the estimation of arable rent which reflect yield risks.

## *Auctions*

Equation 1 and the bid-rent curve in figure 3 present a scenario in which prospective tenants are in a continual process of bidding for land, each adjusting their bid by some fractional amount and enjoying full disclosure of the bids of their competitors. The auction is the practical application most likely to result in such a scenario. Contemporary writers drew particular attention to the custom of auctioning agricultural leases, indicating that they were a rarity. Auctions were apparently held in Devon, described in the

writings of Vancouver and Tanner cited above, but it is not known how widespread the custom was. With this caveat, a test for the effect of auctions in Devon is carried out in the empirical section.

If, as James Caird (1851) and others claimed, landowners were setting their rents too cheaply, then land leased out by auction will carry a higher rent than similar non-auctioned land. Because the auction process is transparent, bidding tenants are able to observe competing bids and respond with a higher bid as they wish. As they bid, the Ricardian surplus is transferred to the landowner who accepts the highest bid. It follows that an observed rent which is below that predicted by Equation 1 implies under-renting by the landowner. The tenant has received some of the Ricardian surplus which is theoretically due to the landowner. In the empirical section, geographically-weighted regression is used to identify those parts of our area of interest in which observed rents most closely matched predicted rents.

## **Data and methods**

Our primary source of data are the 1836 Tithe Commission Files (Kain and Prince 1985). The files are available as a spreadsheet, but with only a ‘district name’ as a spatial reference. There is no common key, and so the district name has been matched case-by-case to the ‘parish name’ in the *GIS of*

*Ancient Parishes*, a somewhat tedious process<sup>4</sup>. The matching provides a combination of the agricultural production data contained in the Atlas with other geo-spatial information, including climate data from the U.K. Meteorological Office, wheat and barley price data published in the *London Gazette* of 1829, soil data, distance and elevation data, occupational observations from the 1851 Census and local agricultural wage-rates. Given the geographic nature of the data, heteroskedasticity has been controlled for in the estimations.

The tithe files contain consistent arable rent, pasture rent and arable yield data for nearly six hundred parishes in eight counties in the west and southwest of England: Cornwall, Devon, Dorset, Somerset, Wiltshire, Herefordshire, Worcestershire and Gloucestershire. Rents and yields for arable land, and rents for pasture land are recorded separately by parish. Pasture yield data, measured in shillings and recorded by the Assistant Tithe Commissioner, are available for Devon alone. Representation by county appears in Table 1 below.

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<sup>4</sup> The Appendix: Data Sources page 191 paragraphs 1 and 2 contains full sources

County	Number of Parishes
Cornwall	67
Devon	160
Dorset	91
Gloucestershire	41
Herefordshire	10
Somerset	141
Wiltshire	75
Worcestershire	6
Total	591

Table 1. Tabulation by county of the parishes.

Data in the files was collected by at most two commissioners, who relied on evidence presented by parties with opposing interests, the landowner and the tithe-owner<sup>5</sup>. There is therefore the possibility of bias, as Jennifer Baker (1993) points out. A first step is to compare yields and rents for parishes within the tithe dataset with equivalent data from the nearest agricultural land not in the tithe dataset. This is completed at the beginning of the empirical section which follows this section. First, we describe the methodology that is used for the three tests.

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<sup>5</sup> Full sources are presented in the Appendix: Data Sources on page 191 paragraph 1.

### *Test 1: Pastoral rents test*

Of the observations in the tithe file, 131 parishes, all in the county of Devon, contain records for both pastoral rents and yields, both reported in shillings. Other parishes contain observations for pastoral rent, but not for yield. There is probably no material reason for this, perhaps an idiosyncrasy of the tithe commissioner involved. For Devon, the rents and yields are measured in shillings per acre. To proxy for cost, we use elevation, and for distance the Euclidian distance between the parish and London is included. Dunn's equation, described above, is used to estimate pastoral rents, using the logarithm of the pasture rent as the dependent variable.

The following equation represents Dunn's combination of Von Thunen's distance decay and Ricardo's land quality insights, and is based on Equation 1 above:

$$r = \beta_0 + \beta_1 Yield + \beta_2 Elev + \beta_3 Dist$$

Yield is expected to have a positive sign, while elevation and distance will have negative signs. If pastoral rents were being set in accordance with Ricardian rent theory, then this equation will explain a large proportion of the variance in pastoral rents.



## *Test 2: Testing for risk compensation*

The test for risk compensation is conducted on arable rents and yields using two different measures of yield risk. These are the variance of temperature in August and the coefficient of variation of the July rainfall. Reported wheat and barley yields are included as independent variables. However, before undertaking any estimation using reported yields, it is important to ascertain whether those reported yields are reliable. If the reported yields are reported in an apparently arbitrary fashion, then there is no point in proceeding. If wheat and barley yields can be predicted with some accuracy using hedonic variables, then it will be possible to include the reported yield figures in the risk compensation test. The equation used for the estimation is

$$WY / BY = \beta_0 + \beta_1 DAYS\text{AF} + \beta_2 MELEV + \beta_3 RANGELEV + \beta_4 JULYRAIN + \beta_5 JULYRAINSQ + \beta_6 AUGRAIN + \beta_7 AUGRAINSQ + \beta_8 AUGTEMP + \beta_9 AUGTEMPSQ + \beta_{10} JULAUGTDIFF$$

where  $WY/BY$  is the reported wheat or barley yield, and the independent variables are as follows. *DAYS*AF is the number of days of airfrost recorded in the parish in one year. Nineteenth-century farmers had no pesticides, and preferred land where there was some frost to kill off insects. *MELEV* is the mean elevation within the parish, included because elevation has a negative effect on grain yields. *JULRAIN* is the amount of rainfall in July, and is

accompanied by its quadratic transformation; similarly for August rain and August temperature. *JULAUGTDIFF* is the difference between July and August temperatures. Farmers prefer a cool July and a hot August to maximize yields (Brunt 2004). If the estimations of reported wheat and barley yield appear to offer a reasonable level of predictive power, then it will be possible to proceed with the risk compensation test.

The risk compensation argument presented in the theoretical section above contends that the tenant will expect a reduced rent in regions where the yield risk is higher. To quantify the yield risk, the variance of temperature in August and the coefficient of variation of July rainfall are used as the measures of  $\varepsilon$ . It will be recalled that we used  $\varepsilon$  above as a stochastic modifier of the yield. August is a critical month for ripening grain crops, and clearly a higher temperature helps to increase yields. In addition, some rainfall is required but too much leads to lodging, increased harvesting expenses in August, and the risk of fungal diseases such as rust (Brunt 2004). The variance of temperature in August and the coefficient of variation for July rainfall for each parish are calculated using a thirty-year climate ‘normal’.

We now define the other variables that will be used as explanatory variables in the risk compensation tests. Above, we noted that if the reported yields for wheat and barley are plausible then those would be used. Local wheat and barley prices are found by interpolating prices reported at registered

markets on 23 September 1829, and published in the *London Gazette*<sup>6</sup>. Controlling for local prices avoids the need to include transport costs to market. We include the total population living within a five kilometer radius of the parish because the size of the population is related to the availability of both agricultural labor and local markets for inputs and outputs. In the theoretical section above, we noted that the negotiation of a rent reasonable to both the landowner and the prospective tenant should also take account of differences amongst landowners. So far the focus has been on the risk aversion of the tenant. But landowners, too, are not a homogenous group and so account should be taken of potential differences. An ideal situation would be one in which we had access to the names of the landowners of each of the 600 parishes in the region of interest. We might then be able to compare rent-setting by landowner-cluster if, as is likely, landowners were in possession of land in more than one parish. Unfortunately, while this information does exist in the original tithe documentation, it is not available to this author.

However there are other possibilities. One is the percentage of the county which was enclosed during the ‘Parliamentary’ enclosures of 1793-1815, the period of the French Wars (Turner 1980). Enclosure was an expensive business for the landowner, but also a lucrative one in the long run. Gordon Mingay (1997) estimates that after allowing for the costs of enclosure, “the net return to the landowner must often have been of the order of 10-20 per

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<sup>6</sup> Full details provided in the Appendix: Data Sources page 191 paragraph 5.

cent, which made enclosure one of the best investments of the age” (Mingay 1997, p.99).

As part of the process of enclosure, the landowner was able to renegotiate rental contracts, and also to extinguish tithes. It is plausible that the owners of enclosed land approached the management of their estates with a more business-like attitude and that rents increased in regions where enclosure occurred. To include the effects of parliamentary enclosure, we use a multi-level regression approach (Rabe-Hesketh and Skrondal 2008). The ‘fixed’ part of the regression is an estimation of arable rent against the hedonic variables such as climate. The ‘random’ part of the estimation is the percentage of the county enclosed during the years 1793-1815. The source of the percentage data is Turner (1980, Appendix: Data Sources, p. 191 paragraph 7).

The risk compensation equation is as follows:

$$r = \beta_0 + \beta_1 WY + \beta_2 BY + \beta_3 ELEV + \beta_4 WHTPRICE + \beta_5 BARLPRICE + \beta_6 POP5KM + \beta_7 RANGELEV + \beta_8 AUGTEMPVAR + \beta_9 JULYRAINCOV + \gamma ENCL1793$$

where the dependent variable,  $r$ , is the per rent per acre for any parish,  $WY$  is the wheat yield,  $BY$  is the barley yield,  $ELEV$  is the elevation,  $WHTPRICE$  is the local wheat price,  $BARLPRICE$  is the local barley price,  $POP5KM$  is the size of the population living within a five kilometer radius of the parish, measured from the 1841 census.  $AUGTEMPVAR$  is the variance of the August temperature

and  $JULRAINCOV$  is the coefficient of variation of July rainfall.  $AUGTEMPVAR$  and  $JULYRAINCOV$  therefore measure the amount of yield risk that the farmer faces. We expect the following signs:

$$\frac{\partial r}{\partial WY} > 0, \frac{\partial r}{\partial BY} > 0, \frac{\partial r}{\partial ELEV} < 0, \frac{\partial r}{\partial PRICE} > 0, \frac{\partial r}{\partial POP5KM} > 0, \frac{\partial r}{\partial AUGTEMPVAR} < 0, \frac{\partial r}{\partial JULYRAINCOV} < 0$$

The final term is the random effect of the percentage of the county which was enclosed during the enclosures of 1793-1815. There are six groups formed by different levels of enclosure, and the parish-level observations are clustered into the six groups. We do not directly estimate  $\gamma$  but instead observe the standard deviation of the constant term for each group.

### *Test 3: Auctions test*

Auctions were apparently used in Devon to lease out land to the highest bidder, as we showed above. If all rents were being set according to Ricardian rent theory, then there should be no difference between the rents in Devon and those in other counties. Ordinary Least Squares (OLS) is not suitable for this test because OLS assumes that there is no local variability in the coefficients of the independent variables, and the results presented are therefore mean estimates of the parameters. However, the assumption that the parameters remain unchanged over a spatial domain is difficult to maintain in a context

where geography is likely to influence the relationship between rent and observable land characteristics (Fotheringham, Brunsdon and Charlton 2002). This is analogous to the assumption made in time-series regression that the parameters remain unchanging over time. For the auctions test, a locally-weighted regression (also called a geographically-weighted regression or GWR) is used.

In GWR, the assumption that the parameters do not change is relaxed, allowing the parameter estimates to reflect more localized data. The GWR regression model is  $y_i = a_0(u_i, v_i) + \sum_k a_k(u_i, v_i)x_{ik} + \varepsilon_i$  where  $(u_i, v_i)$  are the coordinates of the  $i$ th point in space. The assumption is that there is a continuous surface of parameter values, and for each of the points for which we collected data (in our case each parish) we obtain the estimate provided by the function  $a_k(u_i, v_i)x_{ik}$ .

During calibration, observations close to point  $i$  have more influence than data located further away. There are thus some similarities with weighted least squares but with the important difference that the weighting of an observation is no longer constant. The amount of change in the weighting is referred to as the bandwidth; the bandwidth is small in areas where the datapoints are densely distributed and larger in areas where there is more dispersion. For the GWR undertaken in this paper, we allow the bandwidth to adapt to the local density. This is the essential difference between GWR and OLS: under OLS the parameters are estimated globally without reference to

local conditions. In GWR, local conditions provide an effect which decays with distance, or “the weights tend to one for all pairs of points so that the estimated parameters become uniform and GWR becomes equivalent to OLS” (Fotheringham, Brunsdon and Charlton 2002).

For the auctions test, the same equation employed in the risk compensation test is used. The outcome of interest is the local coefficient of determination. If the local coefficient of determination is higher in Devon than elsewhere, this provides some insights into whether the auctioning of agricultural land induced a greater share of the Ricardian surplus to the landowner.

## **Empirical tests**

The rents and the yields reported in the tithe files are for the ‘years of average’, 1829-1835, because the commuted tithe was based on the production of those years. The observations were recorded by the tithe commissioners, based on evidence from landowners and tithe-owner, and there is the possibility of bias (Baker 1975). Table 2 below compares observations for locations from the tithe files and those for the most proximate location independent of the tithe files for which data are available. The source of the independent data is Turner, Beckett and Afton (2001), and is fully described in

the Data Appendix<sup>7</sup>. The tithe files provide rents and yields classified by arable rent (AR), pasture rent (PR), wheat yield (WY), and barley yield (BY). The data from independent sources provide rents and yields with which to compare the closest parish.

Independent Source				Tithe Files				
Name	Rent	WY	BY	Name	AR	PR	WY	BY
Tavistock	18			Peter Tavy	14	24		
Badminton	24			Horton	17	21		
Bradford	28			Monkton Farleigh	28	30		
Longleat	20			Chilmark	16	26		
Lilleshall	25			Bromsgrove	25	32		
Sandford		16	26	Upton Hellions			20	30
Aldbourn		23	45	Ramsbury			22	30
Taunton		29	37	Oake			25	35
Bratton		20		Monkton Farleigh			21	

Table 2. Comparison of parish data.

Note: the parishes and independent sources are matched for proximity. Rents are in shillings per acre. AR is arable rent; PR is pasture rent; WY is wheat yield; BY is barley yield. Yields are in bushels per acre.

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<sup>7</sup> See the Appendix: Data Sources page 191 paragraph 3.



### *Test 1: Pastoral rents test results*

The parishes for which pastoral rents and pastoral yields, recorded in shillings, were both recorded are all in Devon, and number 131. The London market was the final destination for most livestock from the southwest, and so the relevant distance is that between the parish and London. The Euclidian distance is therefore measured and included in the observations for each parish. This provides the opportunity to test the relationship between yield, production costs and distance to market in its clearest formulation. The results below are for Equation 3 defined in the Methods Section above as

$r = \beta_0 + \beta_1 Yield + \beta_2 Elev + \beta_3 Dist$  . The dependent variable is the logarithm of the pasture rent.

Variables	Log Pasture Rent
Pasture Yield	0.0241*** (0.00208)
Elevation	-0.00151** (0.000499)
London Distance	-0.00000218*** (0.000000607)
Constant	3.145*** (0.192)
Observations	131
$R^2$	0.694

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 3. Results for pastoral test.

The coefficients are highly significant, and their signs are as predicted in the theoretical section. The coefficient of determination is 0.694, indicating a reasonably high explanatory power. It is possible that there is some non-linearity in the *London Distance* variable, implying a non-constant cost per unit distance. However, the 131 parishes are close to each other, and on very variable terrain, making estimation of a non-linear parameter problematic. Estimation using a cubic spline for the distance variable provided a statistically significant outcome, but the improvement in the coefficient of determination

was small. Differences in costs of driving to London are more likely to occur because of variations in local terrain rather than distance alone.

These results do not show that landowners were necessarily extracting the entire Ricardian surplus, but they do show that rents changed predictably across the observations.

### *Test 2: Risk compensation test results*

The dataset contains over five hundred parishes for which corresponding arable rents and yields are available, and these parishes are therefore suitable for the risk compensation test. Here, as outlined in the theoretical section above, the prediction is that tenants will demand lower rents in compensation for the riskiness of yields.

The wheat and barley yields reported in the tithe files are for averages, and there is also the possibility of some bias or other inaccuracy. A first step is therefore to assess the reliability of the reported data. This is achieved by regressing reported wheat and barley yields against independently-reported hedonic qualities to make sure that reported yields were reasonable. Using the equation:

$$WY / BY = \beta_0 + \beta_1 DAYSFAF + \beta_2 MELEV + \beta_3 RANGELEV + \beta_4 JULYRAIN + \beta_5 JULYRAINSQ + \beta_6 AUGRAIN + \beta_7 AUGRAINSQ + \beta_8 AUGTEMP + \beta_9 AUGTEMPSQ + \beta_{10} JULAUGTDIFF$$

presented in the methods section above, the results for wheat yields and barley yields are provided below in table 4. Reported wheat yield is the dependent variable in the first equation, and reported barley yield in the second.

VARIABLES	Wheat Yield	Barley Yield
Days Air Frost	0.182*** (0.0423)	0.328*** (0.0569)
Mean Elev	-0.0209*** (0.00438)	-0.0187*** (0.00600)
RANGELEV	-0.00521*** (0.00178)	-0.00542** (0.00274)
JULRAIN	-1.711** (0.839)	-0.833 (1.262)
JULRAINSQ	0.0229*** (0.00814)	0.0170 (0.0122)
AUGRAIN	2.358*** (0.831)	3.102*** (1.187)
AUGRAINSQ	-0.0206*** (0.00631)	-0.0255*** (0.00893)
AUGTEMP	-148.8*** (55.64)	-25.74 (73.30)
AUGTEMPSQ	4.653*** (1.695)	0.917 (2.227)
JULAUGTDIFF	3.484** (1.530)	2.440 (2.236)
Constant	1,164** (455.9)	96.49 (603.3)
Observations	504	504
R-squared	0.486	0.287

Robust standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table 4. Reported grain yields regression.

The results show that reported arable yields were consistent with hedonic variables. Wheat yield can be predicted quite well from climate variables ( $R^2 = 0.486$ ), barley yield less reliably ( $R^2 = 0.287$ )<sup>8</sup>. The results from the regression show that recorded yields were consistent with exogenous variables, in this case climatic variables. It is therefore possible to use the reported yields in the test for risk compensation.

To test for risk compensation, arable rent is regressed against yields, wheat and barley prices in 1829, and the population living within five kilometers of the parish, the variance of the August temperature, and the coefficient of variation for July rainfall... To account for the effect of enclosures, we use a multilevel model, provided below:

$$r = \beta_0 + \beta_1 WY + \beta_2 BY + \beta_3 ELEV + \beta_4 WHTPRICE + \beta_5 BARLPRICE + \beta_6 POP5KM + \beta_7 RANGELEV + \beta_8 AUGTEMPVAR + \beta_9 JULYRAINCOV + \gamma ENCL1793$$

where  $\beta_8$  is the risk variable measured by the variance of August temperature,  $\beta_9$  is the risk variable measured by the coefficient of variation for July rainfall and  $\gamma ENCL1793$  is the random effect of percentage of enclosure of common and waste land in the county during the period 1793-1815. The results are:

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<sup>8</sup> The source of the meteorological data is provided in the Appendix: Data Sources page 191 paragraph 4.

