Abstract

We provide new theory and evidence on the distributional consequences of trade using the 1846 Repeal of the Corn Laws and the subsequent New World Grain Invasion. We make use of a newly-created, spatially-disaggregated dataset on population, employment by sector, property values, and poor law payments (welfare transfers) for around 11,000 parishes in England and Wales from 1801–1901. Following this trade shock, we show that locations with high wheat suitability experience a decline in population, rural outmigration, structural transformation away from agriculture, increases in rural poverty, and sizable changes in property values, relative to locations with low wheat suitability. We develop a quantitative spatial model to account for these empirical findings. We show that the model implies substantial income distributional consequences of this trade shock, both across factors of production, and across geographical locations within England and Wales.

KEYWORDS: trade, income distribution, geography
JEL CLASSIFICATION: F14, F16, F66

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1 Introduction

“A great and hazardous experiment is about to be made, novel in its character, and without the support of experience to guide or direct it, embracing and extending over unbounded interests, and pregnant with results that may prove fatal in their consequences.” (John Gladstone, *Plain Facts Connected with the Intended Repeal of the Corn Laws*, 1846, page 30.)

One of the classic insights in international economics is that trade creates winners and losers. While research has traditionally focused on the effects of trade on the distribution of income across factors and sectors, more recent work has highlighted the uneven geographical incidence of trade shocks. In this paper, we provide new theory and evidence on the distributional consequences of trade using one of the most influential trade shocks in history: the 1846 Repeal of the Corn Laws and the subsequent Grain Invasion from the New World in the second half of the 19th century.\(^1\) The key idea behind our approach is that there is a marked difference in agroclimatic conditions between the Western and Eastern parts of England and Wales, with Western locations more suitable for grass (and hence the grazing of cattle and sheep), and Eastern locations more suitable for the cultivation of cereal grains (historically mainly wheat).

Following Repeal in 1846, we show that locations with high wheat suitability experience a population decline, rural outmigration, structural transformation away from agriculture, increases in rural poverty, and sizable changes in property values, relative to locations with low wheat suitability. We develop a quantitative spatial model to account for these empirical findings. We show that the model is successful in matching the empirically-observed relative declines in population and property values of 20 and 26 percent, respectively, in high-wheat suitability locations. We show that the model implies that this trade shock led to a substantial redistribution of income away from landlords (historically the rural aristocracy) towards workers. We find that geography is an important dimension along which these income distributional consequences occur, with landlords in high-wheat suitability locations experiencing markedly larger declines in relative and real income than those in low-wheat suitability locations.

We make use of a newly-created, spatially-disaggregated dataset on population, employment by sector, property values, and poor law payments (welfare transfers) for around 11,000 parishes in England and Wales from 1801–1901. There are a number of advantages to our empirical setting. First, the Repeal of the Corn Laws and subsequent Grain Invasion provide a large-scale international trade shock. Second, we have data at a fine level of spatial disaggregation over a

\(^1\)Throughout the paper, we use the word “corn” according to the historical British usage of all cereal grains, including wheat, oats, barley and rye, and not restricted to maize. Of all these cereal grains, wheat was by far the most important in the British market.
long historical time period to examine the impact of this trade shock. Third, we are able to measure regional exposure to this trade shock using exogenous measures of agroclimatic conditions. Fourth, we have detailed data on a range of economic outcomes, which enables us to examine the distributional consequences of the trade shock across both factors of production and geographical locations. Fifth, we use individual-level census data to track individuals over time, which allows us to examine the margins through which the economy adjusts to this trade shock. Sixth, 19th-century Britain was a largely laissez-faire economy, and hence provides a setting in which we would expect the market-based mechanisms in the model to apply.

We begin by documenting the size of the international trade shock. In the first 25 years following Repeal from 1846–71, relative arable/pastoral prices decline by around 10 percent, while imports of wheat grow more than fivefold from 1,411-8,952 thousand quarters.\(^2\) The share of wheat imports from the New World (especially Argentina, Canada and the United States) rises from 17-43 percent. In the ensuing three decades from 1871–1901, as the grain invasion from the New World gathers pace, relative arable/pastoral prices decline by a further 15 percent, and imports of wheat expand by an additional 77 percent. The share of wheat imports from the New World more than doubles from 43-95 percent.

We next establish a large-scale reallocation of economic activity in response to this trade shock: (i) within agriculture from arable to pastoral farming; (ii) between agriculture and other sectors; and (iii) between high and low-wheat suitability locations. Between 1871 (the first year of the agricultural census) and 1901, acreage of cereal grains declines by 29 percent, while acreage of permanent pasture rises by 35 percent. From 1851-1901, the share of agricultural laborers in employment declines by more than 20 percentage points in Eastern locations with the highest levels of wheat suitability, which compares to a fall of less than 10 percentage points in Western locations with the lowest levels of wheat suitability.

To provide further evidence on this reallocation, we estimate event-study regression specifications using our exogenous measure of wheat suitability. We include parish and year fixed effects to control for time-invariant unobserved heterogeneity across locations and secular trends over time. We also include interactions between a range of other observed characteristics of parishes and year dummies, which allows for heterogeneity in parish growth rates with each of these observed characteristics (e.g., distance to the nearest city and distance to coal reserves). In the first half of the 19th-century, we find no difference in growth between high and low-wheat suitability locations. Immediately following the Repeal of the Corn Laws, we find a decline in growth in high wheat-suitability locations relative to low-wheat suitability locations. By the end of our sample period in 1901, we estimate a relative decline of population and property values in these

\(^2\)A quarter corresponded to a quarter of a ton, which equalled 8 bushels of 8 gallons each, where a gallon or half-peck was composed of 76,800 grains weight.
locations of 20 and 26 percent, respectively.

We next develop a quantitative spatial model to account for these empirical findings. We consider a world economy that consists of a set of small open economies (parishes in our data). There are three production sectors: agriculture, manufacturing and services. Agriculture consists of the two disaggregated goods of arable farming (cereal grains) and pastoral farming (grazing). Markets are competitive. Goods are produced using labor and land. Each parish is endowed with a continuum of land plots that are heterogeneous in terms of their productivity for producing each good and for residential use. Workers are geographically mobile and have idiosyncratic preferences for each location. Land is owned by landlords who are geographically immobile. Landlords allocate each land plot to the use that offers the highest rental rate.

We use the model to evaluate the impact of an international trade shock that is concentrated in a particular sector (cereal grains). In particular, we undertake separate counterfactuals for the fall in the relative price of arable products following the Repeal of the Corn Laws from 1846-71 and following the Grain Invasion from 1871-1901. We show that the model is capable of rationalizing the observed patterns in the data not only qualitatively but also quantitatively.

We find substantial income distributional consequences of this international trade shock. As in the Heckscher-Ohlin model, the decline in the relative price of arable products implies a decline in the relative and real price of land, since this factor of production is used intensively in the agricultural sector, and in particular in arable farming within the agricultural sector. In contrast to the conventional Heckscher-Ohlin model, we find that these income distributional consequences vary geographically within the economy.

Our paper relates to a number of strands of existing research. First, we contribute to the recent reduced-form empirical literature on the local labor market effects of international trade shocks, including Topalova (2010), Autor, Dorn, and Hanson (2013), Kovak (2013), Autor, Dorn, Hanson, and Song (2014), Pierce and Schott (2016), Costa, Garred, and Pessoa (2016), Dix-Carneiro and Kovak (2017), Caliendo, Dvorkin, and Parro (2019), Kim and Vogel (2021), as reviewed in Autor, Dorn, and Hanson (2016) and Redding (2022). Most of this existing empirical evidence comes from a limited number of recent episodes, including in particular the China shock and trade liberalization in Brazil. In contrast, we provide evidence from another of the most influential trade shocks in history, which enables us to assess the generalizability of existing findings, and to explore similarities and differences. An advantage of our empirical setting is that we have an exogenous measure of the exposure to this trade shock, based on the agroclimatic suitability of locations for wheat cultivation. We examine the role of this international trade shock in propelling structural transformation across sectors and reallocations from rural to urban areas.

Our paper is also related to a recent body of research on quantitative spatial models, including Redding and Sturm (2008), Allen and Arkolakis (2014), Ahlfeldt, Redding, Sturm, and Wolf (2015),

Third, our paper is related to a large economic history literature on the Repeal of the Corn Laws and the “grain invasion” from the new world, including Graham (1892), Nicholson (1904), Lord Ernle (1912), Barnes (1930), Olson and Harris (1959), O’Rourke, Taylor, and Williamson (1996), Howe (1998), Schonhardt-Bailey (2006), Sharp and Weisdorf (2013), Williamson (1990), O’Rourke (1997), Taylor (1999), Sharp (2009), O’Rourke and Williamson (2001), Chepeliev and Irwin (2021) and Cannadine (2019). Most of this historical research has focused on the implications of this trade shock for the distribution of income across factors (labor and the urban proletariat versus land and the rural aristocracy) and sectors (agriculture versus manufacturing and services). In contrast, our work emphasizes the uneven geographical incidence of this trade shock, and the close connection between the redistribution of population between rural and urban areas and the structural transformation of employment across sectors. Whereas most of this historical research is either qualitative or uses reduced-form empirical methods, we examine the ability of a spatial general equilibrium model to account quantitatively for the patterns in the data.

The remainder of the paper is structured as follows. Section 2 introduces the historical background to the Repeal of the Corn Laws and the Grain Invasion. Section 3 summarizes the data sources and definitions. Section 4 presents reduced-form evidence on the impact of this trade shock on economic activity across sectors and locations. Section 5 develops the spatial general equilibrium model that we use to interpret these reduced-form empirical findings. Section 6 shows how the model can be quantified using the observed data on employment, land use and property values. Section 7 undertakes counterfactuals to evaluate the income distributional consequences of this trade shock. Section 8 summarizes our conclusions.
2 Historical Background

The origins of the Corn Laws date back to medieval times, as part of a broader system of regulations to control the price of bread, as the main source of sustenance for the local population. After the repeal of an outdated law of 1463, there was no statutory restriction on the import of wheat until the Corn Law of 1660, which specified domestic price bands within which different levels of import duties would apply. From 1670–1815, the basic format of the law stayed the same, and specified a small “nominal” duty payable when the domestic price was high, as well as a “pivot level” for the domestic price below which larger duties would be payable. In the first half of the 18th century, Britain remained largely self-sufficient in grain, and the import duties were suspended in times of scarcity, which limited their practical impact on the domestic price of wheat. However, with the onset of the industrial revolution in the 1760s and rapid population growth, the Corn Laws became of increasing relevance, as Britain developed into a growing net importer of wheat, with Prussia and Russia the traditional sources of supply.

In the aftermath of the French Revolution, Britain and France were almost continuously at war during the French Revolutionary and Napoleonic Wars from 1792–1815. This widespread conflict in Europe and the inauguration of Napoleon’s continental blockade restricted Britain’s access to wheat imports from continental European countries and led to a rise in the domestic price of wheat and an expansion in domestic wheat production. In Figure 1, we show the price of wheat relative to a price index for pasture products from 1701–1901, using the farm price data from Clark (2004). Both the price of wheat and the pasture price index are normalized to take the value one in 1701, such that the figure shows changes in relative prices over time. During the wartime period from 1792–1815, the relative price of wheat is 10.8 percent higher than during the years before 1792.

With the coming of victory in 1815, the British Tory (Conservative) government of Lord Liverpool became concerned about the potential for an influx of cheap imported grains to lead to a collapse in the domestic price of wheat and a domestic agricultural crisis. To prevent such a crisis, Lord Liverpool’s government passed the Corn Law of 1815, which involved a major increase in levels of protection. In particular, this law prohibited wheat imports when prices were under 82.5 shillings per quarter, and admitted wheat free of duty above this level. As a result, with a few exceptions of some months during the years 1816–19, British ports were closed to imports of wheat until 1825. The main beneficiaries from this increased protection were rural landown-

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3For historical discussions of the Corn Laws, see Nicholson (1904), Lord Ernle (1912), Barnes (1930), Fay (1932), and Sharp (2009).
4See in particular Galpin (1925). For an analysis of the impact of the continental blockade on industrial development in France, see Juhász (2018).
5The pasture price index is based on the price of eleven pasture products: hay, cheese, butter, milk, beef, mutton, pork, bacon, tallow, wool, and eggs.
Figure 1: Relative Price of Wheat from 1701–1901

Note: Price of wheat relative to a pasture price index using the farm price data from Clark (2004); Pasture price index is based on the price of eleven pasture products: hay, cheese, butter, milk, beef, mutton, pork, bacon, tallow, wool and eggs; Gray vertical lines show the years 1792, 1815, 1846 and 1871. Red horizontal lines show means before 1792, from 1792–1815, 1815–1846, 1846–71, and 1871–1901. Straight blue line shows a linear trend from 1846-1901.

ers (primarily the aristocracy who were the traditional sources of support for the Tory party) through the price of land. By contrast, the main groups harmed by increased protection were workers (through a higher cost of living) and manufacturers and merchants (through a reduction in the volume of trade and upward pressure on wages to offset the higher cost of living). In response to political pressure from these opponents, the provisions of this 1815 act were eventually weakened, at first through temporary acts in 1825, 1826 and 1827, which allowed some wheat to be released from bond warehouses, and later through the Duke of Wellington’s 1828 act, which permanently replaced import prohibition with a sliding scale of import duties. Over the period 1815–1846 as a whole, the average domestic relative price of wheat in Figure 1 remained 82.4 percent of its level from 1792-1815 and 91.3 percent of its level before 1792.

In the early 1830s, domestic harvests were plentiful and hence domestic prices remained relatively low, which ensured that discussion of the Corn Laws remained muted. In contrast, from 1837 onwards, poor domestic harvests led to a rise in the domestic price of wheat, and an increase in political protest against the Corn Laws. Supported by the growing constituency of manufacturers, and influenced by the intellectual case for free trade as espoused in Ricardo (1817), the

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6See for example Rogowski (1987). Land ownership in the mid-19th century was highly concentrated in the hands of the aristocracy, with around 80 percent of all land in Great Britain held by estates consisting of more than 1,000 acres as late as 1876 (Cannadine 1990).
Anti-Corn Law League developed into an influential nationwide movement, which was led by Richard Cobden and John Bright from 1838 onwards. Around the same time, the economic recession of 1838 was the stimulus for the formation of the Chartist Movement, which campaigned for greater democratic representation of the interests of working people. In response to this growing discontent, the Tory Prime Minister Robert Peel attempted an initial set of reforms of the Corn Laws in 1842, which reduced the level of import duties. Following continuing failed harvests in Europe during the 1840s (sometimes referred to as the “Hungry Forties”), and with the beginning of the Irish Potato Famine in 1845, political pressure for further reform intensified. Finally, in a move that split his own Tory party and arguably kept it out of government for a generation, Robert Peel passed legislation repealing the Corn Laws in 1846.\(^7\) Repeal gradually reduced import duties to 1 shilling per quarter over the three-year period until 1 February 1849, with the remaining nominal duty ultimately removed in 1869. Over the 25-year period from 1846–1871, the average domestic relative price of wheat in Figure 1 fell to 85.1 percent of its level from 1815–1846, which equalled 77.7 percent of its level before 1792.

Repeal also opened British markets to the external trade shock that occurred in the late-19th century as a result of improvements in transport technology. With increases in the speed, reliability and capacity of steam ships, international freight rates across the North Atlantic fell by around 1.5 percent per annum from around 1840 onwards, with a cumulative decline of around 70 percent points from 1840–1914 (see North 1958, Harley 1988 and Pascali 2017). Following the end of the American Civil War in 1865, the U.S. railroad network rapidly expanded into the interior, with the first transcontinental railroad completed in 1869. These reductions in internal transport costs opened up the grain-growing regions of the mid-West to international markets (see Fogel 1964 and Donaldson and Hornbeck 2016). Subsequent late-19th century expansions in the railroad network in Argentina and Canada made accessible their grain-growing interior regions (see Adelman 1994 and Fajgelbaum and Redding 2022).