VARIABLES	(1) AR		
Wheat Yield	0.941*** (0.0795)		
Barley Yield	0.404*** (0.0583)		
Mean Elev	-0.0210*** (0.00458)		
Wheat 1829	0.283*** (0.0752)		
Barley 1829	0.131* (0.0688)		
POP5KM	3.27e-05*** (1.01e-05)		
RANGELEV	-0.00724*** (0.00219)		
AUGTVAR	-21.56*** (4.902)		
July Rain CoV	-56.13*** (18.39)		
Constant	40.93*** (14.09)	0.831** (0.335)	1.321*** (0.0315)
Observations	510	510	510
Number of groups	6	6	6

Robust standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table 5. Arable rent regression.

These results show that wheat and barley yields increased rents, as predicted. Elevation, a proxy for costs, reduced rents, again as predicted. The farm-gate price of wheat is highly significant, and is positive. The farm-gate barley price is not as significant, reflecting the lesser commercial importance of the barley. The other control variables, *POP5KM* (the population living within a

five kilometer radius of the parish, *RANGELEV* (modeling the costs of cultivation through the ‘roughness’ of terrain reflected in the range of elevations within the parish) are significant and with the expected signs. The two risk variables, *AUGTVAR*, the variance of the August temperature, and *JULRCOV*, the coefficient of variation for July rainfall, both have negative signs and are significant. The implication offered by two separate variables, both of which have a large effect on yields, is that farmers were negotiating a lower rent in compensation for yield risk from a variable climate. The constant terms due to the grouping by percentage of enclosure indicate that the inclusion of this term is significant. In a separate regression, the enclosure variable *ENCL1793* was included as an explanatory variable in a fixed effects regression. It was highly significant and with a positive sign. The implication is that the amount of enclosure was correlated with higher rents in unenclosed land, such as the parishes which form this study. We will discuss this point further below.

### *Test 3: Auctions test results*

To test whether the auctioning of agricultural leases in Devon provided landowners with a greater share of the Ricardian surplus, the location-specific coefficient of determination ( $R^2$ ) for each parish is first found using GWR. A high  $R^2$  implies that rents were being set competitively, and therefore that

landowners were receiving the greatest share of the Ricardian surplus. The same variables used for the risk compensation test are used. The results are shown below in figure 4.

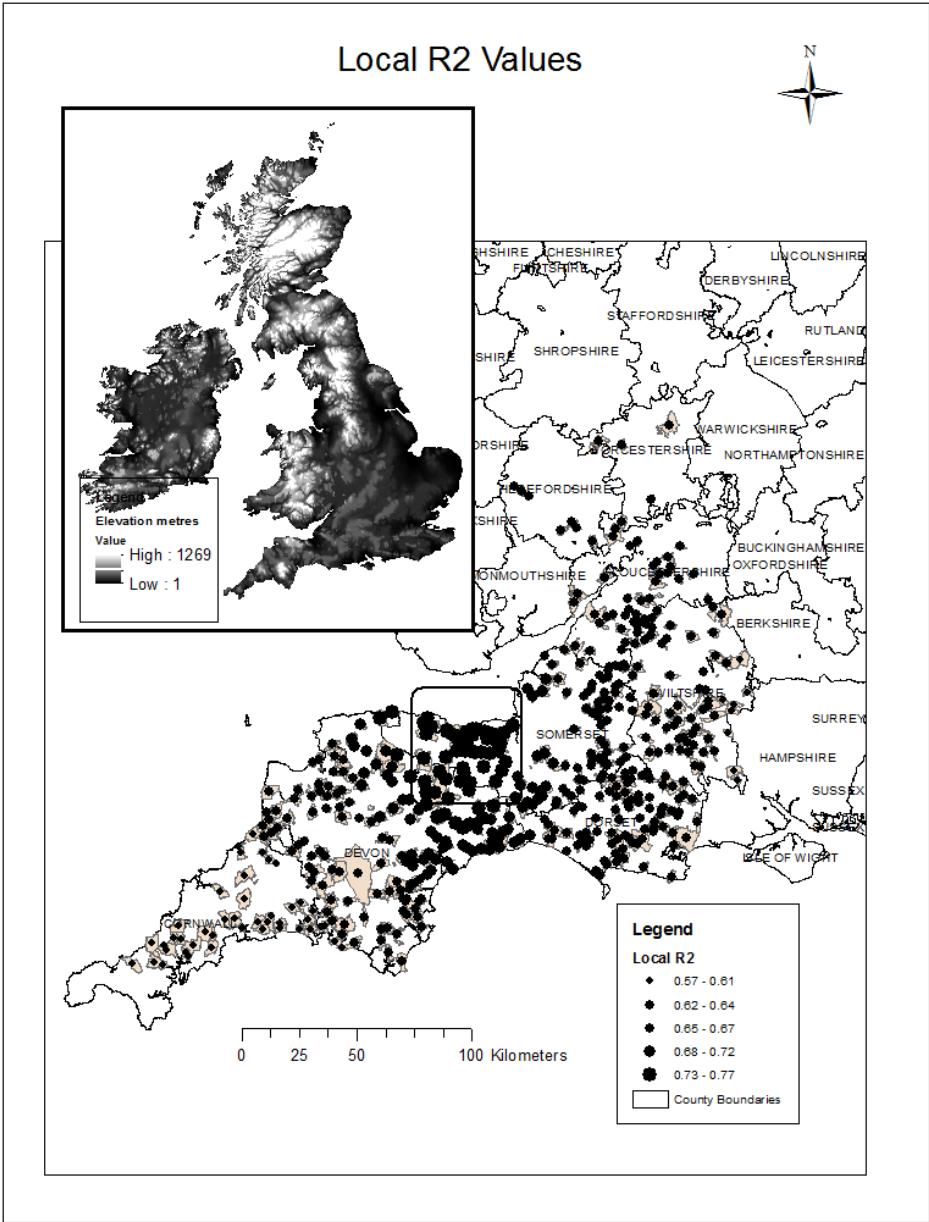


Figure 4. Coefficient of determination by parish.



The R2 values range between a minimum of 0.43 to a maximum of 0.71. The area with the highest R2 values is enclosed by the rounded rectangle in figure 7. A tabulation of quartiles of R2 values by county is below in Table 6.

<b>Quartiles R2</b>					
<b>County</b>	1	2	3	4	<b>Total</b>
Cornwall	47	0	0	0	47
Devon	29	18	41	59	147
Dorset	17	43	22	0	82
Glos	23	12	1	0	36
Hereford	0	5	2	0	7
Somerset	0	18	50	50	118
Wilts	54	12	0	0	66
Worcs	2	1	2	0	5
Total	172	109	118	109	508

Table 6. Local R2 values by county.

The counties with the highest R2, those in the fourth quartile, are exclusively in Devon and Somerset. The highest R2 value is 0.71, indicating a reasonable degree of explanation of rents by the model. The question is why the R2 goes down to 0.43 in other regions, notably Cornwall in the extreme west. A Ramsey RESET test of the estimates of Table 2.5 ( $p=0.01$ ) shows that there is at least one missing variable. These are likely to be climate variables, such as

temperature, but economic variables are also possible. Cornwall in the west of the region of interest had non-farming employment possibilities, such as fishing and mining (Orwin and Whetham 1964). As a result, agricultural wages were a little higher in Cornwall than in Devon, the county to its east. North Devon and the western part of Somerset were rather isolated, with very low farm wages. The eastern part of the region of interest, especially Wiltshire, had rather more non-farm employment opportunities.

One explanation for the low  $R^2$  in those areas is that the relative importance of an agricultural income was less and so the variance of rainfall in July mattered less. Jean-Paul Chavas (1993) has shown theoretically that an exogenous income decreases risk-aversion, and his finding has some empirical support (Binswanger 1980). Unfortunately there are no data which provide exogenous incomes and so this interesting possibility is not tested.

To quantify the auction effect, the regression shown in Table 5 is repeated, but with the addition of an indicator variable for parishes with an  $R^2$  of greater than 0.68. This is the value of the  $R^2$  of the parishes within the rounded rectangle drawn in Figure 6. The indicator variable is positive, and shows that rents in parishes with an  $R^2$  of at least 0.68 were on average 5.7 per cent higher than those elsewhere ( $p=0.027$ ). However, the parishes with a high  $R^2$  were in both Devon and Somerset, as table 6 shows. A dummy for Devon alone is not significant. It is of course possible that agricultural leases

were being set by auction as well as in Somerset, but this author has found no documentary evidence to support this possibility.

Regardless of the documentary evidence, the results indicate that if landowners in the parishes within the rounded rectangle were in fact auctioning their leases, then they received an extra five per cent as a result. However, there are other possibilities, such as omitted variables, measurement errors, and perhaps differences in the ways that various taxes were calculated. In some cases landowners paid local taxes, while in others these were paid by the tenant. It is not clear whether and how such taxes were reflected in the rent paid. It is true that the region within the rounded rectangle does reflect Ricardian rent theory more accurately, but this may be due to causes other than the auctioning of leases. For example, it could be that landowners in that region were relatively lax about enforcing cultural covenant conditions on leases, whereas farmers elsewhere were prepared to accept a reduced rent in exchange for a higher standard of husbandry. In addition, the tests above have been only for arable rent, because we lack wider data for pastoral parishes. The southwest was primarily a pastoral area, and tenants bidding for land were therefore more likely to be interested in the grazing qualities of the land. The importance of pastoral land is reflected in the high explanatory power of *Test 1: Pastoral rents*, provided above.

## Discussion

The purpose of this chapter is to determine whether early Victorian landowners were extracting a consistent share of the Ricardian surplus which Ricardian rent theory (RRT) suggests they should in a competitive fixed-rent land market. The results are of interest because contemporaries, such as James Caird (1851), were frequently scathing of the failure of landowners to extract the maximum share of the surplus, claiming that national agricultural productivity would increase if only rents were set properly. Despite Caird, landowners might perhaps be forgiven for not always setting rents according to RRT. Some older leases were still held under the long-term customary system, and in any case the necessary theoretical basis for valuing land was still under development.

Leaving aside Caird and the very real difficulties of setting the ‘correct’ rent, the findings provided in this chapter are that rents were being set according to RRT, at least for titheable land in the southwest. The southwest was not the most progressive part of Britain, and its distance from London meant that it was perhaps less integrated into the rest of the economy. If rents in the southwest were being set in accordance with RRT, then it seems reasonable that rents elsewhere were too. A similar argument holds for the fact that the rents which are examined relate to titheable land in parishes. If the rents set by the landowner at the parish level extracted a consistent share of

the Ricardian surplus from the tenant, then it probable that the rents set on larger estates did at least the same. From this, it is likely that landowners throughout Britain were receiving the bulk of the surplus. This argument is strengthened by the inclusion of a variable for the percentage of the county's land which was enclosed in the 'Parliamentary' period of 1793-1815. The results showed that arable rents were positively correlated with percentage of enclosure. However, we cannot say that higher enclosures caused higher rents elsewhere in the county just because landowners of unenclosed land copied the rents set by greater landowners on enclosed estates. Much depends on the reasons why some counties received more enclosure attention than others. For example, why was the percentage of enclosure in Hereford only 0.2 per cent, while that for Somerset was 4.5 per cent? There may have been some other as yet unknown factors which both attracted enclosing landowners and increased arable rents.

## **Conclusion**

Taken together, the three tests show that a large amount of useful information is still held in the 1836 Tithe Commission Files, especially when combined with other data. The study has been limited to eight counties in the southwest, by no means closely representative of agriculture in general in early Victorian Britain. There are no suitable records, unfortunately, of the heavily arable counties to the east, or the grazing areas of Cumberland and the

northwest. But if farmers and landowners in the slightly behind-the-times southwest set rents in a manner predicted by agricultural location theory, it is highly probable that more `connected` areas would also set rents in this manner. If this is the case, then the increase in productivity that took place might have tenurial change as its prime mover. Tenurial change came about as a consequence of the high prices during the French Wars, as landowners scrambled to gain a larger share of the Ricardian surplus. In gaining their larger share, they forced their tenants to work harder, as James Caird had predicted. The result was a self-reinforcing virtuous circle, fed by increasing domestic demand, and protected by the Corn Laws.

Chapter 4 examines the robust defense of the Corn Laws put up by tenant farmers, and shows that resistance to the repeal of the Corn Laws was strongest in areas which produced the most wheat. That conclusion supports the findings of this chapter which is that landowners were extracting a consistent share, and perhaps the bulk, of the Ricardian surplus from their tenants.

### **Chapter 3. The advent of rail and British agriculture**

The role of rail in the modernization of the economy and agriculture has been a source of contention in the economic history literature. For Britain, several agricultural historians argue that rail had a substantial effect (Orwin and Whetham 1964; Chambers and Mingay 1966), but numerical estimates of the effect of rail on agriculture are relatively small. For the economy as a whole, estimates range from 5 percent for the United States (Fogel 1964) to 7 to 11 percent for Britain (Hawke 1970). In less developed regions, the results are more impressive. For India, Hurd (1983) finds that in 1900, social savings were nine per cent of national income, while for Brazil the savings were 18 per cent of national income around 1913 (Summerhill 2005). For the U.S. and Britain the results are small given the rapid rate of increase of GDP in both Britain and the U.S. at this time, and the central role that the railways are supposed to have played in that growth. For agriculture alone the estimates are smaller still, at 1.8 percent for the U.S. and between 0.05 to 0.3 percent of GDP for Britain. Such small estimates put in doubt the assertions of the agricultural historians, and invite another analysis. In this paper, we use novel geocoded data and hedonic regressions to approach the old question of how the advent of rail affected British agriculture. We are able to split the effect into the amount brought about by the cost savings in the transport of goods and that brought

about by the reduced costs of bringing inputs, such as fertilizer, to the farm and the restructuring of the industry brought about by rail (Schwartz 2010).

Victorian landowners would have been surprised by Hawke's finding that rail had little influence on the agriculture and the economy. The effect on agricultural rents was well-known, and in 1863 the House of Lords heard that an increase in rent of about seven per cent was to be expected on all land within five miles of a railway station (P.P. 1863)<sup>9</sup>. Landowners were also aware that rural parishes which had a railway station grew faster than those that did not (Gregory and Henneberg 2010). More subtly, the changes in production induced by rail, especially towards profitable dairy production, slowed the flow of migrants to urban areas (Schwartz 2010). Land owners also saw substantial increases in their agriculture productivity. In the first half of the 19<sup>th</sup> century, compound annual growth in real product for agriculture was 1.3 per cent (Deane and Cole 1980), wheat yields increased by about 50 per cent (Allen 2005) and the pastoral sector showed an equally impressive performance (Broadberry 2011). The gains in productivity have been attributed to a wide range of influences, including more use of imported fertilizers (Turner, Beckett and Afton 2001), better breeding of livestock (Trow-Smith 1967), and even the collection of stones from pasture to construct drystone walls (Allen 2005). We argue that some of this gain may well have been due to advent of rail.

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<sup>9</sup> Full details of Parliamentary Papers are given in the Appendix: Data Sources, page 191.



The best-known estimates of the size of social savings from railways are those of Robert Fogel, Albert Fishlow and Gary Hawke (Fogel 1964; Fishlow 1966; Hawke 1970). Their methodology is to “measure the cost to society of doing exactly what it did with the railways, without them” (Leunig 2006, p. 637) or, as Hawke himself puts it, “this is an ex post analogue to the ex-ante concept used in cost/benefit analysis” (Hawke 1970, p.6) Nick Crafts, in a recent summary, has described the method as being “based on estimating the cost-savings of the new technology compared with the next best alternative” (Crafts 2005). For the U.S. in 1890, Fogel finds that the extra costs of moving agricultural products by water and wagon were 1.8 per cent of GDP. From this estimate, he calculates that the transport cost savings brought by rail for all goods, agricultural and non-agricultural, were no more than 5 per cent of GDP. Fogel and Fishlow’s calculations of social savings for the years 1890 and 1859 respectively are heavily criticized by Peter McClelland (1968) who finds their data to be of ‘dubious accuracy’ and that the inference of total social savings without knowledge of transport cost functions is invalid. Nick Crafts notes that Fogel deliberately intended his estimates to be “an upper-bound measure constructed as if demand for transport was perfectly price inelastic” (Crafts 2005, p.1). Gary Hawke also provides a thoughtful critique, noting that Fogel “is seeking to demonstrate that the railway contributed little social saving” and so reduces the importance of “the trickiest, and least quantifiable, problem of

all: the determination of the extent to which technological adjustments to the absence of the railways would have been made” (Hawke 1970, p.10).

Perhaps because he acknowledges the gaps in the work of Fogel and Fishlow, Hawke’s work on the British economy has received less criticism, although he still uses the ‘ex post’ cost benefit method. Hawke calculates the social savings from rail over the years from 1840 to 1870, with a focus on the year 1865 (Hawke 1970; Gourvish 1980). He divides each economic sector’s social savings by national GDP to find sectorial shares. For agriculture, he finds that the savings for wheat transportation by rail were negligible, while for livestock and dead stock combined, the transportation savings provide a share of between 0.05 and 0.31 per cent of GDP for 1865. Data demands limit Hawke’s methodology for agriculture, which requires detailed droving costs, railway freight charges and volumes of stock transported to make a comparison. Unfortunately, such records are scanty, and so his estimates cover a wide range.

Passenger traffic data are more abundant, and this enables Timothy Leunig to use modern cost-benefit techniques to re-estimate Hawke’s calculations of the social savings for rail passengers (Leunig 2006). While his estimates do not greatly differ from those of Hawke, Leunig includes a discussion concerning the actors who gained the greatest social surplus. He

finds that passengers received the most benefit, and that the return on investment for the railway shareholders was small.

We use a hedonic panel approach to calculate the benefits to agriculture from the advent of rail. The use of hedonic approaches has been common in the literature on the determinants of farmland values (e.g. Palmquist and Danielson 1989; Xu, Mittelhammer, and Barkley 1993; Oltmans, Chicoine, and Scott 1988; Craig, Palmquist, and Weiss 1998; Huang et al. 2006; Kirwan 2009). Hedonic approaches have also been used to estimate social savings from improved transportation infrastructure. For example, Lewis-Workman and Brod (1997) estimate the benefits of a new subway line in San Francisco, and find that average housing prices decrease by \$1578 with every 100 feet increase in distance from a subway station; for New York the comparable figure is \$2300. Nelson and Hellerstein (1997) provide an interesting application of the hedonic method to the estimation of the relationship between the cost of access to forests by road and the amount of deforestation. Here they use a novel combination of satellite and geographic information systems (GIS) to measure both forest areas and cost of access. As might be expected, their finding is that deforestation decreases when access is expensive. Our contribution is to apply the hedonic approach to the historical question of measuring the benefit of the railways to agriculture and agricultural productivity.

The cost-benefit method used by Hawke and Fogel has four drawbacks. First, the cost-benefit method does not account for the dynamic changes made by agents as they react to their new economic landscape, a problem hinted at by Hawke in his critique of Fogel provided above. For example, the London milk-shed grew with the railway, and farmers along the route converted from arable farming to dairy production to take advantage of the new access to the London market (Whetham 1964; Atkins 1978; Perren 1975). In remote hill areas, livestock breeders were able to retain their animals for longer and gain the additional revenue from selling fat stock (Orwin and Whetham 1964). Farmers in Cornwall were able to grow strawberries for the London market, impossible without the speed of rail transportation (Schwartz 2010). These entrepreneurial achievements add to agricultural productivity but are overlooked by the standard cost-benefit methodology. Second, the new technology, here the railways, may cause the break-up of an existing dominant transport system, such as that of the U.S. canal system. Similarly, in Britain the introduction of the railway through Harwich broke the monopoly held by steamship companies bringing livestock from the European continent. This fracturing of a dominant system has some value in itself, over and above the change in transport cost, and this value is not captured (Holmes and Schmitz 2001). Third, the cost-benefit method does not include the reduction of the costs of bringing inputs to the farm. Hawke is correct in stating that arable farmers did not use the railways very much for the movement of wheat to

market, but he overlooks the fact that they did use the railways to bring heavy items, such as lime and drainage pipes, to their farms (Holderness 1989). As a result, arable rents raised more than livestock rents as access to railway track improved (P.P. 1863). Fourth, the cost-benefit method has substantial data requirements, while the data needs for estimating observed rent changes are comparatively light. By measuring the change in rent, we do not need to know what input and output alterations the farmer actually made; the changes in rent and track availability are enough, as we show below.