In response to these reductions in international transportation costs, there was an influx of cheap new-world grain into European markets, referred to by O’Rourke (1997) as the Grain Invasion, and an associated convergence in world grain prices (see Offer 1991 and O’Rourke and Williamson 2001). In contrast to a number of continental European countries, which responded to this fall in the price of wheat with increased protection, a legacy of the campaign over the Repeal of the Corn Laws in Britain was a political consensus for free trade, which ensured that British markets remained open to this grain invasion in the closing decades of the 19th century.\(^8\) As a result of this Grain Invasion, the average domestic relative price of wheat in Figure 1 fell to

\(^7\)Although this repeal is frequently interpreted as a political concession by an existing elite to forestall greater political change, a growing historical literature argues that Peel’s decision was influenced by a threefold combination of political interests, ideologies and ideas, including in particular Irwin (1989) and Schonhardt-Bailey (1995).

\(^8\)For further discussion of this legacy of the campaign over the Repeal of the Corn Laws, see Trentmann (2008).
74.4 percent of its level from 1846–1871, or 57.8 percent of its level before 1792, with the decline in the relative price of wheat after 1846 in Figure 1 well approximated by a linear trend.

In Figure 2, we display UK consumption, production and imports of wheat over time (quantities in millions of quarters), where consumption equals the sum of domestic production and imports. In 1831 and 1841 before the repeal of the Corn Laws, UK imports were small in magnitude, and largely originated from traditional sources of supply in Europe. Following the repeal of the Corn Laws in 1846, we observe a progressive increase in UK imports of wheat, which accelerates after the end of the American Civil War in 1865, as the American Mid-West and other New World producers become increasingly integrated into international markets. In the closing decades of our sample, Argentina, Australia, Canada, India and the United States all emerge as major new world sources of supply for wheat. In the aftermath of this grain invasion and the associated decline in the domestic price of wheat, we observe a continuing decline in UK production of wheat in Figure 2 until 1901.

Figure 2: United Kingdom Consumption, Production and Imports of Wheat from 1831–1901.

Notes: Consumption, production and imports of wheat (quantities) in millions of quarters for the United Kingdom based on its 1901 boundaries (England, Wales, Scotland and Ireland); consumption is the sum of domestic production and imports; imports from different source countries indicated by the gray shading and white letters: ARG (Argentina); AUS (Australia); CAN (Canada), IND (India), ROW (Rest of World), RUS (Russia), and US (United States); Source: Sharp (2009).

This Grain Invasion from the new world led to what is referred to as the “great agricultural depression” in Britain from 1870 onwards. Land rental values fell after 1870, both in nominal
terms and relative to wages, as shown in Clark (2002). Large numbers of farmers either went bankrupt or switched from arable to pastoral farming (as discussed in Perry 1972). Arable land shrank over the period from 1871–1901 by 29 percent from 8.2 to 5.9 million acres, while the area of permanent pasture experienced a 36 percent increase from 11.4 to 15.4 million acres (Lord Ernle 1912). Rural depopulation became a source of contemporary debate (Longstaff 1893) and the subject of an official government report (Board of Agriculture and Fisheries 1906). As income from land fell relative to mortgage debt and other encumbrances, many aristocratic landowners chose to divest or break up their great estates, contributing to the decline and fall of the British aristocracy: “Across the whole of the British Isles, the change between the late 1870s and the late 1930s was remarkable, as five hundred years of patrician land ownership had effectively been halted and reversed in seventy” (Cannadine 1990, p. 111).

3 Data

We construct a new spatially-disaggregated dataset on population, employment by sector, property values (rateable values), and poor law payments for England and Wales from 1801–1901. Our main source of data is the population census, which we augment with a number of other sources of data, as summarized below, and discussed in further detail in Online Appendix E.

Spatial Units: Data are available at three main levels of spatial aggregation: parishes (11,448), poor law unions (575) and counties (53). Parishes were historically the lowest level of local government in England and Wales, responsible for the provision of a variety of public goods, including poor relief (welfare payments) since the Poor Law Act of 1601. Parish boundaries are relatively stable during the 19th century, but experience substantial changes after 1901, and hence we end our sample in 1901. We construct constant parish boundary data every census decade from 1801–1901 using the classification provided by Shaw-Taylor, Davies, Kitson, Newton, Satchell, and Wrigley (2010), as discussed further in Online Appendix E1.2.

Following the Poor Law Amendment Act of 1834, these parishes were grouped into poor law unions, which became an intermediate tier of local government, responsible for the administration of poor relief for the parishes within their boundaries. These poor law unions correspond closely to registration districts in the population census and we use these two terms interchangeably. Both parishes and poor law unions aggregate to counties (e.g., Warwickshire), which were historically the upper tier of local government in England and Wales, responsible for the administration of justice, taxes, and parliamentary representation. Parishes have an average area of 13 kilometers squared and 1851 population of 1,590, which compares to an average area of 262 kilometers squared and 1851 population of 26,401 for poor law unions, and an average area of 2,553 kilometers squared and 1851 population of 404,262 for counties.
We focus on parishes as our baseline unit of analysis for two main reasons. First, poor law unions typically aggregate neighboring rural and urban parishes together, whereas we are precisely concerned with the reallocation of economic activity from rural to urban areas. Second, parishes allow us to measure variation in agroclimatic conditions at a much finer level of spatial detail, taking into account local differences in soil conditions and topography, whereas Poor Law Unions average out this variation. In some of our empirical analysis, we distinguish between rural and urban parishes, where we define using two groups using $K$-means clustering based on initial population density in 1801, as discussed further in Online Appendix F4.

**Parish Population:** We construct population data from the parish-level records of the population census of England and Wales, which is enumerated every decade from 1801–1901.

**Employment by industry:** The population census of England and Wales reports detailed information on occupation from 1851 onwards. We use this information to construct employment data for the three aggregate sectors of agriculture, manufacturing and services for each parish.

**Individual-Level Data:** Individual-level records from the population census of England and Wales are available digitally for 1851–1861 and 1881–1901 through the Integrated Census Microdata Project (I-CeM). We use these individual-level records to track people across regions, occupations and industries over time. Building on the record-linking techniques developed for the United States in Abramitzky, Eriksson, Feigenbaum, Platt Boustan, and Perez (2021), we match individuals across the different waves of the population census. Our matching procedure uses a combination of the age, gender, county of birth and name of each individual to select a unique match across consecutive Census waves. Our use of only these matching variables ensures that the matching process is not influenced by individuals’ economic decisions about occupation, sector or location after birth. We focus on men to abstract from the changes in names that historically occurred for many women upon marriage.

In Online Appendix G, we provide further details on the matching process, including match quality and balance statistics for the matched and unmatched samples. An advantage of our empirical setting is the availability of information on county of birth for matching in the individual-level census data, where counties in England and Wales are typically much smaller than those in the United States. For each consecutive pair of census waves, we match around 30 percent of the population. We thus obtain the following matched samples: 5,323,072 (1851–61), 3,686,306 (1861–81), 7,527,280 (1881–1891), and 12,151,542 (1891–1901). Additionally, the population census reports both current county and county of birth for each individual. We use this information to construct a separate measure of bilateral migration since birth between counties, which does

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9The individual-level records for the 1801–1841 and 1871 population censuses are not yet available digitally.
not require name matching across census waves, and includes both men and women.

**Rateable Values:** We measure the value of land and buildings in England and Wales using rateable values, which correspond to the annual flow of rent for the use of land and buildings. In particular, these rateable values correspond to “The annual rent which a tenant might reasonably be expected, taking one year with one another, to pay for a hereditament, if the tenant undertook to pay all usual tenant’s rates and taxes ... after deducting the probable annual average cost of the repairs, insurance and other expenses” (Stamp 1920). With a few minor exceptions, they cover all categories of property, including public services (such as tramways, electricity works etc.), government property (such as courts, parliaments etc.), private property (including factories, warehouses, wharves, offices, shops, theaters, music halls, clubs, and all residential dwellings), and other property (including colleges and halls in universities, hospitals and other charity properties, public schools, and almshouses). They also include both agricultural and non-agricultural land. All categories of properties were assessed, regardless of whether or not their owners were liable for income tax. The main exemptions include roads, canals, railways, mines, quarries, Crown property occupied by the Crown, and places of divine worship. We construct rateable values for each parish for the years for which these are available from 1815–1896 by digitizing the data reported in the publications of the Houses of Parliament (see Online Appendix E1.3).