Agricultural land rental markets were developed by the 1830s and, as Ricardian rent theory predicts, agricultural surplus was transferred to landowners as a higher rent. The change in rent represents the value to the farmer of access to railway track in three ways: the saving from being able to sell his livestock in better condition; the increased profit made by new ventures facilitated by faster transportation; and lower costs for farm inputs such as imported fertilizers and livestock for fattening.

The objective of this chapter is two-fold. First, we tackle the old problem of valuing the benefits of rail by combining a Ricardian approach with novel geocoded data of a panel of estate rents, nearby track, local climate and commodity prices for 1832 to 1865. Second, using results from dynamic panel estimations, we calculate the savings at the national level produced by the transport of all agricultural production by rail and then split these benefits into

those directly generated by lower transport costs and those generated by changes in farmer behavior induced by rail. We then compare these measures of increasing agricultural productivity with measures attributed to other sources. We find that for 1865, Hawke's reference year, rail increased agricultural rents by between 0.98 and 1.28 per cent of total GDP, with a mean estimate of 1.13 per cent, or 7.8 percent of agricultural GDP<sup>10</sup>. By contrast, the mid-point of Hawke's estimates is less than one fifth of ours. Taking Hawke's numbers as the direct cost savings, we show that by giving farmers access to new markets and cheaper inputs, the railways increased agricultural productivity by approximately 0.92 per cent of total GDP, not including the direct savings from lower transport costs for goods to market. Thus, while agricultural productivity grew quickly over this period of time, we find that close to one quarter of that growth came from the advent of rail. We further divide our estimate of social savings as a share of GDP by calculations at the regional level, using recent work by Geary and Stark (2002) to find regional GDP estimates for 1871.

The British railways were built for mineral and passenger traffic, not for agriculture (Gregory and Henneberg 2010). For the railway companies, the carriage of livestock was much less important than minerals, and receipts made up less than four per cent of freight revenue (P.P. 1883). However, farmers seized the opportunity offered by the railways, and we describe below

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<sup>10</sup> Where agricultural GDP is estimated to be STG 120 million per year (Deane and Cole 1980).

how rail changed the movement of agricultural production. The ‘equilibration’ process by which rents are set is pivotal to this article, and so we spend some time examining Ricardian rent theory in the context of Victorian agriculture. With the theoretical aspects in hand, we describe the methodology by which we estimate the transfer of railway cost-savings to landowners as a higher rent. We use dynamic panel methods to estimate the change in rent due to a change in accessibility to railway track. Finally we use the estimates to calculate the social savings for the year 1865, dividing the savings into those which resulted from a more efficient means of transportation and those which resulted from the greater production opportunities available to farmers.

### **The development of the railways**

In 1832, Robert Stephenson demonstrated the Rocket, sparking a ‘railway mania’ across Britain. The construction of new track and the opening of stations, all financed by private capital, were remarkably rapid (Robbins 1998). By 1841, 386 stations had opened as new lines were built (James 1983). In each of the three following decades approximately 1,000 stations were opened (Gregory and Henneberg 2010). A quarter of a million men, about four per cent of the male workforce, were engaged in the work of building the railroads. The result was to join together a large number of shorter lines, originally built for

the purely local transport of minerals, especially coal (Dyos 1969). By 1870, the main network was substantially complete (Turnock 1998; Wolmar 2007).

### *The transportation of food*

London was the primary destination for most livestock, but London is situated far from the breeding areas in the southwest and Scotland. Consequently an ancient system had developed of raising sheep and cattle as far west as Cornwall, and as far north as Scotland, and then selling the young animals on for fattening at various intermediate points (Edwards 1981; Blackman 1975; Hallas 1986; Haldane 1952). The cost of droving was high in terms of drovers' fees but even more costly was the loss of weight experienced by the animals. The railway gave farmers the choice of moving livestock by train, which "probably halved the real transport costs of livestock flows" (Hawke 1970, p. 147). Farmers found freight by rail so attractive that by 1865 the railways had captured the bulk of the livestock flow, and areas which had previously been devoted entirely to breeding and grazing could now participate in the more lucrative fattening stage (Hawke 1970). It is probable that the reduced cost of moving pastoral production to market helped to alter the balance between national pastoral and arable production. At the beginning of the century, the share of pastoral production in national output was approximately 50 per cent



and it increased to 60 per cent in the 1860s at the expense of arable production (Broadberry et al. 2011).

Railways also caused the repositioning of livestock markets. For example, in the 1840s, the market in Lancashire for livestock raised in the isolated Yorkshire dales declined because buyers preferred to purchase stock from areas which were linked by rail. Yorkshire farmers then drove their animals eastwards to make use of the railway connections there (Hallas 1986).

While livestock farmers were the primary beneficiaries of the railways, arable farmers also gained. The use of imported fertilizer increased in this period (Turner, Beckett and Afton 2001) and railways reduced the cost of bringing the fertilizer to the farm, as the House of Lords heard from witnesses in 1863. For example, John Angus stated that the benefits of railway access to his farm were “getting lime and heavy manures” and were worth 2.5 shillings per acre for arable land, and 1 shilling for pasture. Average rents were around 20 shillings per acre, and so the benefits were both large and in the favor of arable land (P.P. 1863, p.53). More important, the crop rotations of the time usually included the folding of livestock at some stage (Trow-Smith 1967). The livestock ate turnips and crop residues, leaving their manure. To augment their supplies of manure, arable farmers began to buy in livestock from the breeding areas, fatten them, and then send them on to market. Livestock could therefore reach London either directly from a livestock farmer, or after having been

fattened at an arable farm en route. Some heavily arable regions became well-known for the fattening and finishing of livestock. Norfolk, for example, took in Scottish bullocks, fattened them and then sent them on to London by rail (Perren 1975; Orwin and Whetham 1964). Arable farmers therefore benefited in three ways: their input and transport costs were reduced, and the throughput of livestock increased their supply of manure.

Agricultural productivity was also growing quickly at this time (Broadberry et al 2011). Gross wheat yields grew from 20 bushels an acre in 1800 to 28 bushels an acre in 1850. In the same time-frame, milk yields grew from 380 to 440 gallons per cow (Allen 2005). This growth has been attributed to the increased use of imported fertilizer (Turner, Beckett and Afton 2001) and better ploughing technology (Brunt 2004). Even the practice of picking up stones to build drystone walls for the enclosure of animals contributed (Allen 2005). Population grew by an annual rate of 0.84 per cent over the period 1700-1860 (Broadberry et al. 2011; Wrigley and Schofield 1989), and much of that growth occurred in London and other industrializing cities (Deane and Cole 1980). By facilitating access to these growing markets and by generating opportunities for new types of agricultural production, railways likely also helped.

## Railways and Ricardian Rent Theory

The productivity of agricultural land consists of both the natural fertility of the soil and the farm-gate value of its production. The farm-gate value of production is, in turn, a function of the transportation costs to market. The farmer closest to the market and on the best land has the lowest marginal costs, and will therefore receive the largest surplus. By contrast, the farmer on land at the greatest distance from the market will receive only just enough surplus to enable him to continue farming. Each parcel of land will therefore have its own surplus or Ricardian rent (Alonso 1964; Chisholm 1962; Peet 1969). Our methods rely on the assumption that landlords were fully able to capture the change in agricultural value associated with the decrease in transport costs. Dunn's equation expresses the Ricardian rent as a function of market price, fertility, cost of cultivation and distance to market (Dunn 1954; Kellerman 1989; Alonso 1964):

$$r = j(p - c) - jgx \quad (1)$$

where  $r$  is rent per unit area,  $j$  is yield per unit area,  $p$  is price per unit at the market,  $c$  is unit cost of cultivation,  $g$  is cost per unit distance to market, and  $x$  is distance between market and farm. Thus, with the introduction of a new transportation technology, Ricardian rents will increase, and they will increase

more in percentage terms for those parcels of land located further from the market.

Nearly all Victorian farmers were tenants (Offer 1991; Porter 1989), and there were usually, although not always, more prospective tenants than farms (Stead 2003). Prospective tenants competed for farmland, each bidding more than the other until a bid that satisfied the landowner was reached. By competing, the prospective tenants bid away any surplus and the winning tenant was left with only 'normal profits' while the landlord captured the surplus. O'Sullivan writes that 'the encouragement to compete for land and to change locations and land prices will only evaporate when a set of prices per acre has been arrived at which equalizes returns to all locations' (O'Sullivan 1981, p. 24).

As transportation costs change, different types of production become financially viable in new locations. Theoretically, the landowner is alert to any change in the profitability of his tenant, and extracts the surplus that the tenant is able to make through a change in the structure of production. The change in rent due to increased railway track availability is thus a function of both the change in transport costs and any change in production. While the cost-benefit method as used by Hawke (1970) captures the effect of the change in transport costs, it does not allow for dynamic changes resulting in behavioral responses by the farmers. In many cases, a comparison of costs with and without the new technology is not possible because of the changes

caused by the new technology. For example, cattle bred to take advantage of rail transportation would have been unable to walk to market because their hooves were unable to support their greater weight over long distances (Trow-Smith 1967). In addition, the railways made possible the transportation of deadstock, although in the period covered by this article, 1832-1865, the volume was limited by a lack of refrigeration and poor distribution arrangements in London (Hawke 1970; Perren 1975).

### *The Ricardian approach and dynamic changes*

Hedonic models of house prices are based on the Ricardian assumption that house prices capture the value associated with their location. These models have been used for many years to estimate the willingness to pay of agents for attributes such as proximity to commuter transport. For example, access to the rapid rail line in Philadelphia increases the value of a home by nearly eight per cent (Voith 1993). The hedonic approach has been widely used in the valuation of agricultural land (Bastian et al. 2002; Chicoine 1981; Shi, Phipps and Colyer 1997). A similar hedonic approach, also called the Ricardian approach, has been used to calculate the impact of climate change on agriculture (Mendelsohn, Nordhaus and Shaw 1994; Schlenker, Hanemann and Fischer 2005). The approach focuses on how the change in climate affects

the value of farmland, in contrast to the traditional approach of studying changing yields under different climatic conditions. If markets are functioning competitively, the land rent equals the net yield of the best use of the land under those climatic conditions (Madison 2000; Kabubo-Mariar and Karanja 2007), and so the change in rent reflects the change in the value of output of the farm.

The hedonic model includes variables to control for changing economic conditions at the market. Quadratic terms are included for climate variables to capture the non-linear response of crops to climate variables such as precipitation. In Equation 2 below, we control for climate variables to estimate the effect of the change in access to the railways:

$$R_{it} = X_{it}\beta + Z_t\gamma + C_i\delta + G_t\iota + S_i\kappa + T\tau + u_i \quad (2)$$

where  $R$  is the rent per acre,  $X$  the length of track,  $Z$  is a vector of commodity prices at the terminal market,  $C$  is a vector of climate variables,  $G$  is a vector of geographical variables,  $S$  is a vector of soil characteristics and  $T$  is an annual time trend to capture unrelated increases in agricultural productivity. In the case of the current estimation,  $Z$  includes prices of the commodities for which we have London price data and which were produced in significant amounts. The London price is used for two reasons. Local farm-gate prices are not available, and London prices would have been known to the farmer through periodicals such as the *Mark Lane Express* and the *London Gazette*. The

livestock market was dominated by London, as we noted above, and therefore it would be with the London price in mind that the farmer calculated the potential returns from either using the railways or continuing to drive his animals (Perren 1989).

We use the Ricardian model in longitudinal format (Massetti and Mendelsohn 2011) so that we can include the dynamic effects provided by increased access to markets. We can also then control for time invariant estate fixed effects. The Ricardian approach allows us to measure the impact on rents of a change in track availability without being concerned about what the farmer was actually producing at any one time. Because rents were set competitively we are able to assume that the farmer adopts the mixture of outputs which maximizes his profit. The most profitable mixture will change over time with both availability of railway track and changes in commodity prices, among other factors, and the value of the farmer's change is reflected in the rent that he is charged.

## **Methods and data**

Our first task is to measure the marginal effect on agricultural rent of a change in the availability of railway track. We do this using by regressing deflated rents on the amount of rail track within a 40 km radius of the estate. We use a 40

kilometer radius because very few of the 31 estates had any railway track within this radius at the beginning of the 1832-1865 time-period, and so the effect of additional track is more clearly identifiable. To measure lengths of railway track, we use the GIS technique of ‘rubber-sheeting’ historical railway maps onto a map showing the location of the estates, and then measuring the appropriate lengths on an annual basis (James 1983). To test our results for robustness, we also estimate rents using the Euclidian distance between the center of the estate and the railhead measured on an annual basis. One difficulty with the second approach is that the Euclidian distance from the estate to nearest railhead will almost certainly overestimate the access to rail, since actual travel distance to the rail is likely larger than the simple linear distance measure (Hsiao, Lu, Sterling and Rutherford 1997; Gutierrez and Garcia-Palomares 2008).

There are two obvious objections to our method of calculating access to track. The first is deciding on the central point within each estate to which measurements of access to railway track are linked. The estates were large, and the landowner’s seat, or mansion, was not necessarily at the center of the land he owned. By measuring the amount of track within 40 kilometers and the mean rent this problem is to some extent remedied. As an illustration of the access to railway track enjoyed by tenant farmers, figure 5 shows Holkham Hall, on the east coast of England, with the railway track available in 1865. There were several stations along the lines (not shown) at which freight could



be loaded or unloaded. It is clear that access to the track is almost equal for each of the farms shown. Holkham's 181 kilometers is much less than the sample mean of 411 kilometers and so for those estates with more track, there was even greater equality of access from each farm.

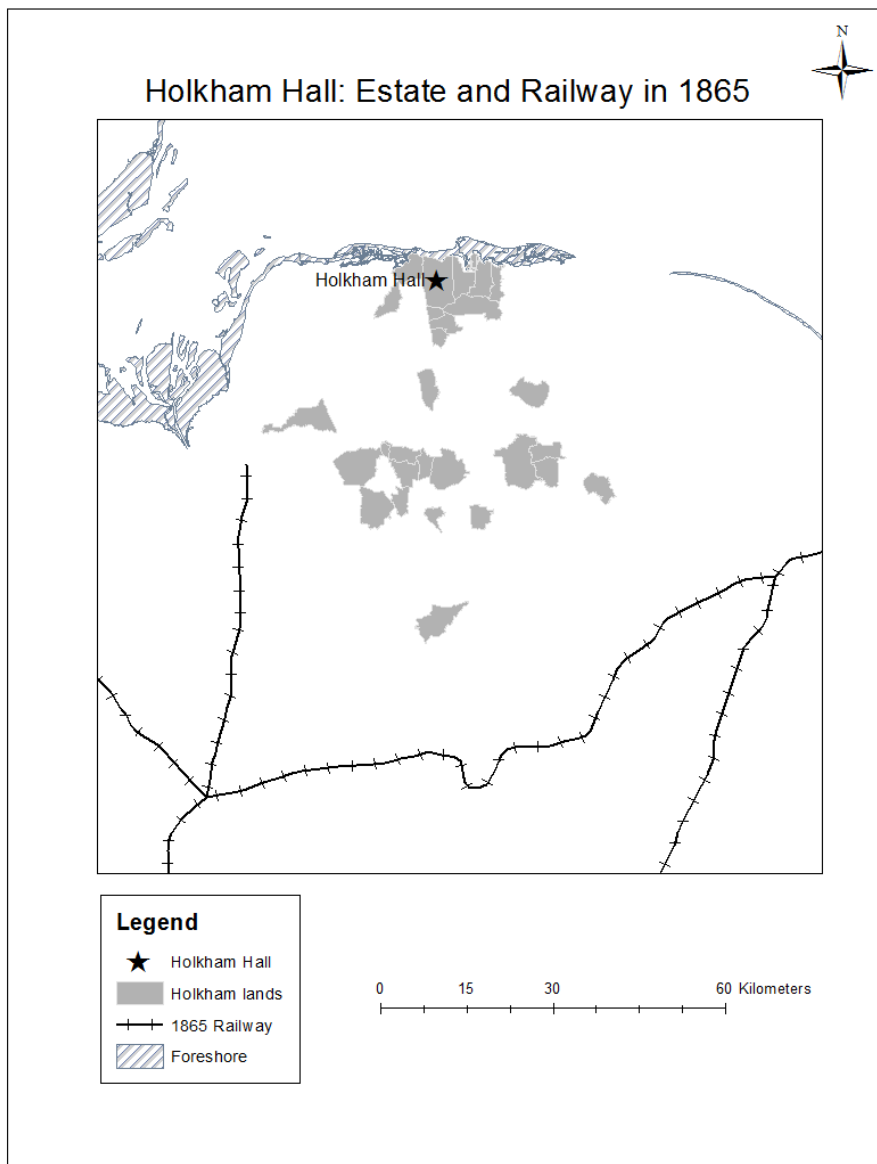


Figure 5. Holkham Hall's land and railway, 1865.

Source: Parker (1975) and author.

A second difficulty concerns the diffusion of land registered as belonging to a particular landowner but in fact located at some distance from the landowner's seat. Of the 31 estates which make up our sample, and which are described in more detail below, we are reasonably confident that 21 estates had at least the bulk of their land within the 40 kilometer buffer zone. We estimated the effect of track for both the 31 and the 21 estates, and the results are very similar. A list of the estates indicating the location of their land appears as table 8 below. An estimation comparing results from the 31 and the 21 estates is provided below as table 8.

Table 7. Estates and their lands

Source: Extracted from data appearing in Turner, Beckett and Afton (2001), see Appendix: Data Sources, page 191.

<b>Estate</b>	<b>Within 40km</b>	<b>Comment</b>
Bolton Abbey	Yes	
Cholmondeley	Yes	
Dalemain	No	Land in both Cumberland and Westmorland
Holker	Yes	
Badminton	Yes	
Bradford	Yes	
Guy's Estate Herefordshire	Yes	
Lichfield Staffordshire	Yes	
Tavistock	No	Land in both Cornwall and Devon
Ashburnham	Yes	
Barking	Yes	
Chevening	No	Land in both Kent and Surrey
Cornwallis	No	Land in both Kent and Sussex
Guy's Estate Essex	Yes	
Guy's Estate Lincolnshire	Yes	
Higham Ferrers	No	Professor Allen's comment of dispersion
Holkham	Yes	
Maxstoke	No	Land in both Warwickshire and Staffordshire
Milton	No	Land in both Northamptonshire and Huntingdonshire
Normanton	Yes	
Petworth	Yes	
Thorndon	Yes	
Ancaster Lincs	Yes	Separate entry (Normanton) for Ancaster's Rutland estate
Beighton	No	Land in both Yorkshire and Derbyshire
Castle Howard	No	Land in both North and East Ridings of Yorkshire
Chatsworth	Yes	
Emanuel	Yes	
Greenwich Hospital	No	Land in Northumberland and Cumberland
Holme Pierrepont	Yes	
Leconfield	Yes	
Thoresby	Yes	

An estimation of the change in agricultural rents with railway proximity requires a rent series and lengths of railway track. Consistent records of historical agricultural rents are rare, and we acknowledge the scholarship of Turner, Beckett and Afton (1997) in publishing those records that have survived. Their records contain 31 estates with a complete rent series for the period under consideration, 1832-65. Full sources of the data are given in the Appendix: Data Sources on page 191.

The 31 estates range in size from 3,000 acres to 10,000 acres and were privately owned, apart from five estates under institutional ownership. The estates are scattered throughout England, as shown in figure 6. The annual rent per acre for each estate is the dependent variable in the estimation of the effect that a change in accessibility to railway track has on rent.

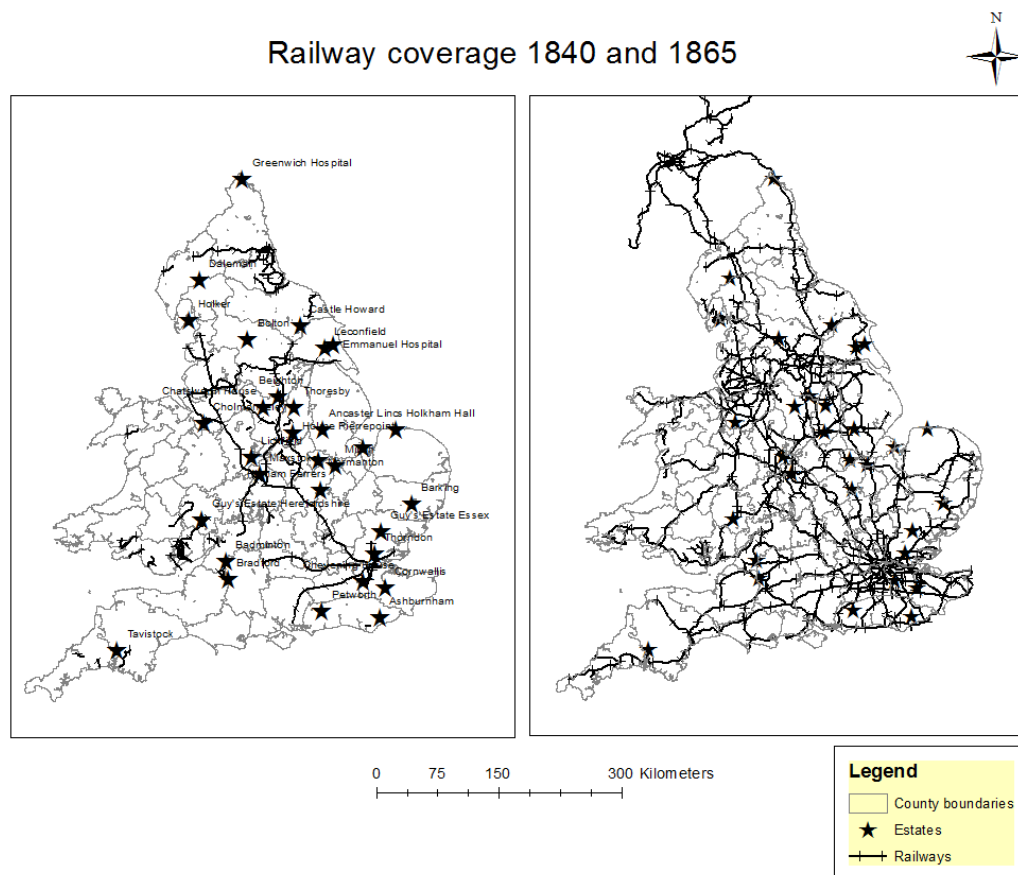


Figure 6. The 31 estates with railways in 1840 and 1865.

Source: Author's mapping from the records provided by Turner, Beckett and Afton (1997) and James (1983).

The very survival of the rent records of these particular estates suggests selection bias, but it is not clear what effect such selection bias would have on our estimates. If anything, one may suspect that large estates with consistent records were better managed, and therefore better able to extract surplus from

their tenant farmers. To check if the rents charged by these estates were similar to other rents at the time, we compare the rents per acre of five large estates with the arable and pasture rents of adjacent land for 1836, the year when we observe a broad range of rents from the tithe files. Depending on the weighting given to arable and pasture rents, the estate rents appear to be consistent.

Estate	Rent per acre	Unenclosed	Arable	Pasture
Tavistock	18	Peter Tavy	14	24
Badminton	24	Horton	17	21
Bradford	28	Monkton	28	30
		Farleigh		
Longleat	20	Chilmark	16	26
Lilleshall	25	Bromsgrove	25	32

Table 8. Rents of large estates and parishes 1836.

(Source: Kain and Prince (1985) and Turner, Beckett and Afton (2001), more detail given in the Appendix: Data Sources on page 191.)

Note: rents are in shilling per acre for land held in large estates compared to land in smaller neighboring parcels. The figures are for the year 1836.

Rents were increasing over our period, as was the amount of rail. Figure 3 shows distance to railway station and rents, and distances to nearest railway

station over time. These data are the averages of the 31 estates, collected by year.

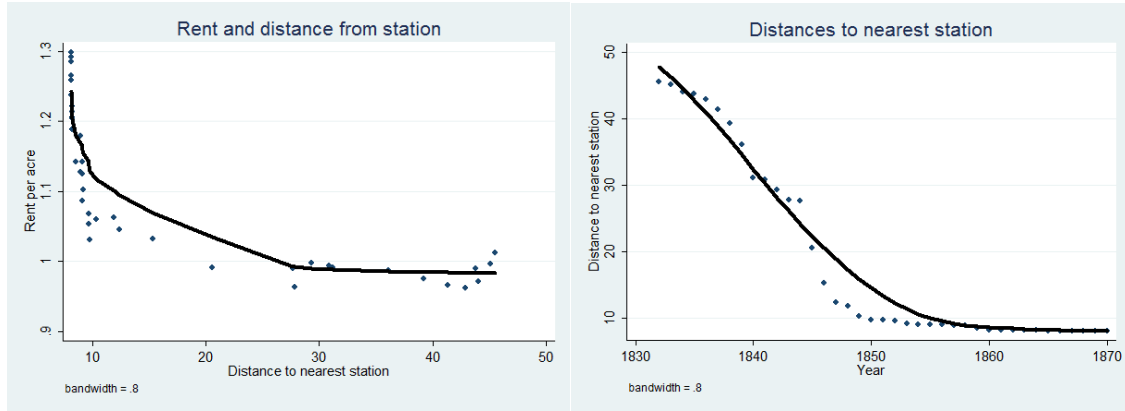


Figure 7. Annual rent and distance to station 1832-1870.

Source: author's calculations.

To test for the effect of proximity to railway track, we regress the deflated annual rents per acre of the 31 agricultural estates over the years 1832-65, using a Ricardian model of the form given above. The important independent variables in the regression are the distance to the nearest station, and the cumulative amount of railway track within 40 kilometers. We include an interaction variable, which is the measure of track availability multiplied by years elapsed since 1832, as well as a time trend. The interaction variable is included to test whether the effect of increased rail access on rent increased or decreased over time.



We include two further sets of independent variables apart from track. Time-variant variables are the deflated London prices of various agricultural commodities (Clark 2004). We also include climate variables, using a set of climate ‘normals’ calculated from a thirty-year average. We specifically control for March rain and July rain, with their quadratic terms, because rainfall during these two particular months was of great importance to the 19<sup>th</sup> century arable farmer, and more so than to his present-day counterpart. The early Victorian farmer lacked modern equipment such as irrigation methods, drying-sheds and combine-harvesters and, as Brunt (2004) finds, these two months were critical. We expect the sign for March rain to be negative, but March rain squared to be positive. March rains can delay spring seeding, but some soil moisture will aid plant growth. By contrast, the signs for July rain will be the opposite, because some rain is needed, but too much rain can damage the standing crops. The 19<sup>th</sup> century farmer had no defense against the ‘rust’ which forms on wet wheat, and the cost of harvesting wheat was higher when the crop was wet (Brunt 2004).

To find site-specific climate data, we use GIS to develop a raster of interpolated values between climate stations. We construct a circular buffer region of 10 kilometers in radius around each estate, and incorporate the interpolated climate data into each buffer. A radius of 10 kilometers provides a buffer area of slightly more than 77,000 acres. This area is larger than any of the estates, and therefore helps to smooth out local effects. The source is the

UK Meteorological Office, described in the Appendix: Data Sources on page 191. We obtain the elevation of each estate from a digital elevation map. We also include a time trend to capture unrelated productivity improvements and population growth over this time period.

### *Statistical methodology*

The dependent variable is the deflated rent per acre per year for each of the 31 estates. The equilibration process of rent and access to lower cost transportation described above is theoretical, may not occur immediately in reality. The number of prospective tenants varies, reducing or increasing the competition; length of time between rent renegotiations is not constant; and both parties will use the previous rent as a reference point. In addition, there may be some asymmetry of knowledge, in that the tenant, especially if he has cultivated the same land for some years, may have more information about that land's potential. The previous rent therefore carries a great deal of information, which we wish to retain. However, inclusion of the lagged dependent variable also brings with it an endogeneity problem. This concern arises because the lagged dependent variable is correlated with the random intercept, having been affected by the random intercept (Rabe-Hesketh and Skrondal 2008). A solution is to use lagged dependent variables as instruments

(Arellano and Bond 1991; Arellano and Bover 1995; Blundell and Bond 1998). Examples of applications of the dynamic panel data methodology are given by Fitzpatrick and McQuinn (2005). Because each estate may have unobservable characteristics associated with rent that may be correlated with access to rail, we also estimate the model using estate fixed effects.

We then use the results of our regression to simulate the effects of the advent of rail for all of British agriculture in 1865, the same reference year used by Gary Hawke (1970). By 1865, the railway expansion had largely occurred and the greater portion of England was covered by rail, (David Turnock 1998). If we can assume that our 31 estates are spatially representative of England and Wales, then the long run total savings are given by  $\frac{b_1 * A * \bar{k}}{(1 - b_2)}$  where  $b_1$  is the rent increase in pounds sterling for each kilometer increase in railway track,  $A$  is the agricultural area at the national level,  $\bar{k}$  is the mean amount of track available for the 31 estates and  $b_2$  is the coefficient on the lagged dependent variable.

### **Results: estimation for 1832-1865**

Our first task is to estimate the change in rent over the period 1832-1865. We do this with two random effects dynamic models, a fixed effects model and a

spatial panel model using fixed effects. In each case, the dependent variable is the deflated rent per acre for each estate. Model A is a dynamic random effects estimation, with the cumulative amount of track within 40 kilometers (*Track within 40 km*) as the independent variable of interest. Model B is a fixed effects estimation with the same variables, and is included as a robustness check. Model C is a dynamic random effects model with distance to nearest station (*Dist to station*) as the key explanatory variable.

VARIABLES	Model A Rent	Model B Rent	Model C Rent
Lagged rent	0.615*** (0.0677)	0.661*** (0.0509)	0.636*** (0.0692)
<b>Track within 40km</b>	<b>0.000355***</b> (0.000102)	<b>0.000332***</b> (6.29e-05)	
Year x track	-1.49e-05*** (3.41e-06)	-9.80e-06*** (2.33e-06)	
Index 1832=0	0.00630*** (0.00207)	0.00336*** (0.000859)	0.000496 (0.00122)
Milk	0.0261*** (0.00383)	0.0248*** (0.00311)	0.0204*** (0.00318)
Beef	0.0288** (0.0143)	0.0336*** (0.00862)	0.0279** (0.0138)
Wheat	-0.0181*** (0.00491)	-0.0126*** (0.00286)	-0.0177*** (0.00459)
Cheese	0.0345** (0.0143)	0.0336*** (0.00907)	0.0459*** (0.0123)
Elevation	-0.00394** (0.00187)		-0.00391** (0.00198)
July rain	0.811*** (0.273)		0.834*** (0.267)
July rain sq	-0.00877*** (0.00308)		-0.00902*** (0.00303)

March rain	-0.258*** (0.0851)		-0.272*** (0.0822)
March rain sq	0.00266*** (0.000965)		0.00279*** (0.000942)
<b>Dist to station</b>			<b>-0.00224***</b> (0.000500)
Year x dist			0.000200*** (5.23e-05)
Constant	-12.41*** (4.191)	-0.277*** (0.0754)	-12.51*** (4.113)
Observations	952	952	953
R-squared		0.771	
Number of estates	31	31	31

Robust standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table 9. Rents and access to track.

A comparison between Models A and B shows that the dynamic panel approach and the simple fixed effects approach, used as a robustness check, present very similar results in particular for the independent variable of interest, *Track within 40 km* (in bold). Model C, a further robustness check, uses the distance from the estate to the nearest railway station *Dist to station* (in bold) as the railway-related variable, and is included as a robustness check. We use Model A in our calculation of social savings.

The coefficient for *Track within 40 km* is positive, showing that rent increases with more nearby track, as Ricardian rent theory would suggest. The interaction variable *Year×track* has a negative sign which implies that the rate

of change of rent is decreasing over time. Much of the rail construction in the second half of the 1832-1865 time-period was the building of shorter lines within urban areas. The main network had already been built, and so the room for cost-savings was reduced.

The model includes the deflated prices of five agricultural commodities, *Milk*, *Beef*, *Cheese* and *Wheat*. These are all highly significant. The wheat price variable has a negative sign, perhaps reflecting the move away from arable and towards livestock in this period. The Corn Laws were repealed in 1846, and foreign wheat began to compete with domestic foreign wheat, albeit slowly at first. Rail would have further increased the price competition between domestic and imported wheat. The more astute farmers moved from grain to livestock, and the signs for *Wheat* (negative) and *Beef* (positive) reflect this shift. In addition, there was a very gradual movement towards feeding of animals with grain when grain prices fell and fodder was short, increasing the profitability of livestock farming (Turner, Beckett and Afton 2001). The coefficients on interactions between commodity variables and track were not significant, indicating that there was no change in the relative value of the railways for those commodities over time. The climate variables are all highly significant and are as expected.

One might be concerned that rents are likely correlated across space, giving rise to problems associated with spatial autocorrelation (Anselin 1998).

We test the residuals of the simple OLS model for spatial correlation using a 4 nearest neighbor, 6 nearest neighbor and a distance weights matrix using the Moran's I statistic, and in all cases we observe no evidence of spatial correlation. This result is likely due to the fact that our estates are distributed across space in such a way that none is particularly close to the other.

Above we discussed a comparison of results for the full sample of 31 estates and the restricted sample of 21. The larger sample contains estates whose land may not be entirely contained within a 40 kilometer radius. The results are below.

VARIABLES	The 31 estates Rent	The 21 estates Rent
Lagged rent	0.615*** (0.0677)	0.577*** (0.0784)
Track within 40km	0.000355*** (0.000102)	0.000415*** (0.000134)
Year x track	-1.49e-05*** (3.41e-06)	-1.65e-05*** (4.58e-06)
Index 1832=0	0.00630*** (0.00207)	0.00607*** (0.00230)
Milk	0.0261*** (0.00383)	0.0245*** (0.00512)
Beef	0.0288** (0.0143)	0.0240 (0.0190)
Wheat	-0.0181*** (0.00491)	-0.0192*** (0.00555)
Cheese	0.0345** (0.0143)	0.0380* (0.0198)
Elevation	-0.00394** (0.00187)	-0.00174* (0.00101)

July rain	0.811*** (0.273)	0.692*** (0.177)
July rain sq	-0.00877*** (0.00308)	-0.00733*** (0.00204)
March rain	-0.258*** (0.0851)	-0.247*** (0.0657)
March rain sq	0.00266*** (0.000965)	0.00236*** (0.000728)
Constant	-12.41*** (4.191)	-9.806*** (2.650)
Observations	952	654
Number of fid	31	21

Robust standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table 10. Comparing the 31 and 21 estates.

The results are very similar and we use the more conservative results for the 31 estates in the calculation of savings at the national level which follows.

### **Valuation of the savings at the national level**

The coefficients estimated in Table 9 provide the mean increase in rent per acre for a one kilometer increase in railway track availability. The increase in rent is the amount of money a tenant would be prepared to pay in return for the benefits provided by the railway. To find the savings at the national level for 1865, we multiply the coefficient for rent increase per added kilometer within



40 kilometer by the mean length of track within 40 kilometers. This provides the mean increase per acre for the 31 estates.

We first extend this estimate to the national scale by multiplying the mean increase by the agricultural area for England and Wales. Later, we repeat the estimates at the regional level. For the national level, the coefficient is found from Table 2. The mean track is the mean length of track within 40 kilometers of the 31 estates in 1865 (411.76 kilometers, standard deviation 197 kilometers). The total agricultural area is 24.5 million acres, recorded as an estimate for 1865 by HMSO (1968). The GDP is £822 million, the nominal GDP for 1865 used by Hawke (1970) and provided by Mitchell and Deane (1962, p. 367).

Table 11. Social Savings 1865.

The figures are in £1,000s. Source: Hawke (1970) and author's calculations.

<b>Hawke</b>	<b>Min</b>	<b>Mean</b>	<b>Max</b>
Wheat	8		300
Stock	407		2,600
Hawke Total	487	1,694	2,900
<b>Authors Calculations</b>			

<b>Model A ('buffer')</b>			
Total Agriculture	8,054	9,296	10,550
Difference	7,567	7,602	7,650
<b>Model C ('nearest station')</b>			
Total Agriculture	4,011	5,700	7,127
Difference	3,524	5,908	4,227

Table 11 compares the estimates made by Gary Hawke (1970) with those of the authors. The figures are in thousands of pounds sterling. Hawke calculates savings separately for wheat and pastoral production, where pastoral production includes both livestock and deadstock. Gains to the national economy from the transportation of imported wheat have been excluded.

We provide the arithmetic mean for Hawke's calculation, but are careful to note that he did not provide a mean, only lower and upper bounds, and was generally cautious in his conclusions. We provide a 95 per cent confidence interval for our two models. Model A uses the cumulative length of track within 40 kilometers of the estate as the independent variables for the effect of railway access, while Model C uses the distance from the estate to the nearest railhead measured annually. The rows marked 'Difference' provides the authors'

calculations less that of Hawke. We use Model A in our calculations below in preference to Model C because the Euclidian distance to nearest station is likely an underestimate of the actual distance. Further, we do not know that the farmers used the nearest railway station in preference to another station which might perhaps have been further away but which offered superior facilities. Timetables, terrain between the station and the estate and provision of livestock cars would also have affected his choice of station.

The mean figure from Hawke's work, provided in table 11, is £1,694 thousands. Hawke uses a figure of £822 million for the GDP of 1865, resulting in a social saving of just over 0.2 per cent. The estimate of the total saving from the railways that we use is the mean saving; £9,296 thousands, more than five times his estimate. Using the same figure for GDP provides a percentage of 1.13.