**Poor Law Transfers:** The poor law corresponded to a system of welfare transfers for the poor, dating back to the 1601 Poor Relief Act, as discussed in Boyer (1990) and Renwick (2017). Originally, these welfare transfers were administered at the parish level, and provided money and resources for those in need, typically referred to as “outdoor relief.” After the 1834 New Poor Law Act, parishes were grouped into Poor Law Unions, and there was a move towards housing poor law recipients in designated workhouses, typically referred to as “indoor relief.” Nevertheless, substantial amounts of outdoor relief continued to be given, even after 1834. We construct poor relief payments for each Poor Law Union for 1841, 1851, 1860, 1870, 1881 and 1891 by digitizing the data reported in the publications of the Houses of Parliament (see Online Appendix E1.4).

**Agricultural Prices, Production and Trade:** We use data on the prices of wheat and pasture products for English agriculture from Clark (2004). We obtain data on total wheat imports and wheat imports from different exporting countries for the United Kingdom from Sharp (2009), Sharp (2010), and Sharp and Weisdorf (2013).

**Agricultural Production:** We use county-level data on agricultural land use in acres from the Agricultural Returns of the United Kingdom from 1871–1901. Agricultural acreage is reported for a number of different categories: (i) wheat, (ii) other corn crops (e.g. barley, oats and rye), (iii) permanent pasture or grass not broken up in rotation, (iv) clover, sanfoin and grasses under
rotation, (v) green crops (potatoes, turnips and swedes, mangold, carrots, cabbage, kohlrabi and rape, and vetches), and (vi) bare fallow (land remaining uncropped for a season and kept free of vegetation). We also use data on cultivated land area for a number of different crops from the 1801 crop census, as used in Caprettini and Voth (2020), and the 1836 Tithe surveys. We construct our exogenous measure of exposure to the grain invasion using data on the suitability of climate and soil conditions for the cultivation of wheat from the United Nations Food and Agricultural Organization Global Agro-Ecological Zones (GAEZ) dataset, as used in Costinot, Donaldson, and Smith (2016). Consistent with 19th-century farming practices in England and Wales, we use the measure of wheat suitability for low-input and rain-fed cultivation.

4 Reduced-Form Evidence

In this section, we present reduced-form evidence on the impact of the grain invasion following the Repeal of the Corn Laws on structural transformation, population, property values and spatial, sector and occupational mobility. In Section 4.1, we introduce our exogenous measure of location exposure to the grain invasion, based on the suitability of agroclimatic conditions for the cultivation of wheat. In Section 4.2, we provide evidence on the relationship between structural transformation and wheat suitability over time. In Section 4.4, we estimate an event-study specification for population and wheat suitability over time. In Section 4.5, we estimate a similar specification for property values. Finally, in Section 4.6, we use our individual-level data to evaluate the different margins of adjustment to this trade shock for individuals in locations with different levels of wheat suitability.

4.1 Grain and Grazing Regions

An advantage of our empirical setting is that there is a marked difference in agroclimatic conditions between the Western and Eastern parts of England and Wales. In particular, the warm ocean current of the North Atlantic Drift and the prevailing winds from the South-West generate greater cloud cover, more precipitation, and lower average temperatures in Western areas. Many of the more mountainous areas of England and Wales are also concentrated in these Western areas (such as the Welsh mountains and the Lake District), with a line of hills (the Pennines) running approximately down the middle of England. As a result, these more rugged Western areas typically have thinner and more barren soils. In contrast, the Eastern parts of the country are in the rain shadow of these mountains, with lower cloud cover, less precipitation, and higher average temperatures. These Eastern areas are also more low-lying, with thicker and more fertile soils.

10See, for example, the classic volume on the physical geography of the British Isles by Goudie and Brunsden (1995).
in part because of the accumulated sediment from the water erosion of the more mountainous areas to the West. For these combined reasons of climate, terrain and soil, Western locations are more suitable for grass (and hence the grazing of cattle and sheep), while Eastern locations are more suitable for the cultivation of corn (historically mainly wheat, but also barley, maize, and rye).

Figure 3: Caird’s Western-Grazing and Eastern-Corn Counties and Wheat Suitability (UN GAEZ).

Notes: Panel (a): Reproduction of Caird’s (1852) original map; the thick black line shows his division between the grazing and the corn counties; the thin red line shows the outline of England and Wales used to georeference the original map; Panel (b): Low-Input, Rain-Fed Wheat Suitability from the United Nations Global Agro-Ecological Zones (UN GAEZ); lighter shading corresponds to greater suitability for wheat cultivation.

This difference in agroclimatic conditions has been reflected in longstanding differences in agricultural land use between Western and Eastern regions. In his seminal mid-19th century study of the state of English agriculture, Caird (1852) drew a line approximately down the middle of England that separated the “grazing counties” of the West from the “corn counties” of the East, as shown in a reproduction of his original map in Panel (a) of Figure 3. As a check on the relevance of this distinction, we superimpose the Caird line on a map of low-input, rain-fed wheat suitability from the United Nations Global Agro-Ecological Zones (GAEZ) data in Panel (b) of
Figure 3. Although this GAEZ measure is computed for the period 1961–1990, these differences in relative agroclimatic conditions between the Western and Eastern parts of England and Wales have been stable for centuries. As shown in the figure, we find a close correspondence between the Caird line and wheat suitability as measured by UN GAEZ. Despite these clear differences between Western and Eastern areas, we also find some heterogeneity in wheat suitability within each of these parts of England and Wales, which we exploit using our spatially-disaggregated parish-level data. In particular, for each parish, we compute mean wheat suitability across 5 arc-minute pixels within its geographical boundaries.

We now use this exogenous measure of wheat suitability based on agroclimatic conditions to provide causal evidence on the impact of the grain invasion on the distribution of economic activity across sectors and regions.

4.2 Structural Transformation

In this subsection, we examine the relationship between structural transformation and wheat suitability over time. We begin by confirming that West-East location within England and Wales is accompanied by systematic differences in agricultural practices. In particular, arable farming (including corn cultivation) is substantially more intensive than pastoral farming (including the grazing of cattle and sheep). Whereas cattle and sheep can be left to graze in fields and pastures, corn cultivation involves labor-intensive horticultural tasks, such as plowing, sowing, weeding, harvesting and threshing.

In Figure 4, we display the shares of farmers (red) and agricultural laborers (blue) in employment in 1851 (solid lines) and 1901 (dashed lines) against West-East location, as measured by the Eastings of the British National Grid (BNG) of the Ordnance Survey (OS). In each case, we show the fitted values from kernel (Epanechnikov) regressions (dark lines) and the 95 percent confidence intervals (light gray shading). We find that the share of farmers in employment is relatively flat and, if anything, declines as one moves further Eastwards, with the peak share of employment occurring at an Easting of just over 200 (where Swansea in Wales has an Easting of 266). In contrast, the share of agricultural laborers in employment increases progressively as one moves further Eastwards, consistent with these more Easterly locations specializing in more labor-intensive corn cultivation.

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11We provide further direct evidence on the relationship between arable/pastoral farming and exogenous agroclimatic conditions using the 1836 Tithe maps for unenclosed land in Section F2 of the online Appendix.

12Despite this stability in relative agroclimatic conditions, there was an increase in overall temperature levels during the medieval warm period (900–1300 CE) and a decrease in overall temperature levels during the little ice age (1300–1850 CE), as discussed for example in Fagan (2019).

13The first year for which employment by industry is available in the population census is 1851. To provide a benchmark for the interpretation of the Eastings, the Guildhall in the center of the historical City of London has an Easting of 532 kilometers.
Figure 4: Employment Shares of Agricultural Laborers and Farmers in 1851 and 1901 by Easting

Notes: Kernel (Epanechnikov) regressions of employment shares on Easting across parishes in England and Wales; dark lines show fitted values and lighter shading shows 95 percent point confidence intervals; Eastings are based on the British National Grid (BNG) of the Ordnance Survey (OS) and measure East-West location, where the Guildhall in the center of the City of London has an Easting of 532 kilometers.