Now we are in a position to split the benefits of railway access into its components: the cost savings from being able to move production by rail compared to droving and the second resulting from production changes. We find railways generated a further £7,602 thousand in savings beyond Hawke's mean calculation of savings from direct transport costs. This figure appears in the row 'difference' in table 3 for Model A. The difference is worth just over 0.92 per cent of GDP. In other words, the extra 0.92 per cent quantifies the improvements that entrepreneurial farmers enjoyed when they took advantage

of the new production possibilities offered by the railways. Agriculture's annual total production in the 1860s was approximately £120 million (Deane and Cole 1980), and so the total saving produced by the railways was worth 7.75 per cent of this figure, while the productivity gain driven by rail in 1865 over and above pure changes in moving product amounts to well over half of that.

Although agriculture's share of national GDP dwindled from 23.4 per cent in 1831 to 14.2 per cent in 1871 (Deane and Cole 1980), agriculture's own GDP was increasing as a consequence of feeding a larger and wealthier population. The railways helped this process along by facilitating transport to these new markets. Shortly after the beginning of our time-period, the railways contributed 0.5 per cent of agricultural GDP. The share rose steadily, reaching nearly 8 per cent of agricultural GDP by 1865. Figure 3 shows the social savings from the use of railways in agricultural as a share of national GDP (solid line, right vertical axis) and agricultural GDP (dashed line, left vertical axis).

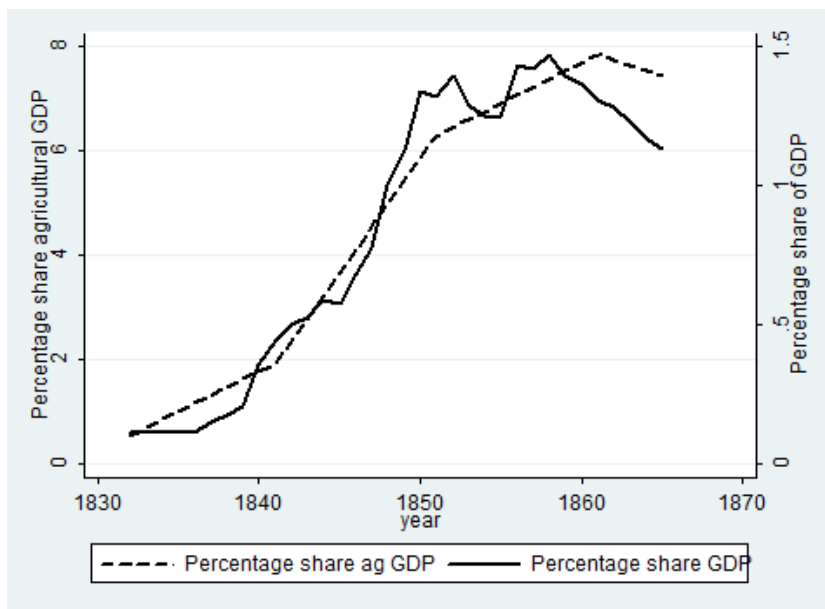


Figure 8. Social savings as a share of GDP.

Source: calculations by authors, see text, and Deane and Cole (1980).

In total, we calculate that the advent of rail added £9.30 million to agriculture in the 30 year period from 1831 to 1861, while agricultural GDP grew by £39.3 million over those same three decades (Deane and Cole 1980).

### Calculations at the regional level

Recently, Geary and Stark (2002) have provided a means for calculating GDP by region. They provide results for 1871 for eight regions within England. Using the estimates provided by Geary and Stark, we wish to find whether

there was a regional variation in the contribution of the railways. There are some difficulties. First, our sample size is only 31, and so allocating the 31 estates over eight regions would result in a very small sample for each region. We have therefore divided England into four zones (northeast, southeast, southwest and northwest) and allocated estates to zones. Second, we used the HMSO estimate of 24.5 million acres for the cultivated area of England and Wales for the national figure. We now need to allocate that area among the four regions. The southern part of England contains more land than the north, and so we have allocated two-thirds to the two southern regions and one-third to the two northern regions. We have also calculated the mean track for the estates within each region, and then found the contributions on a regional basis. The result is below in table 13.

Region	Mean Track kms	Coefficient	Savings £M	GDP 1871 £M	Share per cent
NE	453	2.97E-04	1.22	120.7	1.01
SE	419	5.94E-04	4.84	364.3	1.33
SW	339	1.77E-04	1.75	73.7	2.37
NW	381	3.52E-04	2.03	201.6	1

Table 12. Regional contributions.

Source: Geary and Stark (2002) and author's calculations.

The regional differences in savings are interesting. The southeast has the greatest savings by far, almost certainly because of the importance of the London market. Perhaps more interesting is the result for the southwest. The southwest was almost entirely agricultural at this time, and lagged behind the rest of Britain in virtually all spheres of development. The railway came late to the southwest not reaching Exeter until 1844 (James 1983), probably because the amount of mineral deposits was small. As a result the mean length of track within each estate was rather smaller than elsewhere. However, regional GDP was sufficiently small that the savings made by the railway were greater.

### **Consumer surplus and competition**

Our calculations above are restricted to the wealth created for the agricultural sector by the railways, and we have not considered the total consumer surplus or TCS (Jara-Diaz 1986). This is because we wish to test the results found by Hawke (1970) against those produced by a newer methodology. The TCS would include reduction in the cost of agricultural commodities at the market and the less quantifiable improvements in the quality and range of foodstuffs available.

Although the development of the railway companies and their tracks was financed entirely privately, Parliament was concerned about the potential for an oligopolistic outcome. Railway companies were warned that “large scale

mergers were unlikely to win Parliamentary approval” and might invite unwelcome scrutiny (Channon 2001, p.110). Railway companies avoided some of the scrutiny by charging all customers equally for supposedly equal services, with a Railway Clearing House, set up in 1842, as the accountant for inter-company revenues. The reduced rates induced by competition would form part of the TCS but there is little data to work with.

Competition between railway companies and their closest rival for livestock, coastal steamers, is more informative. Cattle were moved by sea from the continental Europe to Britain via the port of Harwich using a well-developed system of steamers. In 1863, the Great Eastern Company began its own service of steamers, linked to its railway terminus in Harwich. The effect was to reduce the charges of the existing steamship companies. An estimate of the transport cost savings as a result of the competition is £125,000 for 1865 (Hawke 1970, p.143) which may or may not have been passed on to the consumer.

## **Discussion**

The development of the railways during the time-period 1832-65 provided farmers with a serendipitous solution to the old problem of how to transport goods to market. The early railway entrepreneurs built their lines first for



mineral, and then human, rather than animal transport. As we have noted above, there is considerable anecdotal evidence of farmers making use of the railways to save costs. Arable farmers saved money on the cost of bringing heavy inputs, such as fertilizers to the farm, while livestock farmers were able to reduce the loss of weight in their livestock which resulted from droving. Agricultural location theory would suggest that the savings in cost would be bid away by other prospective tenants and transferred to the landowners as an increased rent.

Our finding is that the savings were 1.13 per cent of GDP for 1865, rather more than the range of 0.05 to 0.31 per cent of GDP calculated by Gary Hawke (1970).<sup>11</sup> Our estimates are probably a lower bound because we have made the implicit assumption that all the gains from the railways were passed on to the landowner as higher rent. It is possible, perhaps even likely, that the tenant was able to retain some share of the gains. In Chapter 4 we show that tenant farmers self-organized against the repeal of the Corn Laws in 1846. If rents moved as seamlessly as Ricardian theory suggests, then the retention of some of the surplus goes towards explaining their response to loss of domestic protection.

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<sup>11</sup> Hawke makes similar social savings calculations for wheat, but finds these to be extremely small. This finding is plausible, because wheat is not perishable and was historically transported by the cheaper canal and sea routes. There is little evidence of farmers transporting wheat by rail, whereas cattle freight volumes form a part of the records of several railway companies (P.P. 1867).

We were also able to split the contribution from the railways into the portion coming from a straightforward saving on transport costs, and an increase in productivity as a result of reduced transport costs. The two contributions were respectively 0.2 and 0.92 per cent of GDP in 1865. In addition, we have shown that the regional contributions of the railways varied in the way that might be expected. The savings in absolute form were greatest in the more developed south-east, which included London, but were higher in terms of share of regional GDP in the less-developed south-west. This pattern fits the same pattern in the comparison between countries described in the introduction. The share of the social savings in the U.S. and Britain was rather smaller than the share in less developed countries, such as India and Brazil.

As we have stressed throughout this article, the contribution of the railways was not limited to savings on transport costs to farmers. The railways allowed farmers to choose between a wider choice of production alternatives, and pick the production mixture most profitable to them. The example of Cornish strawberries being sold in London, noted in the Introduction, is emblematic of the wider choice (Schwartz 2010).

Considerable sums of money were transferred to landowners in the form of the higher rent resulting from the availability of railway track, as we have shown above. A natural destination for funds received as a result of transport improvements would be investment in railway stock, and there is evidence that

landowners did finance construction of railways near to their estates. Coke of Norfolk, owner of the Holkham Hall that appears in figure 1 and a noted 'improver', spent a significant part of his rental income on local railways (Wade Martins 1980). In another example, the dukes of Buccleuch and Devonshire jointly advanced the large sum of £30,000 for a local railway in 1844 (Beckett 1989). The effect can only have been to increase the productivity of their estates and thus to raise rents yet further.

The era of railway expansion is marked by the Corn Laws crisis of 1846, during which Sir Robert Peel's government achieved the feat of making a parliament of landowners vote away the import tariffs on wheat provided by the Corn Laws (McLean and Bustani 1999). A rather flimsy justification for the imposition of the Corn Laws in 1815 had been the need to stimulate domestic agriculture at a time of insecure foreign food supplies. In the first half of the 19<sup>th</sup> century, agricultural production did grow quickly (Broadberry et al. 2011; Allen 2005), and very little foreign wheat was imported (Fairlie 1965). By the 1840s, the point came when, as Susan Fairlie writes, the Corn Laws were not protecting the British farmer 'against a continental post-war glut', but were instead leading to 'a situation in which their retention threatened Britain with famine' (Fairlie 1965). Peel, a landowner himself, observed that British agriculture no longer needed protection, and therefore the Corn Laws might be repealed in the national interest (Evans 2006). As we have shown above, the railways contributed to the speed with which agricultural productivity

increased, and by encouraging livestock over grain production (Jones 1962), it is possible that they advanced the timing of the repeal of the Corn Laws.

While the method we have demonstrated does produce estimates without the need for a great deal of data, there are some drawbacks. First, the method relies on the assumption of a complete pass-through of cost-savings to the landowner. Given that we might assume that a portion of this surplus remained in the hands of the tenant farmers, our estimates of the social savings would be a lower bound on the true benefits to agriculture of rail. Unfortunately it is not possible to test for this because the extent of surplus extraction would depend on the character and skills of the landowner or his agent. However, we do know that there were usually more prospective tenants than farms available, especially for the better-managed estates (Wade Martins 1980). A second drawback is that our sample consists only of land collected in large estates, each owned by one man. That said, when we compare our sample to rents charged for smaller parcels, it appears as if rents charged within a county are similar to those we use for our analysis.

Finally, our method relies more heavily on inference than the cost-benefit method. The reduction in data requirements comes at the expense of the assumption that the amount of railway track surrounding the 31 estates provides a representative sample of all agricultural land in England and Wales. We think the assumption is valid because the sample includes estates in

heavily rural areas remote from London (for example Holker in the northwest) as well as estates on the fringes of London itself (for example Thorndon). In addition, as have argued above, a great deal of the railway network which was eventually to cover the whole country was completed by 1865 (Turnock 1998). As a simple test, at the national level in 1865 there were 0.076 kilometers per square kilometer. For the 31 estates the ratio is virtually the same at 0.08 kilometers per square kilometer. As a result, while we are confident that the distribution of railway track to rural regions was reasonably equal, it remains the case that we need to assume that our estates are representative of the agricultural nation as a whole.

## **Conclusion**

Hawke (1970) writes that agricultural historians have laid considerable emphasis on the importance of the railways, citing Orwin and Whetham (1964) and Chambers and Mingay (1966). Hawke disagrees with their views, stating that the railway trade in “livestock and dead meat had interesting qualitative effects on the economy of England and Wales, but the quantitative effects on the growth of that economy were not large” (Hawke 1970, p. 156). While our measure of social savings remains small relative to total GDP, and is only 7.8 percent of agricultural GDP, our result appears to be in favor of the

agricultural historians. Railways did contribute to economic growth by eliminating the waste of weight in livestock that resulted from droving, and, more importantly, by allowing farmers to participate in a wider range of farming activities. By facilitating these alternative activities, the railways substantively contributed to the productivity of agriculture and may have accelerated the repeal of the Corn Laws in 1846. In addition there would surely have been consumer benefits which we have not calculated.

We have offered an alternative method of calculating social savings from the building of the railways. Our method is dynamic, and incorporates observed behavior, rather than relying on assumed elasticities. By contrast, the cost-benefit method as used by Hawke (1970) does not incorporate the changes in economic behavior that agents undertake in response to fresh opportunities offered by the new technology. We provided anecdotal evidence of surprisingly quick adaptations, such as the extension of milk sheds, or livestock production structures.

Despite the increase, it remains the case that the contribution of freight by rail of agricultural commodities was only a small proportion of GDP. This might be because England and Wales already had a relatively sophisticated system of markets, as Nick Crafts (2005) has pointed out, and GDP was growing quickly as a result of manufacturing unrelated to agriculture. In addition, we have restricted ourselves to the savings induced at the farm level,

and have therefore not taken into account the savings that were almost certainly enjoyed by the final consumer. The total consumer surplus from the use of railways by agriculture will surely have been much larger.

Our work is in a similar spirit to a number of recent papers looking at the productivity enhancements brought about by transportation and communication technologies. In many ways, the introduction of the railways is paralleled by the introduction of cellphones into previously unconnected rural areas (Chong, Galdo and Torero 2005) because both new technologies reduce both the costs of doing business and asymmetries in information. As with the Peruvian villagers studied by Chong, Galdo and Torero, British farmers had no control over the location and timing of their new technology, but showed that they could capitalize very quickly on the new opportunities that this technology opened for them.

## Chapter 4. Constituency interests and the Corn Laws Crisis of 1846

Sir Robert Peel's Conservative Party won the 1841 General Election on a platform of 'altar, cottage and throne', meaning the continued supremacy of the Anglican Church and domestic protection for agriculture. From 1815 to 1846 the Corn Laws protected the British wheat market, and their continuation became almost an article of faith for the Conservative Party. As a result, landowners and their tenants persisted in the belief that agricultural protection would continue indefinitely. Tenant farmers had been active in pushing for tariff protection from foreign wheat at the end of the French Wars in 1815, and continued to make their wishes heard (Crosby 1977). Accordingly, the national acreage laid to wheat was predicated on the continuance of tariff protection. In addition, rural areas tended to worship at Anglican churches and, as we show below, were resistant to any move that might be construed as supporting the Roman Catholic Church. Yet Peel effectively sabotaged that platform within four years of gaining office by both voting funds towards the Irish Catholic Seminary at Maynooth and repealing the Corn Laws. The response from the counties was vigorous, leading to Peel's forced resignation shortly after Repeal had been passed by the House of Lords in 1846.

The purpose of this chapter is to measure the pressures that Members of Parliament (MPs) felt during the debates over Maynooth and Repeal, to estimate



the pressures, and then to discuss the change in the number of contested seats in the subsequent 1847 General Election.

Peel's decision to move towards the removal of protection for domestic wheat markets has attracted a very large literature, perhaps because none of the main schools of political economy can explain why a parliament of landowners voted in apparent contradiction of their own interests. As Iain McLean writes, "the median member of each house voted in favor of Repeal, whereas any model based on material interest predicts that he would have voted against" (McLean 1999, p. 2). Three strands of explanation appear in the more recent literature. Cheryl Schonhardt-Bailey characterizes the Conservative Party as a "coalition between two interest-based alliances", which ruptured when the Peelites "shifted their votes to match more closely the free-trade leaning preferences of their constituents" (Schonhart-Bailey 2003; Schonhart-Bailey 1988). She argues that changes in the electorate and the economy raised the political cost of maintaining a protectionist policy (Schonhart-Bailey 1988). It is certainly true that the electorate and the economy were changing. The 1832 Reform Act had widened the franchise to allow in more 'men of business', and industry's share of the economy was growing at the expense of agriculture. However, these were not overnight changes and so cannot explain the abrupt rupture in the "interest-based alliance" which occurred in 1845 (Howe 1997). A second strand in the literature depends more on ideology and less on economic interests. Timothy

McKeown argues that the changes that Schonhart-Bailey points to did indeed create a situation in which a “winning coalition for Corn Law abolition could be assembled” (McKeown 1989). He attributes the assembly to the Irish Repealers, but does not produce conclusive arguments for this. A third strand suggests that Peel was a master-strategist and political entrepreneur, constructing a winning coalition with the Whig opposition in order to save the aristocracy from itself (McLean 1999; Lusztig 1995). While the third strand provides an interesting and plausible explanation, it does not lend itself to analysis by the roll-call method.

The purpose of this chapter is not to attempt to ‘explain’ Repeal but, more modestly, to concentrate on the constituency influences placed on MPs in the months before Repeal. The argument is that tenant farmers were capable of independent thought and voting, and were able to make their preferences clear to their MPs. There is no claim that their political activities had a qualitative impact on the outcome of the Repeal vote, but the chapter does aim to show that in some rural constituencies their activities stiffened the resolve of some MPs to vote against Repeal. Elsewhere, researchers have asked why so many Conservative MPs voted with Robert Peel to repeal the Corn Laws, in the so-called Peel’s ‘puzzle’. Instead, we argue that had the tenant farmers taken no political action, the Conservatives who voted with Robert Peel in favor of Repeal of the Corn Laws might have been more numerous. As we noted above, tenant farmers forced the resignations of at least eight free-trading MPs, and at the

by-elections which followed, Conservatives pledged to vote against Repeal won the seats. This accounts for eight votes against Repeal, and no doubt other Conservatives quietly considered their position.

The contributions of the chapter include an analysis of voting by MPs in the Third Reading of Repeal in May 1846 and their subsequent probability of re-election in 1847. To estimate the pressures at the constituency level on the MP, we regress observed voting behavior against constituency and personal characteristics, with new sources of data integrated into constituency observations using GIS techniques. We have augmented the well-known Aydelotte dataset with observations for each constituency on the per capita amount of wheat imported or exported from the constituency, the share of tenant farmers in the electorate, the percentage of constituency residents worshipping at an Anglican church on Census Day 1851, the margin of victory in the preceding 1841 General Election <sup>12</sup>. The augmented dataset allows us to determine the relative importance of agriculture to a constituency given the level of security at which the MP held his seat. We also examine the 24 by-elections held in the months before the final Third Reading of Repeal in May 1846, and test the strength of tenant farmer influence in forcing the resignation of the sitting MP and in the election of his successor. We find that pastoralists and arable farmers did place different pressures on their MPs, and

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<sup>12</sup> Data sources are provided in the Appendix: Data Sources page 191.

that the voting of county MPs was somewhat influenced by the proportion of tenant farmers in their electorate.

## **Electoral competition**

In the 1840s, only a decade since the Reform Act of 1832, many seats were still uncontested. As Hugh Cunningham writes, “in a majority of the ten elections held between 1832 and 1868, one third or less of the seats were contested” (Cunningham 2001, p.35). However, as Norman Gash points out, the absence of contest does not mean that the candidate had not been subject to a selection process (Gash 1953). Deciding on the candidate in uncontested seats was usually the result of negotiations between the constituency’s magnates who wished to avoid the heavy cost of fighting an election.

There was however a gradual movement towards the contesting of elections, especially in the urban ‘borough’ seats. Gary Cox gives figures for the increase in contested elections: 59 per cent contested in the nine elections held after 1832, 80 per cent after 1867, and 86 per cent after 1885 (Cox 1987, p127). Reasons for the increase include the easier transport, especially within counties, provided by the new railways and, less obviously, by the increase in suffrage.

In the counties, progress seems to have been slower, possibly because landowners were still able, or considered themselves able, to marshal their tenants to vote as directed. As a result, the likely outcome of elections was more apparent and so a compromise could be reached more easily (Gash 1953).

The distribution of contested elections and constituency type appears below.

Contested	County	Small Boro'	Large Boro'	University	Total
Yes	70	111	140	0	321
No	185	88	58	6	337
	255	199	198	6	658

Table 13. Contested elections by type.

Results for the 1841 General Election. Source: see Appendix: Data Sources, page 191.

It is apparent that county and large borough elections were opposites. County elections were dominated by uncontested seats, while most elections in large boroughs had been contested.

Part of the contribution of this chapter is to measure the effect of having had to contest an election on the MP's voting over Repeal and, given that the MP had won his seat in an election, the effect of his winning margin on his voting. As we show below, those who had contested their seats were more likely

to vote for Repeal, but the more secure their victory, then the more likely they were to vote against Repeal.

## **Politics in the 1840s**

The Reform Bill of 1832, passed by a Whig government, had begun the construction of a wider and more representative franchise (Phillips and Wetherell 1995; Briggs 1959). Many of the old 'rotten boroughs' in which the electorate numbered only a handful all under the control of one man, had been swept away. The qualifications for gaining the vote were relaxed, and members of the emerging middle-class were able to vote for the first time in the General Election which followed the Reform Act. The new qualifications for the franchise were based on property, because a 'stake in the country' was an essential title to political power. The Reform Act passed through the House of Commons with 345 votes in favor, and 236 against, and went on to the House of Lords. During the debate in the Lords, the Marquis of Chandos, a prominent landowner and 'farmer's friend' instigated an amendment to give the county vote to tenant farmers with a rent of not less than £50 a year (Briggs 1959).

While the Reform Act was certainly a step towards democracy, the electorate was still not representative of the population. In addition, the old habits of vote-buying and pervasive 'influence' were still evident (Kitson Clark

1951). Apart from corruption, the politics of the time was marked by a lack of central party control over candidates, and candidates were able to make almost any promise they wished in order to gain election (O’Gorman 1982).

Apart from a brief spell in the 1830s, the Conservatives were out of government until 1841. During their time out of office, Robert Peel reorganized the party and, with Francis Bonham, developed a Conservative headquarters at the Carlton Club in London (Gash 1953). However, the seeds of the split within the Conservative Party can be dated from this time, and in particular the electoral platform by which the party regained power. The results of the 1841 General Election, and especially the Conservative Party’s successes in rural areas, are important to understanding the split between ‘Peelite’ and ‘Protectionist’ members of the party, and are discussed in more detail below.

### *The 1841 General Election*

The Conservative Party under Sir Robert Peel won the 1841 General Election with a clear but unbalanced majority. The Conservative electoral platform had stressed a commitment to the supremacy of the Church of England, the continuation of the monarchy and, most important, protection for the agricultural sector. Many MPs presented themselves as ‘the farmer’s friend’

and as a result the Conservatives won most of the rural constituencies. As Eric Evans writes, the Conservatives “were the party of rural England and its small market towns” (Evans 2006, p.46). Table 1 shows the distribution of seats by party and by type.

	<b>County</b>	<b>Urban</b>	<b>University</b>	<b>Total</b>
Conservative	184	179	6	369
Whig/Liberal	71	218	0	289
Total	255	397	6	658

Table 14. 1841 General Election Results.

The majority of Conservative MPs won their rural ‘county’ seats as a result of the ‘altar, throne and cottage’ platform, and most of them were strong Protectionists themselves. Peel had hinted at a reformist agenda in the Tamworth Manifesto of 1834, but nothing was heard of this agenda in 1841. During the Corn Laws crises, the accusations of ‘betrayal’ made by Protectionists against Peel were justified because, intent on a return to office, he had done nothing to inform potential voters of his true economic intentions. Conservative victory in 1841 was a victory for Protectionist Conservatism, not Peelite Conservatism (Evans 2006). As a result, Peel’s leadership was



dangerously exposed to rebellion consequent in any change in his policy over the narrow issues on which his party had won their seats. We now discuss the two major changes in policy which infuriated his rural backbenchers in particular. We begin with the Maynooth controversy.

### *The Maynooth Division*

Peel had begun his political career as Irish Secretary and was therefore familiar with the poverty and increasing unrest of Ireland. Although Ireland's problems were actually economic, Peel took the view improvement to the Irish education system would help to ease the rising unrest which was beginning to threaten the Act of Union between Ireland and England. He began with the Academic Institutions (Ireland) Act in 1845, but ran into heavy opposition from Anglicans and, less predictably, from the Vatican (Read, 1987:138). As a result, the proposed non-denominational colleges were never built.

Peel had more success, but at the cost of even more controversy, when he proposed to convert the annual grant to the Maynooth seminary into an endowment and to increase the amount of money. Rural backbenchers and the newspapers reacted to Maynooth with outrage. The core of the dissension concerned state support for a religious belief other than that of the established Church. Edward Miall, editor of the *Nonconformist*, wrote that the Maynooth

Bill was a ‘measure which can only be taken as a preliminary to the payment by the state of the Roman Catholic priesthood’ (Spall, 1990). Ten thousand petitions against Maynooth raised a million and a quarter signatures (Read, 1987). Harriet Martineau described the Maynooth Question as the ‘great political controversy of the year, the subject of which society seemed to be going mad’.

Peel’s Cabinet colleagues were aware of the political cost of Maynooth. Sir James Graham, Peel’s closest colleague, noted that ‘we have lost whatever slight hold which we ever possessed over the hearts and kind feelings of our followers’ (Parker, 1899). Graham was right. Of all Conservatives, 147 voted against the Government in the Second Reading, and 159 for the motion. The voting was even closer at the Third Reading, with the Conservatives being almost exactly divided. The motion was carried only because substantial numbers of the Whig-Liberal Opposition voted for the motion, a precursor for the Corn Laws division almost exactly a year later.

We are interested in the constituency-Church relationship at both levels because in the empirical section below we include each MP’s voting decision over Maynooth as a variable in the regression. To provide more depth, we examine the relationship between a political constituency and the Church of England at two levels. The first level is degree of support for the Church of England according to whether the constituency was agricultural, mixed or industrial. The second level concerns the alignment of interests between rural

clergy and the owners of arable land, an alignment made much of by the Anti-Corn Law League.

The 1851 Census of Religious Worship is unique in being the only census in which respondents were asked about their religious observance. There are obvious problems in analysing responses of this type, but it seems that observance at Anglican churches was highest in areas where the population density was lowest, and which were closer to London (Coleman, 1980). Dissent was concentrated in cities and industrial areas, typically in the north-west of the country. The tables below reports attendance at the Church of England against type of district.

```
. tab cofe_r4 dcdist,chi2
```

4 quantiles of cofe	dcdist			Total
	1	2	3	
1	24	27	111	162
2	24	89	36	149
3	64	66	15	145
4	80	47	7	134
Total	192	229	169	590

Pearson chi2(6) = 237.3856 Pr = 0.000

```
. somersd cofe_r4 dcdist
Somers' D with variable: cofe_r4
Transformation: Untransformed
Valid observations: 590
```

Symmetric 95% CI

cofe_r4	Coef.	Jackknife Std. Err.	z	P> z	[95% Conf. Interval]	
dcdist	-.4445169	.0296293	-15.00	0.000	-.5025892	-.3864446

Table 15. Church attendances.

Cross-tabulation of percentage of constituency residents attending an Anglican Church on census-day 1851. Source: see Appendix: Data Sources, p.191 para 11.

Here 'dcdist' is the categorisation of areas of Britain by 'type': 1 is agricultural; 2 is mixed; 3 is industrial. Rural areas apparently possessed more attendees at Anglican churches than other less agricultural areas. There is weak evidence ( $r = 0.25$ ) that Anglican attendance increased with the ratio between arable and livestock. Why this might be so is unclear. It is possible that the nature of the farming activity itself caused the difference. A study of religious attendance in Cheshire shows that morning work on dairy farms reduced attendance at Anglican morning services. The Methodists gained adherents by offering services later in the day (Coleman, 1980; Walker, 1966). Figure 4 below shows the distribution of Anglican attendance at the level of the county.

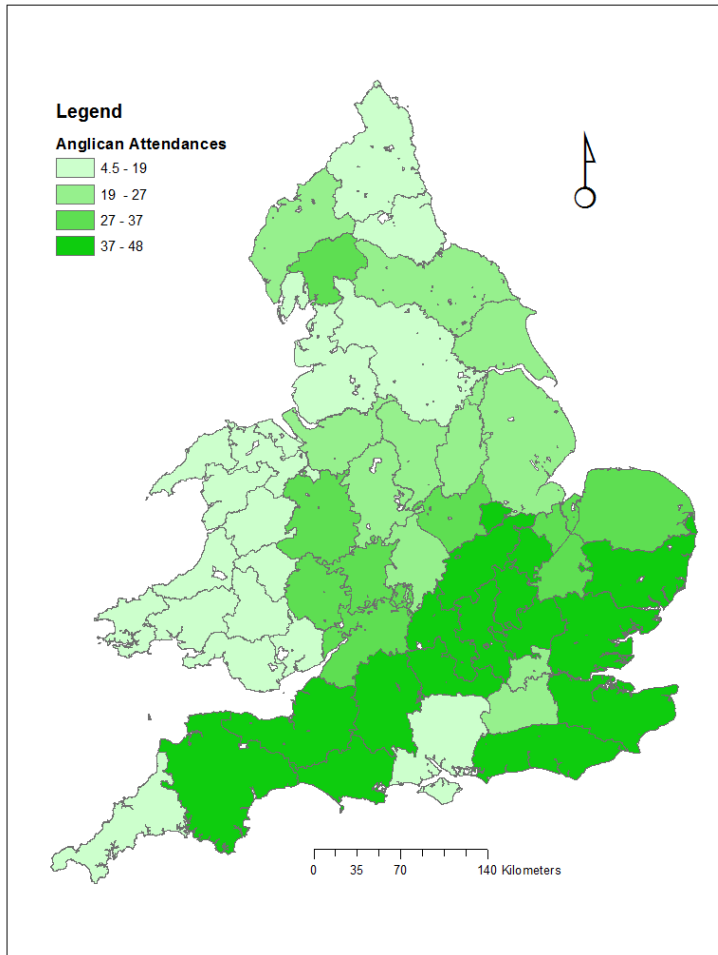


Figure 9. Anglican attendances.

Source: 1851 Census, mapping by author. Sources: see Appendix: Data Sources p.191 para 11.

We now discuss the alignment of interests between clergy and landowners. The ties between landed elites and the rural clergy were historically strong. For example, some landowners had the right to appoint

clergy to 'livings' within parishes controlled by them, and the clergy in return looked to landowners for their more general support. Anthony Trollope's Barchester Towers was a reality in many rural parts of England, and the system of clerical patronage was only just beginning its decline by mid-nineteenth century.

Anglican clergy had had for many years the right to a tithe of ten per cent of agricultural production within their parish. The extent to which the tithing was enforced depended on the voracity of the clergymen involved, and usually the relationship was amicable enough. The situation changed in the late 1820s and early 1830s when agricultural depression increased the resentment that farmers felt towards those clergy who insisted on exacting their tithe. Some reform of the tithe was clearly necessary and the Whig government instituted the Tithe Commutation Commission, which reported in 1836. The task of the Commission was to value the production of each titheable field, so that the physical harvest could be commuted to a 'corn rent' based on the average price of wheat over the previous seven years. Now not only farmers and landowners but also the clergy benefited from high wheat prices.

The obvious alignment of interests was a natural target for the Anti-Corn Law League, who attacked the credentials for Christianity of clergymen who supported the Corn Laws. The League's argument was two-fold. First, the League suggested that allowing one class to grow rich at the expense of the hunger of another was hardly in the spirit of Christianity. For example, in

1842, the League published an address to farmers which used the teachings of Thomas Cranmer to state that high wheat prices were the equivalent of theft in the eyes of God (Spall, 1990:102). Second, and more subtly, the League tied free-trade in wheat to free-trade in religion. This was an attempt to encourage Dissenters to the League's side. The actions of the League had some success among the higher-ranked clergy, especially after the League began to publish 'its list of mitred bread taxers who voted for the famine laws' (Spall, 1990:103). In the 1846 Corn Laws division, sixteen Anglican bishops voted with Peel in favour of Repeal, nine against.

While some of the 'bread-taxing bishops' might have changed their minds and voted for Repeal, it appears from the scanty data available that rural clergy were not won over to the League. For example, at a Conference of Ministers of Religion organised by the League in 1841, only two Anglican churchmen were present among the nearly six hundred and fifty ministers who attended (Spall, 1990:102). It seems probable that ordinary clergy at the parish level would support MPs who voted against Repeal. A rural churchman would have required an unusual level of self-confidence to sermonise in favour of Repeal before a congregation of farming families.

Maynooth presented a turning point in Peel's relationship with his backbenchers, especially those from a rural constituency. As Schonhardt-Bailey (1988) observes, it was at this time that the rupture between the Prime Minister and the 'country gentlemen' was apparent. Maynooth passed against

heavy Conservative rebellion, but only because the Liberal Opposition supported the bill. As result, we expect that a decision to vote against Maynooth will be a significant predictor of voting against Repeal.

### *Emergence of a Protectionist Party*

Almost from the beginning, Peel began his more liberal economic policy. In 1842, the Corn Laws were moderately relaxed, and livestock farmers lost import protection. The Canada Wheat Bill of 1843 allowed the import of wheat from Canada at a very low duty, and the 'altar' part of the platform was discarded when the government granted money to the Irish Catholic Church under the Maynooth Bill of 1845. Despite rebellion from within his own party, Peel managed to get these measures through Parliament because the Whig and other opposition parties supported the measures. Peel's continued survival was therefore possible not so much because of the strength of his own leadership, but more because of the lack of plausible leadership among the 'country gentlemen' of his own party.

Conservative MPs were sometimes placed in the awkward position of having to serve two masters, each of whom wanted a different vote. During the debate over the importation of Canadian wheat, some MPs voted against the government to appease their constituents, while in fact wanting to support the



government. William Yates MP told Peel, “all the Cons. Want (but you know all this) to vote with the Govt. but they are afraid of offending their constituents” (cited in Adelman 1989). This small rebellion by rural backbenchers was quickly crushed by Peel, who threatened to resign unless those who rebelled reversed their votes. The backbenchers were well aware that they had, at least for the moment, no alternative leader and came to heel.

This situation changed in January 1846 when Peel introduced his bill to repeal the Corn Laws, provoking the Conservative Protectionists into action. Lord George Bentinck emerged as their reluctant but determined leader, and a Protectionist group formed within the Conservative Party (Stewart 1971). Bentinck, surely one of the more curious characters to emerge in early Victorian politics, was a backbencher who had rarely spoken in the House, and who was frequently engaged at his large racing stables. He felt intensely betrayed by Peel’s apparently overnight conversion to free-trade, and spoke for many Conservative MPs when he complained about being “sold”. Under Bentinck, a Protectionist party began to form, with its own offices and administration. An important tactic of the new group was to put up Protectionist candidates at by-elections and, encouraged by tenant farmers, Protectionist candidates won 16 out of the 24 by-elections held between January and May 1846 (Jones and Erickson 1972).

Repeal passed at its Third Reading on 15 May 1846 but, again, only with support from the Opposition. The Protectionist majority of the Conservative Party voted against the Bill, but 114 Conservative ‘Peelite’ MPs voted with Peel and for Repeal. The outcome of the vote is below in Table 2, but it should be noted that tabulations differ, not helped by errors and duplications in Hansard. The result below is based on Aydelotte’s dataset, but his records do not indicate whether an MP who is not recorded as voting was in fact an MP at the date of the division. We have tried to determine whether an MP held a particular seat by examining the voting results from divisions chronologically adjacent to the division of interest. If the MP voted in an ‘adjacent’ division but not in the division of interest, then we assume that the MP held office but for an unknown reason did not vote.

	<b>Against</b>	<b>For</b>	<b>Absent</b>	<b>Total</b>
<b>Conservative</b>	241	114	21	376
<b>Opposition</b>	10	235	34	279
<b>Total</b>	251	349	55	655

Table 16. Repeal voting in 1846.

(Source: Aydelotte dataset, see Appendix: Data Sources page 191 paragraph 7).

Note: one MP remains unaccounted for. After the disenfranchisement of the corrupt borough of Sudbury in 1844, the total number of seats was 656.

Although the government won the vote over Repeal, the fact that less than half of the Conservative MPs voted for the measure meant that Peel had lost the confidence of his own party. There are indications that he was aware that he would be forced to resign well before the vote. The end came two weeks later, when Repeal had been passed by the House of Lords (Adelman 1989; Gambles 1999). The government proposed an Irish Coercion Bill, which the Whigs did not support. Egged on by a vindictive group within the Conservative party, notably Bentinck and the future prime minister Benjamin Disraeli, the government was defeated and Peel resigned forthwith. That this would happen was apparently well-known. A crowd of well-wishers had accompanied him on foot to Parliament, and were waiting for him when he emerged (Gash 1953).

With the Conservatives in disarray, the Whig party won the General Election which followed in 1847. The 'Peelites' joined the new government in which some of them, notably William Gladstone, served with great distinction.

## **The politics of agricultural protection**

During the French Wars, a blockade of the Channel caused wheat prices and agricultural rents to increase. At the end of the war in 1815, landowners,

urged on by tenant farmer societies, moved to secure their higher rents by protecting domestic wheat markets (Adelman 1989; Ward 2004; Fairlie 1965; Williamson 1990). The result was the Corn Laws, enacted by a parliament of landowners in what Walter Bagehot called ‘the finest brute vote in creation’. The Corn Laws of 1815 prohibited the import of foreign wheat until the domestic price had reached the price of 80 shillings a quarter. They were relaxed in 1828 so that the level of import duty was dependent on the domestic price, and further relaxed in 1842 by lowering the ‘pivot point’ at which duty became payable. The Corn Laws were finally repealed in 1846, and the United Kingdom moved towards free trade in all goods (Fairlie 1969; Williamson 1990).

Agriculture is not homogenous, and the interests of pastoral and arable farmers diverge, revealed by the lack of an agricultural bloc within Parliament. Neither category of agricultural interest moved to help the other when threatened by loss of protection. The lack of mutual support is demonstrated by the case of livestock farmers. The domestic cattle market benefited from protection, but meat was a luxury item, and the cost and difficulty of shipping live cattle meant that there was little competition from overseas (Orwin and Whetham 1964). Despite the lack of foreign competition, livestock farmers strongly resisted Peel’s attempt to remove livestock protection in 1842. MPs from pastoral constituencies, led by William Miles, attempted to amend the import legislation but were unsuccessful (Crosby 1977). Their proposed amendment, known as the Miles Motion, represented the first occasion when

the 'country gentlemen' challenged their leader. A feature of the voting over the Miles Motion is that arable farmers did not rush to support cattle farmers. As a result livestock farmers felt no obligation to vote in support of arable farmers, especially if there was a prospect of lower feed grain prices. When it was their turn to resist the removal of protection, wheat farmers presented a much more organized opposition (Wordie 2000) but, likewise, their efforts were not supported by livestock farmers. In fact, as we shall see in the analysis below, MPs from pastoral counties were more likely to vote for Repeal.