Between 1851 and 1901, the share of farmers in employment remains relatively constant across locations with different West-East orientation. By contrast, the share of agricultural laborers in employment declines for all locations, with the greatest declines observed for locations with Easting of more than 400 (where Birmingham has an Easting of 408), with the result that the gradient of agricultural laborers in East-West orientation is much shallower at the end of our sample period than at its beginning. Therefore, we find greater structural transformation away from agriculture in Eastern-corn locations than in Western-grazing locations following the grain invasion of the late-19th century.\(^\text{14}\)

In Figure 5, we tighten this connection between structural transformation and wheat suitability, by displaying the changes in the shares of sectors in employment from 1851–1901 against our wheat suitability measure (normalized to lie between 0 and 1). In each case, we show the fitted values from kernel (Epanechnikov) regressions (dark lines) and the 95 percent confidence intervals (light gray shading). As shown in the top-left panel, there is a much greater overall decline in agricultural employment in high wheat suitability locations. Comparing the top-left and top-right panels, this greater decline in agricultural specialization in high wheat suitability locations is mainly driven by a larger reduction in the share of agricultural laborers in employment in

\(^{14}\)For further evidence on the structural transformation of England and Wales over the 19th century, see Section F4 of the online Appendix.
those locations, consistent with a decline in corn cultivation that is intensive in the employment of these agricultural laborers.

In the bottom-left panel, we show that there is little relationship between the change in manufacturing’s share of employment and wheat suitability. This finding confirms that the more rapid decline in agriculture in high wheat suitability locations is not driven by a general equilibrium “Dutch Disease” effect from a more rapid expansion of manufacturing as part of the industrial revolution that began in the 1760s. This finding is also consistent with the fact that the expansion in manufacturing after 1760 was concentrated in the new large industrial cities of Manchester and Birmingham and in the existing urban center of London, which are located in areas with very different levels of wheat suitability (low, medium and high respectively).

Figure 5: Change in Employment Shares from 1851–1901 by Wheat Suitability.

Notes: Kernel (Epanechnikov) regressions of the change in sectoral employment shares on wheat suitability (normalized to lie between 0 and 1) across parishes in England and Wales; dark lines show fitted values and lighter shading shows 95 percent point confidence intervals.
Finally, as shown in the bottom-right panel, the counterpart of a more rapid decline in agricultural employment shares in high wheat suitability locations, and little systematic pattern for changes in manufacturing employment shares, is a more rapid rise in services employment shares in high wheat suitability locations. This pattern of results is in line with the idea that the reduction in employment opportunities for agricultural laborers as a result of the grain invasion increased the relative importance of local services as a source of rural employment, including in particular personal services for the gentry and aristocracy that dominated rural economic life in England and Wales until the great agricultural depression of the late-19th century.\footnote{As discussed above, around 80 percent of all land in Great Britain was held by estates consisting of more than 1,000 acres as late as 1876 (see Table 1.1. in Cannadine 1990).}

Taken together, this pattern of results is consistent with the negative trade shock from the grain invasion in the second half of the 19th century disproportionately affecting Eastern-corn locations. These findings are in line with the historical narrative on the great agricultural depression in England after 1870, which emphasizes that these Eastern-corn locations were more heavily hit, and discusses the rural depopulation as a result of agricultural laborers leaving the land, land sales by great estates in response to declining rents, and a switch from arable to pastoral farming.\footnote{See Fletcher (1961) and Perry (1973) on the great agricultural depression; Graham (1892), Longstaff (1893) and Board of Agriculture and Fisheries (1906) on rural depopulation; see Thompson (1963) and Cannadine (1990) on the break-up of the great estates; and Perry (1972) on the geography of agricultural bankruptcies and the switch from arable to pastoral farming.}

### 4.3 Reallocation Within Agriculture

In this subsection, we provide further evidence in support of our mechanism that the trade shock from the grain invasion disproportionately affected locations that were suitable for corn cultivation as opposed to the grazing of cattle and sheep. In particular, we use our county-level data on the acreage of agricultural land allocated to different uses from the Agricultural Returns of the United Kingdom. We focus on the period from 1878 (the first year for which wheat cultivated area is reported as a separate category) to the end of our sample in 1901.

In Panel (a) of Figure 6, we display the change in wheat’s share of agricultural land area from 1878–1901 against its initial share in 1878. Each blue dot corresponds to a county in England or Wales and we also show the regression relationship between the two variables. As shown in the figure, we observe a decline in wheat’s share of agricultural land in all counties, which ranges up to 8 percentage points. Consistent with the grain invasion disproportionately affecting corn-growing regions, we find that those counties with the highest initial wheat shares (up to 25 percentage points) experience the greatest declines in wheat’s share of the agricultural land. The regression relationship between two variables is negative and statistically significant at conven-
tional critical values, with a slope coefficient of -0.331 (standard error of 0.033) and a regression R-squared of 0.77.\textsuperscript{17}

In Panel (b) of Figure 6, we display the change in permanent pasture’s share of agricultural land area from 1878–1901 against the initial share of wheat in agriculture land area in 1878. For the vast majority of counties, we observe an increase in permanent pasture’s share of agricultural land area. Furthermore, we find that those counties with the highest initial wheat shares experience the greatest increases in permanent pasture’s share of agricultural land area. The regression relationship between two variables is positive and statistically significant at conventional critical values, with a slope coefficient of 0.321 (standard error 0.092) and a regression R-squared of 0.16.

Figure 6: Reallocation of Agricultural Land from Wheat Cultivation to Permanent Pasture.

(a) Change in Wheat Share of Agricultural Land 1878–1901
(b) Change in Permanent Pasture Share of Agricultural Land 1878–1901

Notes: Panel (a): Change in wheat share of agricultural land from 1878–1901 against initial wheat share of agricultural land in 1878; Panel (b): Change in permanent pasture share of agricultural land from 1878–1901 against initial wheat share of agricultural land in 1878; in addition to wheat and permanent pasture (for grazing of animals), agricultural land area also includes other corn crops (e.g., barley, oats and rye), clover, sanfoin and grasses under rotation, green crops (potatos, turnips and swedes, mangold, carrots, cabbage, kohlrabi and rape, and vetches), and bare fallow (land remaining uncropped for a season and kept free of vegetation).

Overall, these results provide further support for our mechanism, and suggest that our findings are not capturing a common decline in all agricultural activities. We find a pattern of changes in agricultural land use consistent with the idea that the grain invasion disproportionately affected corn-growing regions and led to a reallocation of economic activity within agriculture towards the grazing of cattle and sheep.

\textsuperscript{17}This regression relationship does not simply capture mean reversion for all agricultural goods. If we regress the change in permanent pasture’s share of agricultural land from 1878–1901 against its initial share in 1878, we find a coefficient that is positive (0.031) and not statistically significantly different from zero (standard error 0.049), with a regression R-squared of 0.01.
4.4 Population

In this subsection, we provide reduced-form regression evidence on the impact of the grain invasion on the spatial distribution of population in England and Wales, using our parish-level population data that are available every census decade from 1801–1901. We consider the following event-study specification for the relationship between log parish population and our measure of wheat suitability:

\[
\ln L_{jt} = \sum_{\tau=-40}^{\tau=70} \beta_\tau (W_j \times I_\tau) + (X_j \times \delta_t) + \eta_j + d_t + u_{jt},
\]

where \(j\) indexes parishes; \(t\) indicates the census year; \(L_{jt}\) is parish population; \(W_j\) is an indicator variable that is one if a parish has above-median wheat suitability and zero otherwise; \(\tau\) denotes treatment year, which equals census year minus 1841 as the last census year before the repeal of the Corn Laws; the excluded category is treatment year \(\tau = 0\) (1841); recalling that our sample starts in 1801 and ends in 1901, we have 40 years before and 70 years after the treatment; \(I_\tau\) is an indicator variable that is one for treatment year \(\tau\); \(X_j\) are controls for observable parish characteristics that could affect population growth and \(\delta_t\) are time-varying coefficients on these controls; we include among these controls (i) travel time to the nearest market town; (ii) travel time to the nearest coalfield; (iii) distance to London and distance to Manchester; (iv) Easting and Northing of the parish centroid; (v) an indicator that is one for Wales; (vi) an indicator that is one for urban parishes based on the 1801 distribution of population densities; \(\eta_j\) is a parish fixed effect; \(d_t\) is a census-year dummy; and \(u_{jt}\) is a stochastic error.\(^{18}\) In our baseline specification, we report standard errors clustered by poor law union, which allows the error term to be serially correlated across parishes within poor law unions and over time.\(^{19}\)

In this specification, the parish fixed effects (\(\eta_j\)) allow for time-invariant unobserved heterogeneity in the determinants of parish population that can be correlated with wheat suitability. The census-year dummies (\(d_t\)) control for secular changes in population across all parishes over time, as a result for example of aggregate population growth. The key coefficients of interest (\(\beta_\tau\)) are those on the interaction terms between wheat suitability (\(W_j\)) and the treatment year indicators (\(I_\tau\)). These coefficients have a “difference-in-difference” interpretation, where the first difference compares parishes with above and below-median wheat suitability, and the second difference undertakes this comparison between treatment year zero (census year 1841) and each preceding or succeeding census year. The main effect of each of our controls for observable

\(^{18}\)We describe in Appendix F4 the construction of the urban indicator and the construction of measures based on the transportation network (travel time to the nearest market town, and travel time to the nearest coalfield).

\(^{19}\)As robustness checks, we report Heteroskedasticity and Autocorrelation Consistent (HAC) standard errors following Conley (1999), and standard errors clustered two-way by 100 quantiles of wheat suitability and 560 poor law unions following a similar approach to Adão, Morales, and Kolesár (2019).
parish characteristics \((X_j)\) is captured in the parish fixed effect. The interactions between the census-year dummies and these controls \((X_j)\) allow for heterogeneity in population growth rates depending on these observable parish characteristics.

In our baseline specification, we report results using the conventional two-way fixed effects estimator. However, a recent empirical literature has highlighted that the interpretation of this two-way fixed effects estimator can be problematic in the presence of treatment heterogeneity and a variable timing of the treatment. In our empirical setting, we have a common timing of the treatment (the Repeal of the Corn Laws in 1846). Nevertheless, in Online Appendix H4, we demonstrate the robustness of our results to the use of alternative difference-in-differences estimators, including Borusyak, Jaravel, and Spiess (2021), De Chaisemartin and d’Haultfoeuille (2020), Callaway and Sant’Anna (2021) and Sun and Abraham (2021). In our empirical application, we find a relatively similar pattern of results across all of these estimators.

Figure 7 displays the estimated treatment coefficients \((\beta_\tau)\) from our baseline specification including this full set of controls. The vertical bars correspond to the 95 percent confidence intervals clustered by poor law union, while the vertical red line shows the Repeal of the Corn Laws in 1846. In the early decades of the 19th century, high and low wheat suitability locations have similar rates of population growth, with all estimated coefficients close to zero and statistically insignificant. This pattern of results is consistent with the Corn Law of 1815 limiting the fall in the domestic wheat price after the end of the Napoleonic Wars and thereby preserving the profitability of corn cultivation in the opening decades of the 19th century.

By contrast, shortly after the Repeal of the Corn Laws, we observe a sharp decline in rates of population growth in locations with high wheat suitability relative to those with low wheat suitability. This decline in rates of population growth becomes statistically significant at conventional critical values in 1871, and continues to increase in absolute magnitude through to 1901, which is consistent with an approximately linear decline in the relative price of wheat after 1846 in Figure 1. By the end of our sample period, we find a relative decline in population of around 20 percent in high wheat suitability locations compared to low wheat suitability locations.\(^{20}\) This timing corresponds closely to the secular decline in the relative price of wheat and sharp increase in UK imports of wheat after 1846 in Figures 1-2. This pattern of results is also consistent with the wider historical narrative discussed above, in which the decline in employment opportunities for agricultural laborers led to a population outflow from rural areas.

At first sight, this finding that the trade shock from the grain invasion induced a redistribution

\(^{20}\)While we show 95 percent confidence errors based on standard errors clustered on poor law unions in Figure 7, we find a similar pattern of results using Conley HAC standard errors with a 10km spatial lag and a two period time lag (e.g., standard error of 0.031 compared to the coefficient of about -0.165 for 1901) and standard errors clustered on 100 bins for quantiles of wheat suitability (e.g., a standard error of about 0.04 for 1901). In Table H.1 (Section H4 of the online appendix), we report the full set of standard errors for all years.
Notes: The figure shows the estimated treatment effects ($\beta_t$) from the differences-in-differences specification (1) using interactions between years and an indicator variable that is one for parishes with above-median wheat suitability and zero otherwise; vertical lines show 95 percent confidence intervals based on standard errors clustered by poor law union. The specification conditions on parish and year fixed effects, and interactions between year and (i) travel time to the nearest market town; (ii) travel time to the nearest coalfield; (iii) distance to London and distance to Manchester; (iv) Easting and Northing of the parish centroid; (v) an indicator that is one for Wales; (vi) an indicator that is one for urban parishes based on the 1801 distribution of population densities.

Of population across locations stands in contrast with research for more recent trade shocks, such as the China shock, which has found muted population responses. There are a number of reasons why there could be greater population mobility in our empirical setting of 19th-century England and Wales than for contemporary trade shocks. First, there was a much more limited welfare state. In the early-20th century United States, which also featured a limited welfare state, such large-scale population movements were observed in response to changing economic and political opportunity, including for example the migration of African-Americans from the South to the North, as examined in Wilkerson (2011) and Platt Bousan (2020). Second, to measure population movements between rural and urban areas, and because there was little long distance commuting to work in an era in which walking was the dominant mode of transport for working people, we use the relatively small spatial units of our 10,000 parishes. We thus capture migration from the countryside to the nearest town or city, which would be obscured by relatively larger geographic units, such as counties or even modern-day commuting zones (of which there are only around 700 in the much larger geographic area of the United States).21

21Consistent with this, we find that more than two thirds of all migration between parishes is within 50 kilometers using our matched individual-level population census data.
As a robustness check, we re-estimate the regression specification (1) including separate treatment-year interactions with indicators for low wheat suitability (bottom tercile) and high wheat suitability (top tercile), where the excluded category is the middle tercile. As shown in Figure 8, low wheat suitability locations experience a weakly statistically significant increase in population relative to those with medium wheat suitability, while high wheat suitability locations experience a statistically significant decrease in population relative to those with medium wheat suitability. Therefore, we find a consistent pattern of results at both the top and the bottom of the distribution for wheat suitability, providing further support for the idea that our results capture a systematic trade shock from the grain invasion that unevenly affects locations with different levels of wheat suitability.

Figure 8: Estimated Treatment Effects for Log Population with Respect to Wheat Suitability (Terciles).

Notes: The figure shows the estimated treatment effects from the differences-in-differences regression specification (1) using interactions between years and separate indicator variables for parishes with wheat suitability in the bottom and top terciles (the excluded category is the middle tercile); vertical lines show 95 percent confidence intervals based on standard errors clustered by poor law union. The specification conditions on parish and year fixed effects, and interactions between year and (i) travel time to the nearest market town; (ii) travel time to the nearest coalfield; (iii) distance to London and distance to Manchester; (iv) Easting and Northing of the parish centroid; (v) an indicator that is one for Wales; (vi) an indicator that is one for urban parishes based on the 1801 distribution of population densities.

As a further specification check, we re-estimate our baseline regression specification (1), augmenting it with treatment-year interactions with an indicator for above-median grass suitability. In Figure 9, we show the estimated coefficients on both wheat suitability (in blue) and grass suitability (in green). Consistent with our results capturing the effects of the grain invasion, we
find a similar pattern of estimates for wheat suitability, with negative and statistically significant treatment effects of around the same magnitude as before. The estimates for grass suitability are positive (rather than negative); this finding of positive estimated treatment effects for grass suitability is consistent with historical evidence of a reallocation from arable to pastoral farming. They are also consistent with the systematic difference in agroclimatic conditions between the Western and Eastern parts of England and Wales shown in Figure 3 above. As the grain invasion depressed the economic activity in Eastern-corn areas, this increased in relative terms the levels of economic activity in Western-grass areas.

Figure 9: Estimated Placebo Treatment Effects for Log Population with Respect to Wheat and Grass Suitability.

Notes: The figure shows the estimated treatment effects ($\beta_t$) from the differences-in-differences specification (1) using interactions between years and an indicator variable that is one for parishes with above-median wheat suitability; dashed black line shows estimated treatment effects from a placebo differences-in-differences specification using interactions between years and an indicator variable that is one for parishes with above-median grass suitability; vertical lines show 95 percent confidence intervals based on standard errors clustered by poor law union. The specification conditions on parish and year fixed effects, and interactions between year and (i) travel time to the nearest market town; (ii) travel time to the nearest coalfield; (iii) distance to London and distance to Manchester; (iv) Easting and Northing of the parish centroid; (v) an indicator that is one for Wales; (vi) an indicator that is one for urban parishes based on the 1801 distribution of population densities.