### **The farmer as political activist**

Over ninety per cent of early Victorian farmers were tenants, renting land from the owner of an estate (Offer, 1991). The tenant farmer gained the vote in 1832 through a late amendment to the Reform Act put forward by the Marquis of Chandos, one of Buckinghamshire's three MPs, and popularly known as the 'farmer's friend'. Chandos proposed an extension of the county electorate to include 'tenants at will' paying at least fifty pounds a year in annual rent. In some counties, tenant farmers made up a third of the electorate (Crosby 1977).

As noted above, the Conservatives won the 1841 General Election through an appeal to the rural electorate, but this left them indebted to the tenant farmers. While it is true that the tenant farmers had voted for the

Conservatives, it does not follow that tenant farmers are easily tempted into political action. Norman Gash writes that the early Victorian farmer, whether tenant or owner-occupier, was unlikely to take interest in or have much knowledge of politics. Yet Gash goes on to remark that when the “agricultural interest” was stirred, “the county electorate could convey its opinions with considerable emphasis whether they were in agreement or not with the views of the landlord” (Gash 1953, p. 178). In general, however, rural electors saw no harm or loss of principle in voting as their landlords suggested. As a result, tenant farmers were unaccustomed to organizing themselves for political action on their own behalf, instead trusting the gentry to take the lead.

The situation changed in January 1846 when Peel announced his intention to remove agricultural protection. As we have seen above, a Protectionist group within the Conservative party emerged, led by Bentinck. Part of their strategy to force Peel to back down over Repeal was to call upon MPs who had made ‘pledges’ concerning the Corn Laws to affirm that they would honor those pledges. A large number of Conservative MPs had made such pledges as part of their electoral campaign in 1841, not believing that they would ever be called upon to make good on them.

Tenant farmers quickly responded to the new and active leadership. Over thirty local associations of protectionist farmers met during the first six weeks of 1846, and MPs began to feel direct pressure. The Buckingham

Agricultural Protection Society asked MPs for the borough and county of Buckingham to resign if they held free-trade views; Sir Thomas Freemantle, MP for Buckingham, did do so, causing a by-election which was won by a Protectionist candidate. The two MPs for Dorsetshire resigned their seats in order to fight for re-election as free-traders, but found so little support in the county that they left the election unopposed, their seats being taken by Protectionists (Ramsden 1998). Of twenty-four by-elections held in early 1846, sixteen were won by Protectionists (Jones and Erickson 1972, p.18). Peel himself acknowledged the pressure put on him by the Protectionists in letters to his brother: 'Many [MPs] talk of resigning their seats... They feel they cannot conscientiously vote against me, yet are inclined either to give up Parliament or to pass through the ordeal of re-election' (Crosby 1977). We analyze the results of resulting by-elections below in the Analysis section.

## **The structure of agricultural production**

As James Caird (1851) pointed out the majority of wheat production took place in the eastern counties, while livestock were raised in the southwest, Wales and Scotland. Repeal of the Corn Laws concerned agriculture interests and this section describes the geography of those interests.

The eastern counties where wheat was grown also had a low population density, and as a result a surplus of production over consumption of wheat. In contrast, other areas, such as the industrializing northwest, showed a deficit in wheat production. The Corn Laws meant that nearly all wheat was domestically produced, and so wheat was moved, usually by land, from surplus to deficit counties. From official statistics, it is possible to calculate the per capita surplus and deficit for each county in England, Wales and Scotland. Figure 10 below shows the distribution of surplus and deficit.



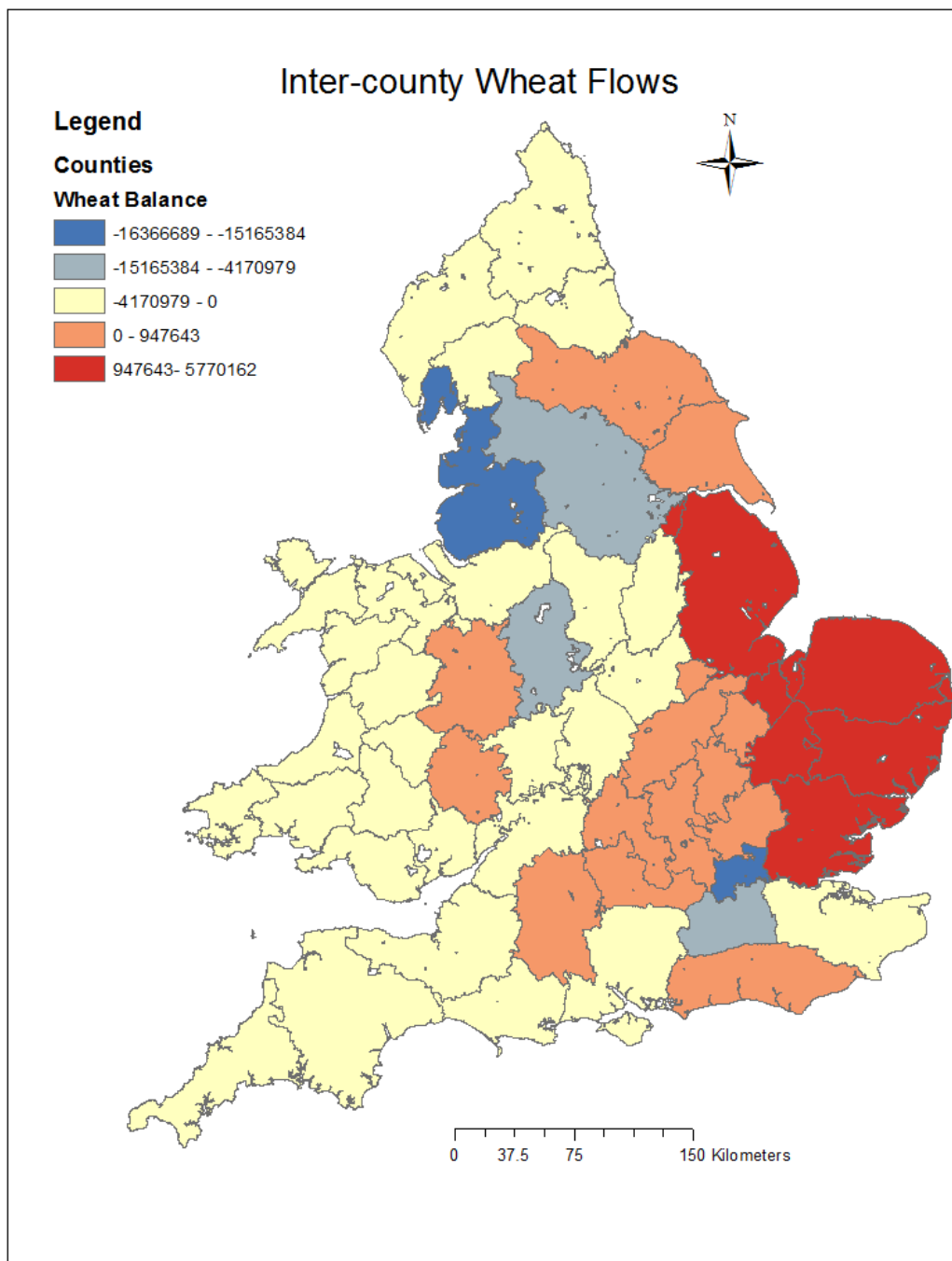


Figure 10. Inter-county wheatflows.

(Source: author's own calculations from Parliamentary Papers, see text and Appendix: Data Sources, page 191)

Livestock breeding was concentrated in areas distant from London, primarily the southwest of England, Wales and Scotland. Most livestock was fed on grass, but by the 1840s the feeding of cattle in stalls was becoming more common, especially among arable farmers who were then able to concentrate the collection of manure (Turner, Beckett and Afton 2001). Pastoralists might therefore be expected to welcome Repeal because in the absence of tariff protection feed grain prices would be reduced.

## **Political pressure and the MP**

We assume that the MP attempts to maximize his chances of being re-elected by balancing pressures from the economic interests of his constituents, his personal financial interests, and his party (Cox 1987) Here we identify those interests and predict voting outcomes.

### *Economic interests within the constituency: farmers*

Farmers are split into pastoral and arable for the purposes of this analysis, but the reality was not as clear-cut (Orwin and Whetham 1964). We

suggest that pastoral farmers prefer to have less protection for wheat, because that will result in lower feedstock prices. However, they wish to retain protection for livestock markets. MPs from constituencies which are dominated by pastoral farmers will therefore vote in favor of motions which reduce arable protection.

By contrast, arable farmers are not concerned with livestock, and wish to retain protection for wheat. As we described above, surplus counties exported wheat to deficit counties. The economic interest of wheat surplus counties is to maintain protection because wheat exports are all they have. MPs from wheat-exporting constituencies are expected to vote against motions which reduce arable protection.

Farmers who are farming intensively will have a high ratio of wage-laborers (Kellerman 1983). Both arable and pastoral farmers engage wage-laborers, but the nature of arable farming requires more laborers per unit area of land. As a result, we expect that a higher ratio of laborers to farmer will be associated with pressure on the MP to vote against any relaxation of protection. This is because the import of foreign wheat will change their comparative advantage.

In some county constituencies tenant farmers make up thirty per cent or more of the electorate (see figure 9 above). County constituencies with a high proportion of tenant farmers are expected to put pressure on their MPs to vote

against relaxation of protection, and several free-trading MPs certainly felt this pressure, being forced to resign. Why the tenant farmers should have felt so strongly about loss of protection is interesting, because if the Ricardian rent-setting theory discussed above in Chapter 3 was being followed, then rents should have risen and fallen with supply and demand. If a loss of protection reduced the domestic price of wheat, as the farmers feared, then rents should have fallen also. A possible explanation is that the tenants were retaining more of the surplus from farming than their landowners knew. In this case, tenant farmers would clearly wish to retain protection for the domestic market for wheat.

### *Economic interests within the constituency: employers*

Constituencies located in wheat-deficit areas are not as dependent on agriculture as those in exporting areas, and therefore prefer cheaper bread to continued protection. The fate of agriculture is not their concern. They depend on wheat imported from surplus counties, and so their bread becomes more expensive with distance from area of wheat production. Employers of industrial labor wish to have cheaper bread to keep wages down. As a result we expect that voters in wheat-deficit and urban constituencies will put pressure on their MPs to vote for motion which reduce arable protection. The fact that

the Anti-Corn Law League began in the industrializing north-west of England is evidence of this pressure (Pickering and Tyrell 2000; Longmate 1984).

### *Religious adherence*

Above we have indicated that the residents of rural areas were more likely to attend an Anglican church than the residents of industrial areas. If an MP wishes to maximize his chances of reelection then he surely could not ignore the religious inclinations of his constituents as a proxy for their agricultural interests. The section above on the Maynooth division described the hostile reaction in the counties to Peel's decision to increase funding to Maynooth, and we therefore expect that county-level opposition to any substantive reform initiated by Peel will be strong.

## **Statistical methodology**

The MP confronted with a division has three choices: to abstain, to vote for or to vote against the division. We wish to estimate the probability of a vote for or against the division, given a set of constituency and personal variables. Restricting the analysis to observed votes runs the risk of introducing selection

bias because the views of those MPs who abstained are de facto ‘censored’ and excluded. As Heckman (1979) shows, ignoring censored observations will bias the estimates. Clearly some method that includes the unexpressed views of the censored MPs is required. Below, we describe the methods that attempted.

The decision process of the MPs can be considered to be in the form of a tree: to vote or not, and then for or against. The nested logit approach would work well but for two problems. First, the decision not to vote results in a degenerate outcome, but this difficulty can be solved. Second, the nested logit approach requires costs and benefits specific to each choice. The nested-logit approach works well when comparing, for example, selection of mode of transport, but we do not know the costs and benefits to an individual MP of voting for Repeal. We do know the post-hoc costs and benefits (defeated, re-elected) but this information is only a subjective probability at the time that the MP has to make his decision. It is true that we do know whether the MP held his seat as a result of a contest, and if the seat was contested, the margin of victory. However, an attempt to use this information was not successful.

Heckman’s model accounts for censored observations by using a selection equation and an outcome equation. The selection equation has as its binary dependent variable whether or not the subject has some observed response or not. The disturbances from the selection equation are used in the outcome equation, carrying forward the unexpressed data from the censored

observations. The Heckman model may also be written as two probit equations, for example voted or not as the selection equation, and then voted for or against as the outcome equation. Unfortunately, the Heckman model requires that the selection equation contains one more variable than the outcome equation. The extra variable is the 'exclusion' variable. It is often difficult to find a variable which can be included in the selection equation and then omitted from the outcome equation. Attempts using selection variables including age and distance of the constituency from London were not successful.

The possible methods that remain are binomial and multinomial regressions. Binomial logistic regressions are quick and relatively easy to implement, but they do not use all the data and have other limitations (Whitten and Palmer 1996). Multinomial logit (MNL) and multinomial probit (MNP) are rather easier to implement than the nested logit and Heckman methods and have therefore been used more widely, for example by McKeown (McKeown 1989). However, MNL requires that the disturbances be independent and homoscedastic, leading to the independence from irrelevant alternatives (IIA) assumption (Greene 2003). The IIA assumption is restrictive, although it can be tested (Hausman and McFadden 1984). MNP relaxes the need for the IIA assumption, but at the expense of computational time and some difficulty in reaching convergence of the maximum likelihood estimation. Our dataset is

relatively small, and there are only three outcomes (abstain, vote for, vote against) and so we use the MNP method.

## **Analysis**

The object is to examine the influence that the tenant farmer had over his MP during the 1841 Parliament and especially just before Repeal in May 1846. It was during these months of crisis that tenant-farmer protection societies forced some MPs to resign. The first analysis is for Repeal in May 1846, with controls for party, and without controls for party. The influence of the tenant farmer becomes clearer when the analysis is restricted to county constituencies only. An analysis of the 24 by-elections that took place in the months before Repeal follows.

The issue of whether or not to control for party when regressing voting records for the 1841 Parliament is contentious. W.O. Aydelotte, whose dataset forms the basis for this chapter, claims that failing to control for party is “an elementary statistical error” (Aydelotte 1967, p. 57). However, neither Cheryl Schonhardt-Bailey nor Timothy McKeown control for party, and because Aydelotte does not himself use multiple regression methods it is not clear what he means by ‘control for’. Schonhardt-Bailey is criticized by Michael Lusztig for not controlling, on the grounds that “the Whig’s remarkable cohesiveness on



the issue of repeal suggests that partisan consideration played some role” (Lusztig 1995, p. 396). In a footnote, McKeown explains that including a party variable caused his important ‘corn’ variable to change sign (McKeown 1989, p. 376).

Michael Lusztig’s remark concerning party cohesiveness bears some examination. By January 1846, Peel had shown that he no longer expected all the Conservative MPs to vote with him, and the Whigs had only recently embraced the cause of Free Trade. Many Whigs were landowners too, and indeed some of the greatest (Thompson 1966; Porter 1989). Partisan considerations were not necessarily binding, especially at a time when overall party discipline was weak (O’Gorman 1982; Conacher 1972). Below we perform regressions with and without controls for party.

$$P(V = 1) = \beta_0 + \beta_1 \text{WheatBalance} + \beta_2 \text{MAYD} + \beta_3 \text{COFE} + \beta_4 \text{SMBORO} + \beta_5 \text{LGBORO} + \beta_6 \text{GovtOfficer} + \beta_7 \text{CONT} + \beta_8 \text{MARGIN} + \beta_9 \text{PARTY}$$

In the model above, we wish to estimate the probability of an MP voting for relaxation ( $P(V=1)$ ) dependent on eight explanatory variables. *Wheat Balance* represents the dependency of the constituency on wheat imports or exports. As we showed above, this could be a large negative number when the constituency imports wheat, or a large positive number for a constituency whose economy is based on the export of wheat. *MAYD* is an indicator variable for voting on the Maynooth division, coded as against = zero. *COFE* is the percentage of the

constituency who attended an Anglican church on Census Day 1851. *SMBORO* is an indicator for a small borough, *LGBORO* for a large borough. *Govt Officer* is an indicator variable for whether the MP had served as an officer in the Conservative government, provided by Aydelotte (1967). *CONT* is an indicator variable for whether or not the MP gained his seat through an electoral contest, and *MARGIN* represents the number of votes between 'first' and 'last' candidate. *PARTY* is an indicator variable for party membership.

With the results coded for likelihood of voting for Repeal, we expect the following signs:

*Wheat Balance*: negative. Wheat growers will vote against Repeal because reduction in protection will decrease the price of wheat.

*Maynooth*: positive. MPs from rural areas rebelled against Maynooth, and the rift within the Conservative Party dates from this time. The variable is coded as 1 for support for Maynooth, and so voting in favor of more money for Maynooth is linked to voting for Repeal.

*COFE*: negative. The correlation between attendance at an Anglican church and rurality has been described above.

*Borough*: these are by definition urban areas, and so would be expected to vote for Repeal in the hope of obtaining cheaper bread (Pickering and Tyrell 2000; Longmate 1984). However, small boroughs retained some attachments to rural

areas through backward and forward linkages, such as supply of farm inputs, and so the coefficient for small boroughs will be smaller than that of larger boroughs.

*Government Officer*: Repeal was a government-sponsored motion, led by the Prime Minister. Government Officers depended on the government by definition for patronage. A clear positive sign should therefore result.

*CONT(ested)*: Uncertain

*MARGIN*: Uncertain

*PARTY*: Since we know that Repeal passed, then this variable should be highly significant and positive.

The estimation in table 17 is coded as voting in favor of removal of protection for domestic wheat markets.

VARIABLES	(1) For Repeal	(2) Absent
Wheat Balance	-1.05e-07** (4.20e-08)	-9.22e-08* (5.01e-08)
Maynooth Voting	1.207*** (0.314)	-0.182 (0.407)
COFE	-0.0579** (0.0264)	-0.0570 (0.0365)
Small Borough	0.934** (0.407)	0.291 (0.542)
Large Borough	1.167*** (0.436)	0.388 (0.612)
Govt Officer	2.358*** (0.561)	1.324 (0.807)

Contested	0.950** (0.383)	0.00122 (0.563)
First-Last Margin	-0.00154* (0.000837)	-0.000691 (0.000981)
Party Breakdown 2-way	2.636*** (0.414)	1.571*** (0.560)
Constant	-1.356** (0.582)	-0.868 (0.781)
Observations	317	317

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table 17. Voting for Repeal.

The variable *Wheat Balance*, representing the size of a constituency's export or import of wheat, is negative. The negative sign for the coefficient means that wheat-deficit constituencies will vote for relaxation, while wheat-exporting constituencies will vote against relaxation. The other signs are as expected. *CONT*, representing whether or not the MP had faced an electoral contest, is positive. This implies that MPs who had fought an election were most likely to vote for Repeal. However, as we noted above, contested elections were more prevalent in the boroughs than in the counties, and so this result is not especially surprising. The *MARGIN* provided the number of votes between last winning candidate and next placed 'loser', provided that there had been a contested election. This has a negative sign, but is not highly significant. The implication is that the greater the margin, the less likely the MP would be to vote for Repeal. This might be construed as follows: MPs with insecure seats

preferred to vote for Repeal, as being the less risky option. *PARTY* is highly significant and positive, reflecting the fact that Liberal Opposition voted for Repeal almost unanimously.