4.5 Property Values

In this subsection, we use a similar event-study specification to examine the differential impact of the grain invasion on the value of land and buildings across parishes of England and Wales. We use our baseline specification (1) with (log) rateable values in 1815, 1843, 1852 and 1881 as
the dependent variable. As above, our key coefficients of interest are the difference-in-differences estimates ($\beta_\tau$), which capture the treatment effect of wheat suitability on the growth of rateable values over time. We choose 1843, the last period before the Repeal of the Corn Laws, as the excluded category. We include parish fixed effects and year dummies, as well as interactions between our observable parish characteristics and year dummies, to control for other potential determinants of rateable values growth.

Figure 10: Estimated Treatment Effects for Log Rateable values with Respect to Wheat Suitability.

Figure 10 displays the estimated treatment coefficients ($\beta_\tau$), where the vertical bars correspond to the 95 percent confidence intervals clustered by poor law union, and the vertical red line shows the Repeal of the Corn Laws in 1846. We find a similar pattern of results for rateable values as for population above. In the early decades of the 19th century, areas with low and high wheat suitability have similar rates of growth of rateable values, with the estimate for 1815 close to zero and statistically insignificant. Following the Repeal of the Corn Laws, we find a substantial and statistically significant decline in rateable values in high wheat suitability locations relative to those in low wheat suitability locations. Again we find that this treatment effect grows in magnitude over time, which is consistent with the approximately linear decline in the relative
price of wheat in Figure 1 above. For rateable values, this treatment effect captures the impact of the grain invasion on the value of land and existing buildings, as well as on the construction of new buildings. It also captures both the direct effect of the grain invasion on property values and its indirect or general equilibrium effects through the reallocation of population across locations. areas with different levels of wheat suitability. Taking all of these effects together, we find a reduction in the relative value of land and buildings in areas with above-median wheat suitability of around 25 percent by the end of our sample period.

4.6 Individual-level Data

Although our parish-level data are informative about net changes in population, they do not distinguish between migration versus differential birth and death rates as alternative explanations for population changes. To provide econometric evidence on the historical narrative that the grain invasion led to rural outmigration in high wheat suitability locations, we make use of our individual-level data based on linking records of the Integrated Census Microdata Project (I-CeM). We use these data to examine the different margins of adjustment through which individuals in high wheat suitability locations responded to the trade shock of the grain invasion.

We use our matched samples of individuals between each pair of consecutive census years. We treat the first pair of census years from 1851–61 as a pre-period, using the fact that the “grain invasion” does not really take off until after the end of the American Civil War in 1865. We pool the remaining pairs of census years from 1861–1881, 1881–1891, and 1891–1901 as a post-period. We use the matched data between each pair of consecutive census years to compute several measures of mobility: (i) an indicator that is one if an individual moves to another census registration district; (ii) indicators that are one for rural-urban or urban-urban migrations between registration districts respectively; (iii) an indicator that is one if an individual moves two-digit occupation; and (iv) an indicator that is one if an individual moves one-digit industry.

Using these measures of mobility, we find substantial reallocation across locations, occupations and sectors. On average, across 10-year matches between census years, we find a probability of moving parish of around 0.4; registration district of about 0.3; county of around 0.2; two-digit occupation of above 0.6; and one-digit sector of over 0.5. As a check on these results from name matching across census waves, we find an average probability on living outside the county of birth of around 0.4 in each census year, consistent with substantial mobility.22

We now examine the relationship between these individual mobility decisions and the grain invasion. As a first step, we estimate kernel (Epanechnikov) regressions of each of our measures

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22 Using individual-level records from the 1940 U.S. population census, which report current county and country five years previously, Hornbeck (2020) finds that 17 percent of people moved counties over that five-year period, where U.S. counties are substantially larger than those in England and Wales, which together have approximately the same total land area as the U.S. state of Georgia.
of individual mobility between an initial and subsequent census year on the wheat suitability of the individual’s parish in the initial census year. In Figure 11, we display the fitted values (darker lines) and 95 percent point confidence intervals (light shading) clustered at the parish level from these kernel regressions. We use blue to denote the pre-period and red to denote the pooled post-periods.

Figure 11: Probabilities of Changing Registration District, Occupation and Industry with Wheat Suitability (blue: 1851–61; red: pooled 1861–81, 81–91, 91–01)

Notes: sample of matched individuals from 1851–1861 (blue) and pooled sample of matched individuals from 1861–1881, 1881–1891, 1891–1901 (red); dark lines show kernel (Epanechnikov) regressions of reallocation probabilities on wheat suitability; lighter shading denotes 95 percent point confidence intervals; Panel (a) shows the probability of moving to a different registration district (poor law union); Panel (b) shows the probability of moving to a rural registration district (poor law union); Panel (c) shows the probability of moving to a different 2-digit occupation; and Panel (d) shows the probability of moving to a different 1-digit industry.

As apparent from the figure, we find strong evidence in support of the historical narrative
that the grain invasion led to increased outmigration from rural to urban locations. In the top-left panel, the probability of migrating to another registration district increases between the pre- and post-periods for high wheat suitability locations relative to low wheat suitability locations. In the top-right panel, this increased outmigration is not driven by movements to other rural locations. Between the pre- and post-periods, we actually find a fall in the probability of migrating to rural registration districts, which is somewhat larger for low wheat suitability regions than for high wheat suitability regions. We also see strong evidence of increased reallocation along the other adjustment margins of occupation and industry in response to the grain invasion. In the bottom-left and bottom right panels, the probabilities of moving two-digit occupation and one-digit industry both increase between the pre- and post-periods in high wheat suitability locations relative to low wheat suitability locations.

We next show that this pattern of results is robust to controlling for a wide range of other potential determinants of individual mobility decisions. In particular, we consider the following regression specification:

$$M_{ijt} = \sum_{t \in T} \beta_t (W_j \times I_t) + (X_j \times \delta_t) + \eta_j + d_t + u_{ijt}$$  \hspace{1cm} (2)$$

where the unit of observation is an individual $i$ located in parish $j$ in census year $t$; $M_{ijt}$ is an indicator that is one if an individual moves (either location, occupation or sector) between a pair of consecutive census years and zero otherwise; we estimate this specification pooling the pairs of consecutive census years for which the individual-level data are available: 1851–61, 1861–1881, 1881–1891, 1891–1901; the excluded category is the pre-period 1851–61, such that $\beta_t$ and $\delta_t$ are estimated for each post-period relative to the pre-period; the other variables are defined above; we again include interactions between observable parish characteristics and year dummies, using the same set of observable parish characteristics as for our event-study specifications above. To ensure comparability with our parish-level results above, we weight the observations on individuals such that all parishes have all weights. In our baseline specification, we report standard errors clustered by poor law unions, which allows the error term to be serially correlated across individuals within unions and across census years within unions.

In this specification, the parish fixed effects ($\eta_j$) allow for time-invariant differences in mobility across parishes that can be correlated with wheat suitability. The census-year dummies ($d_t$) control for secular changes in mobility over time. The time-varying coefficients on the controls ($\delta_t$) allow for differential trends of mobility across parishes with different values for these controls (e.g. parishes close to industrial centers could have larger or smaller increases in mobility over time than other parishes). The key coefficients of interest ($\beta_t$) are those on the interaction terms between wheat suitability ($W_j$) and the census-year indicators ($I_t$), which capture the extent to which parishes with above-median wheat suitability exhibit larger or smaller increases
in mobility over time than those with below-median wheat suitability. Again, these coefficients have a “difference-in-differences” interpretation, where the first difference is between parishes with different wheat suitability, and the second difference is between later census years (1861–81, 1881–91) and the baseline census year (1851–61).

In Panel A of Table 1, we report the estimation results using four different measures of spatial mobility: (i) spatial mobility across registration districts in column 1, (ii) spatial mobility across registration counties in column 2, (iii) rural-urban migration spells in column 3, (iv) urban-urban migration spells in column 4. In line with our results above, we find a substantial and statistically significant increase in spatial mobility over time in parishes with high wheat suitability relative to those with low wheat suitability. As shown in column 1, the probability of outmigration at the parish level goes from 3 percentage points higher between 1861 and 1881 to 5 percentage points higher between 1891 and 1901. This effect is large relative to the average outmigration probability of around 0.30 at the district level discussed above. As shown in column 2, we find similar results for outmigration at the level of registration counties. From columns 3 and 4, this increase in outmigration is mostly driven by movements from rural to urban areas, consistent with the negative impact of the grain invasion largely falling on rural areas.