### *The Opposition*

The Whig opposition, led by Lord John Russell, were fairly late converts to Repeal, although they had indicated that they intended to move to a fixed duty on wheat imports during their last government. In November 1845, Russell took advantage of unrest among the Conservatives by announcing that he was now in favor of free trade. While the great majority of the Opposition voted in favor of Repeal as table 12 indicates, it is interesting to examine the predicted probabilities of voting for Repeal among the Opposition. We do this in two ways. Figure 12 provides predicted probabilities of voting for Repeal for the Opposition only.

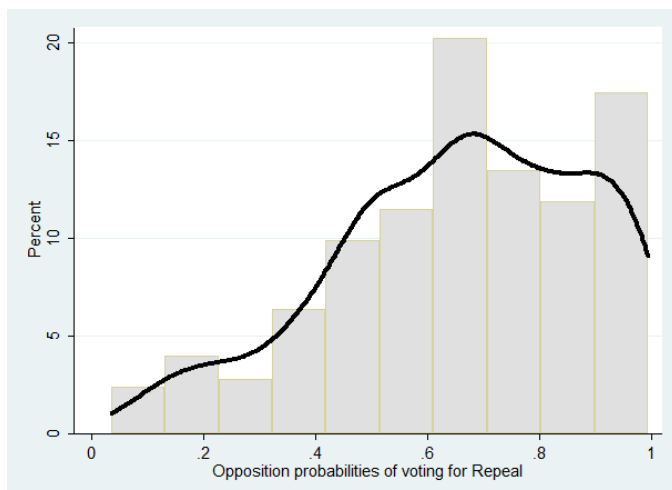


Figure 11. Opposition predicted probabilities.

It is apparent that although the majority of the Opposition are predicted as voting for Repeal, a substantial proportion are not ( $p < 0.5$ ). It is possible that in a free vote there would have been sufficient Protectionists on both sides of the House to have blocked Repeal. We discuss this point further below in the context of by-elections.

Table 12 also shows that ten Liberal MPs voted with the Protectionist Conservatives against Repeal. Of these ten, one was Irish and so is excluded from the analysis. The predicted probabilities of voting for Repeal for the remainder are below 0.5 except for two cases ( $p = 0.51$  and  $p = 0.66$ ). These two cases are interesting because in the first case, which is from Sussex, the MP is related only by marriage to the landed class. In the second case, the MP has no relationship at all to the landed class. In the other seven cases, the relationship

to the landed class was much higher; one MP (the member for the highly arable and rural county of Lincoln) was a peer. For those Opposition MPs who voted against Repeal, a connection with the landed interest appears to explain their decision to vote with the majority of the Conservatives and against the rest of the Opposition. Voting against the rest of their parliamentary party did not materially damage their chances of re-election in 1847. Five of the ten were re-elected, three were not re-elected and two did not stand.

### *By-elections*

There were 24 by-elections between January 1846 and the Third Reading in May 1846. Eight of these were as the result of resignations forced by tenant farmer protectionist societies, others due to the death or elevation to the House of Lords of the sitting member (Jones and Erickson 1972). Those MPs who had won their seat on the basis of supporting the agricultural status quo, but who were now free-traders, faced a difficult choice. Of the 24 by-elections, the Protectionists won 16 by unseating a sitting MP who was a free-trader. The summary statistics are revealing, and analyzed in table 18. In by-elections won by a Conservative candidate, free-traders won in constituencies with a large negative wheat balance, and Protectionist candidates won in constituencies with a large positive wheat balance.

<b>Won by</b>	<b>Mean wheat balance</b>
Free-trader	-212507
Protectionist	88267

Table 18. Summary statistics from by-elections.

Source: author's own calculations

The results show the success of Bentinck's policy of fighting every by-election as strongly as possible. The success suggests an argument that, had Peel been forced to call a General Election before the Corn Laws crisis had been resolved, then he might have either lost altogether or won only by promising to maintain agricultural protection. As we noted above, some Opposition MPs voted against Repeal, and there might perhaps have been more in a free vote. The argument faces two difficulties. First, fighting elections requires talented candidates and costs a great deal of money. The Protectionists lacked fiscal resources and more important the men of sufficient caliber to stand as candidates. Second, as time passed, it was becoming more apparent to the rest of the electorate, especially the 'men of business' in Parliament, that the Corn Laws were an anachronism. Bentinck was certainly hoping to delay Repeal until a General Election but he had no great hopes of actually winning. He was apparently driven by anger against Peel's 'betrayal', and this also accounts for the vindictive manner in which he forced Peel's resignation.



### *Peel's fall and 'shirking'*

The Corn Importation Bill left the House of Commons in May 1846, after being voted through at its Third Reading and enacted by the House of Lords two weeks later. Peel's resignation was inevitable at some point, as everybody knew. The resignation was forced by a particularly vindictive group of his own party, mainly the Protectionists led by Bentinck, but also including Benjamin Disraeli, the future leader of the Conservative Party and prime minister. The government had proposed an Irish Coercion Bill, but this was not supported by the Whig opposition, and the bill failed. Peel resigned almost immediately, and a General Election took place in 1847. The results for that election are interesting from a political science point of view because of the polarization that had occurred over one issue, agricultural protection.

A political representative, such as a Member of Parliament 'shirks' when he or she does not vote in a manner that reflects the platform on which he or she was originally elected (Lott and Davis 1992). A cross-tabulation of Conservative voting over Repeal and re-election in 1847 is interesting, and appears below.

<b>Elected 1847</b>	<b>Protectionist</b>	<b>Peelite</b>	<b>Absent</b>	<b>Total</b>
<b>No</b>	77	44	8	129
<b>Yes</b>	164	70	13	247
<b>Total</b>	241	114	21	376

Table 19. Conservative voting on Repeal and re-election.

Conservative MPs who had voted against Repeal had a slightly higher probability of re-election, perhaps most Conservative MPs were originally elected on the ‘altar, throne and cottage’ platform discussed above, and so voting against Repeal strengthened their reputation for protectionism. The issue of agricultural protection did not die with Repeal, and continued to dominate discussions within Conservative politics for some years, before being quietly dropped by Benjamin Disraeli (Ramsden 1998). Those MPs who voted against Repeal had clearly not been shirking, and so would be welcome in constituencies which still hoped for a wheat tariff.

The model, estimated above with results in table 17, can also be used to provide predicted probabilities. We may use predicted probabilities to compare the observed voting behavior of MPs with the action that the model would predict. For example, if the predicted probability of an MP voting for Repeal is greater than 0.5, then we would expect the MP to vote for Repeal. The predicted

probability of him voting as predicted we call VAP. By stratifying by constituency type (county, small borough, large borough) we can compare the probabilities of reelection by differing electorates. Table 20 provides the score of ‘voting as predicted’ (VAP in quartiles) and whether or not the MP was re-elected in the 1847 General Election.

Quartile of VAP	Not re-elected	Re-elected	Total
1	13	9	22
2	4	15	19
3	7	10	17
4	9	31	40
Total	33	65	98

Table 20. Re-election in large boroughs

Re-election of MPs in large boroughs by predicted voting for Repeal (VAP)

Source: author’s calculations.

By eye, with confirmation by a Somers test, there is a strong positive relationship between ‘Voting as Predicted’ (VAP) and electoral outcome in the 1847 General Election. This is not surprising, because we have already seen that the statistical significance of the urban vote was strong. The thirteen MPs

who were not re-elected were all Conservatives and whose tended to be those with more experience. A comparable table for county MPs and for MPs from small boroughs shows no such pattern, although there is the beginning of a relationship for small boroughs.

The observation that county seats seemed less affected by the difference in observed and predicted behavior of their MPs suggests a test of increase in competition for county seats. There were 83 elections in 1847 which were for county seats previously not contested. A tabulation of results by incumbency is below in table 21.

Lost/Won	Non-incumbent	Non-local incumbent	Local incumbent	Total
Lost	30	1	5	36
Won	17	5	25	47
Total	47	6	30	83

Table 21. 1847 results and incumbency.

Source: Craig (1989).

From the table, it is apparent that the probability of winning a contested election in a previously uncontested seat favored the local incumbent.

An analysis of the Conservatives who voted for Repeal, the Peelites, is less revealing (Jones and Erickson 1972) because their political identify was

not clear. They had not formed an independent party in 1847, nor were they to do so. Peel remained a backbencher and showed no inclination to take up active politics again (Conacher 1972). As a result, the Peelites were gradually absorbed into the Whig party, which eventually developed into the Liberal party (Ramsden 1998). As a result, it is not possible to make an argument that Peelites were being punished for shirking.

## **Discussion and conclusion**

The results found above show that voting over Repeal was indeed a “mare’s nest” as Aydelotte puts it (Aydelotte 1967). The new agricultural variables we have provided indicate that the ‘puzzle’ has several dimensions. The finding over ‘shirking’ is interesting. Using several different methods, we find that Conservative MPs who voted for Repeal had a higher probability of re-election than those who did not. The majority of Conservative MPs had been elected in 1841 on the altar, throne and cottage platform, and so voting against Repeal added to a reputation for protectionism. Hopes for a renewal of protection did not vanish with Repeal, and so in 1847 some electors might have considered the election of a proven Protectionist to be an insurance policy. However, protectionism never regained momentum as an electoral issue. Bread

prices rose in 1847, which would have increased opposition to a return to a wheat tariff in the wheat-importing constituencies.

## **Chapter 5. Conclusion**

The goal of this research is to examine the activities of the tenant farmer in the early Victorian era, especially over the years from 1830 to 1846. Three different 'lenses' were used to examine his impact both as a payer of rents and as a political activist.

The first lens was a cross-sectional analysis of rent-setting in the southwest of England in the 1830s, using data from the 1836 Tithe Commutation files. Changes in the institutional arrangements for land tenure had recently occurred and leases were now predominantly set to a rack rent, and we wished to determine whether leases from the 1830s were set according to Ricardian rent theory (RRT). If they were, then this implies that landowners were receiving, at the least, a consistent share of the Ricardian surplus. Three separate tests were performed: the response of pastoral rents to yield and distance to market; compensation by way of a reduced rent in return for increased yield risk; and for a difference in rents if agricultural land was let out by auction. We found that rents for the six hundred parishes were set according to RRT, and therefore the landowners were receiving a consistent

share of the RRT. We also argued that because the southwest was rather remote from the rest of Britain and thus less closely integrated into the market system, if the southwest followed RRT, then the rest of the country surely did.

We further argued that the transfer of Ricardian surplus might explain the productivity increase that we know occurred in England in the first half of the 19<sup>th</sup> century. We cited evidence from other countries and other times as support for the claim. Unfortunately, the Tithe Commutation data is cross-sectional, and so we cannot test for changes in surplus transfer over time. This remains an interesting research question.

The second lens was a longitudinal analysis of the effect on agricultural rents of accessibility to railway track. The railways developed quickly over the period 1832-1865, and there is plenty of anecdotal evidence to show that farmers made good use of them. The transport of production to market saved the tenant farmer considerable sums, and we were interested in knowing what happened to that money. RRT suggests that under competitive conditions, the savings will be transferred to the landowner as an increased rent, and this is what we found.. We broke down this sum into straightforward transport cost savings and the more interesting increases in productivity. Increases in productivity occurred because farmers were able to maximize their comparative advantage as a result of a wider range of production options. We provided the

emblematic example of strawberries being grown in Cornwall for consumption in London (Schwartz 2010).

The third lens was rather different, being concerned more with the politics of the agricultural interest and less with Ricardian rent theory. Previous research has defined the crisis as a move towards free trade. The voting through of Repeal in May 1846 clearly resulted in free trade, but concentrating on this aspect only neglects other interesting insights. This is the first research to quantify the impact of the tenant farmer, who forced at least eight free-trading MPs to resign. This was a remarkable achievement given the circumstances of the time. Tenant farmers had only recently received the franchise, and by the nature of agriculture, farmers are physically isolated. The large degree of self-organization that they achieved reflects the intensity of their response to the threat of loss of agricultural protection.

In essence, the three lenses are each peering at one aspect of one phenomenon. This is the growth of productivity in British agriculture in the first half of the 19<sup>th</sup> century. Chapter 2 showed that agricultural rents were being set in accordance with RRT, and therefore productivity might be expected to result. Chapter 3 indicated that the railways were saving farmers large amounts of money in transport costs and, just as important, allowing them to increase productivity. Chapter 4 demonstrated that productivity in a different way. As we showed, the voting of MPs over Repeal closely matched the interests



of their constituencies, which included the flow of wheat. The impression is one of a Britain with a highly integrated system of food production and delivery. In this sense, Robert Peel's instinct that domestic agriculture was strong enough to withstand the removal of agricultural protection was correct.

Agriculture apparently flourished in the years after Repeal, in the so-called 'golden years'. Farmers made large profits, and landowners continued to invest in the latest technological advances, including steam threshing and ploughing and drainage systems. The prosperity was, however, very temporary, because it was the result of a growing domestic population and an absence of foreign wheat available for import. Some prescient farmers switched their production from an arable base to one dominated by pastoral production. For example, William Barker ran a mixed farm in Sussex in the 1840s. In the 1860s, he sold off his sheep flock and replaced it with a larger dairy herd, and concentrated on that (Turner, Beckett and Afton 2001).

For those who failed to make any adaptation, the deluge of American wheat which arrived in Britain from 1869 onwards was disastrous (Perry 1974). There were calls for a return to a closed domestic wheat market, but this was no longer politically acceptable. Land prices went into a long decline which ended only in 1914 when, one century after Waterloo, wartime demands for food yet again came to agriculture's rescue.

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## Appendix: Data Sources

Below we list the sources of the data we use in the analyses above. The majority of the datasets were obtained from the United Kingdom Data Archive (History Data Service) to whom we are most grateful. We acknowledge the contributions to scholarship made by the depositors of the data. We list data obtained from the History Data Service first, with the appropriate catalogue number. We note that the original data creators, depositors, copyright holders, funders of the Data Collections and the UK Data Archive bear no responsibility for the further analysis and interpretation of the original data found in this research paper.

1. The tithe-file spreadsheet used in Chapter 2: Kain, R.J.P., *Atlas of: UK Data Archive* [distributor], 1981. SN: 1659, <http://dx.doi.org/10.5255/UKDA-SN-1659-1>
2. We linked the 'Atlas' tithe-file spreadsheet to: Southall, H.R. and Burton, N., *GIS of the Ancient Parishes of England and Wales, 1500-1850* [computer file]. Colchester, Essex: UK Data Archive [distributor], March 2004. SN: 4828, <http://dx.doi.org/10.5255/UKDA-SN-4828-1>
3. Michael Turner, John Beckett and Bethany Afton have deposited two important datasets. These are: Turner, M., Beckett, J. and Afton,

B., *Agricultural Rent in England, 1690-1914* [computer file]. Colchester, Essex: UK Data Archive [distributor], July 1997. SN: 3691, <http://dx.doi.org/10.5255/UKDA-SN-3691-1>

and

Turner, M., Beckett, J. and Afton, B., *Crop Yields and Animal Carcass Weights in England, c.1700-1914* [computer file]. Colchester, Essex: UK Data Archive [distributor], April 2003. SN: 4517, <http://dx.doi.org/10.5255/UKDA-SN-4517-1>

4. Climate data came from the Meteorological Office. There are three relevant sets of data. The British Atmospheric Data Centre, part of the Natural Environment Research Council holds data from 1853 to the present, accessible via <http://badc.nerc.ac.uk/browse/badc/ukmo-midas>. Registration is required for approved use, and some expertise is required in the handling of the data.

More easily accessed is Historic Station Data at <http://www.metoffice.gov.uk/climate/uk/stationdata/>. Station data files are updated on a rolling basis, usually ten days after the end of each month. Also useful are thirty-year averages, accessible at

<http://www.metoffice.gov.uk/climate/uk/averages/19611990/>

5. Wheat and barley prices came from the *London Gazette*, accessible at <http://www.london-gazette.co.uk/search>. For the 1829 wheat and barley

prices used in Chapter 2, the publication date was 29 September 1829. The information was taken from pages 1768-71.

6. The House of Lords Sessional Papers of 1863 Volume XXXIV contains the report of a Select Committee on the Charging of Entailed Estates for Railways. This was document was obtained as a Google e-book at

<http://books.google.ca/books?id=5uVbAAAAQAAJ&pg=RA2-PA9&lpg=RA2-PA9&dq=house+of+lords+railways+rent+1863&source=bl&ots=FrV2m79bac&sig=FE8u-vro2CZ3Ppw7mrBTrhMfu4M&hl=en&sa=X&ei=sexcUNTXLciviAKe4IH4Bw&sqi=2&ved=0CDUQ6AEwBA#v=snippet&q=rent&f=false>

7. The ‘Aydelotte’ dataset used in Chapter 4 is formally called *The British House of Commons Roll Call Data*. The data, reference ICPSR 7384, were made available by the Inter-University Consortium for Political and Social Research. The data were originally collected by William O. Aydelotte, Department of History, University of Iowa. Neither the original collector of the data nor the Consortium bear any responsibility for the analyses or interpretations presented here.

The Aydelotte dataset lists Ayes and Noes for the two divisions of interest, but does not directly indicate whether an MP who did not vote was absent or not an MP at that time. The dataset contains data on 815 MPs, while the number of seats was 658. The overlap occurs because of resignations and re-elections. We have tried to determine the status of ‘missing’ MPs by

examining divisions adjacent to those in question. If an MP voted in an adjacent division, but was recorded as ‘missing’ in the division of interest, then we amend his record to ‘absent’. We have not been able to improve the records entirely. Despite best efforts, two MPs are still unaccounted for. Unfortunately Hansard records only the names of those who voted.

8. The GIS shapefile used to delineate political constituencies in Chapter 4 was provided by the University of Portsmouth, U.K. The author wishes to acknowledge the assistance of Tom Brittnacher, University of British Columbia, in obtaining the shapefile. The shapefile was kindly provided by the University of Portsmouth, “©University of Portsmouth; Author: Humphrey Southall and the Great Britain Historical GIS”. The shapefile was used by the author while a student at the University of British Columbia.

9. For *Wheat Balance*, we calculate production based on yields recorded in the 1867 statistics multiplied by acreage laid to wheat. We subtract domestic consumption within the county by providing each person with eight bushels a year. We subtract an amount for seeding by multiplying wheat acreage by 2.25 bushels per acre. We note that Allen (2005) uses a figure of 2 bushels per acre, but have used 2.25 because this was the estimate used in official publications.

10. 1834 Electoral Returns. The 1866 Summary of Electoral Returns Relating to Counties: England and Wales 1865-66 contains data on numbers of electors

by type, including ‘Occupying Tenants’. For some counties there are records for 1835-36, which is the data used in this dissertation. Records for 1864-65 are also given and these are more complete. However, in the thirty-year interval the share of tenants in the total electorate may well have changed. The years 1835-6 are closer in time to 1846, the year of the Corn Laws crisis, and so the earlier figure is used.

11. Population and religious data came from the Census of Great Britain. 1851, xliii.73: “Tables of the population and houses in the divisions, registration counties, and districts of England and Wales; in the counties, cities, and burghs of Scotland; and in the islands in the British seas.”