We find that this increase in spatial mobility is mirrored by increases in occupational and industrial mobility. More specifically, we replace the outcome of the previous specification (2) with four measures of occupational mobility: (i) occupational mobility across 2-digit occupations, but within districts, in column 1, (ii) a measure of joint mobility (changing occupations and districts) in column 2, (iii) a measure of mobility out of agriculture (including both farmers and agricultural laborers) in column 3, (iv) mobility across 1-digit industries in column 4. We find a high incidence of occupational mobility in parishes with high wheat suitability: on average, occupational mobility across 2-digit occupations is about 3 percentage points higher between 1881–1891 and 1891–1901; this effect is however entirely driven by individuals moving across occupations and districts (see column 1 versus column 2). A share of this mobility across occupations and parishes can be explained by a movement out of agriculture, as shown in column 3, and more generally by movement across 1-digit industries, as shown in column 4.

Taking the results of this section together, we find strong evidence that the grain invasion led to outmigration from the areas most affected, with the largest increases in outmigration from rural to urban areas.

23We provide further evidence on agricultural restructuring due to the “grain invasion” in Online Appendix F2.
Table 1: Wheat suitability and spatial/occupational mobility.

<table>
<thead>
<tr>
<th>Panel A: Spatial mobility</th>
<th>Districts</th>
<th>Counties</th>
<th>Rural-urban</th>
<th>Urban-urban</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat suitability × 1861–1881</td>
<td>.0147</td>
<td>.0235</td>
<td>.0133</td>
<td>.0001</td>
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<tr>
<td></td>
<td>(.0066)</td>
<td>(.0064)</td>
<td>(.0050)</td>
<td>(.0029)</td>
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<tr>
<td>Wheat suitability × 1881–1891</td>
<td>.0214</td>
<td>.0093</td>
<td>.0118</td>
<td>-.0016</td>
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<tr>
<td></td>
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<td>(.0058)</td>
<td>(.0047)</td>
<td>(.0030)</td>
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<tr>
<td>Wheat suitability × 1891–1901</td>
<td>.0527</td>
<td>.0121</td>
<td>.0195</td>
<td>.0204</td>
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<tr>
<td></td>
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<td>(.0098)</td>
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<td>(.0065)</td>
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<td>Observations</td>
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<td>9,759,420</td>
<td>9,759,420</td>
<td>9,759,420</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel B: Occupational mobility</th>
<th>Occupations only</th>
<th>Occupations/locations</th>
<th>Agriculture</th>
<th>Industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat suitability × 1861–1881</td>
<td>-.0109</td>
<td>.0139</td>
<td>.0254</td>
<td>.0129</td>
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<td></td>
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<td>(.0060)</td>
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<tr>
<td>Wheat suitability × 1881–1891</td>
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<td>(.0059)</td>
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<td>Wheat suitability × 1891–1901</td>
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<td>Observations</td>
<td>5,385,948</td>
<td>5,385,948</td>
<td>1,426,520</td>
<td>5,385,948</td>
</tr>
</tbody>
</table>

Note: Standard errors are reported between parentheses and are clustered at the union-level. The unit of observation is an individual at a given time \( t \). All specifications condition the analysis on parish fixed effects, time fixed effects and controls for observable parish characteristics interacted with time dummies: (i) travel time to the nearest market town; (ii) travel time to the nearest coalfield; (iii) distance to London and distance to Manchester; (iv) Easting and Northing of the parish centroid; (v) an indicator that is one for Wales; (vi) an indicator that is one for urban parishes based on the 1801 distribution of population densities.

5 Theoretical Framework

Motivated by these empirical findings, we now develop a quantitative spatial model to evaluate the aggregate economic impacts of the Repeal of the Corn Laws and the subsequent Grain Invasion and their distributional consequences across geographical locations.\(^{24}\)

We consider an economy that consists of a set of locations indexed by \( i, j \in J \). These locations correspond to parishes in England and Wales in our data. We model these parishes as small open economies that face exogenous goods prices on world markets and are linked through labor mobility. There are three sectors indexed by \( k \in \{ A, M, S \} \): Agriculture (A), Manufacturing (M) and Services (S). The agricultural sector consists of two disaggregated goods indexed by \( g \in \{ G, F \} \): arable (G) and pastoral (F).

The economy is populated by a sequence of non-overlapping generations. In period \( t \), a measure of workers \( \bar{L}_it \) is born in location \( i \), such that the economy’s total population is \( \bar{L}_t = \sum_{i \in J} \bar{L}_it \). Workers are geographically mobile and choose their preferred location given

\(^{24}\)See Section B of the Online Appendix for a more detailed exposition of the model and the derivation of all theoretical results in this section of the paper.
bilateral migration costs and their idiosyncratic preferences for locations. We model migration as occurring at birth to match a key feature of our individual-level census data, in which we observe both current location and county of birth. To streamline notation, we suppress the implicit dependence on period $t$, except where otherwise indicated.

Each location $i$ is endowed with a continuum of land plots indexed by $\varphi \in K_i$, where $K_i$ corresponds to land area. Each land plot $\varphi$ in location $i$ has the same supply of floor space $h_i$, which implies that shares of floor space and land area are the same within locations. The total supply of floor space in location $i$ is $L_i = h_i K_i$. Floor space is used residentially (for housing) and commercially as a production input in each sector. Land in each location is owned by a measure of immobile landlords. Landlords decide whether to allocate each land plot to agriculture, manufacturing, services or housing. If they decide to allocate a land plot to agriculture, they choose whether to engage in arable or pastoral farming.

We allow locations to differ from one another in terms of their amenities, productivities in each sector, and the supply of floor space, as well as in bilateral trade and migration costs. We use the model to examine the impact of an international trade shock that is concentrated in a particular sector (arable farming) on structural transformation across sectors and the distribution of economic activity across locations.

### 5.1 Preferences

Preferences are defined over consumption goods in each sector and residential floor space and are assumed to take the Cobb-Douglas form. A worker $\psi$ from location $i$ that chooses to live in location $j$ obtains the following indirect utility:

$$u_{ji}(\psi) = \frac{B_{ji} b_{ji}(\psi) w_j}{\kappa_{ji} P_{Cj}^{1-\beta_H} P_{Hj}^{\beta_H}}, \quad 0 < \beta_H < 1,$$

where $w_j$ is wage income in location $j$; $B_{ji}$ captures common amenities that make location $j$ more or less attractive to workers from location $i$; $b_{ji}(\psi)$ is an idiosyncratic amenity draw for an individual worker $\psi$ born in location $i$ that determines the attractiveness of location $j$ to that worker; $\kappa_{ji}$ is an iceberg mobility cost that takes the form of a reduction in a worker’s instantaneous utility from living in a different location $j$ from her birth location $i$; we parameterize this iceberg mobility cost as a function of distance ($\kappa_{ji} = \text{dist}_{ji}$); and absorb any unobserved determinants of bilateral mobility costs into bilateral amenities ($B_{ji}$); $P_{Cj}$ is the consumption goods price index in location $j$; and $P_{Hj}$ is the price of housing in location $j$.

---

$^{25}$Although we model the worker match-specific shocks as occurring to preferences, there is a closely-related formulation in terms of an idiosyncratic shock to worker productivity. We assume for simplicity that migration costs are the same across sectors, and only vary by destination location $n$ and birth location $i$, but it is straightforward to also allow them to vary across sectors.
We assume that idiosyncratic specific amenities are drawn independently across individuals and locations from the following Fréchet distribution: $F_{ji}(b) = e^{-b^{1/\chi}}$, where $\chi > 1$. We normalize the scale parameter to one, because it enters the model isomorphically to the common amenities ($B_{ji}$). The shape parameter $\chi$ controls the dispersion of worker idiosyncratic amenity draws across locations and sectors.

Landlords have the same preferences as workers, except that we abstract from idiosyncratic amenity shocks for landlords, because they are geographically immobile, and hence these idiosyncratic amenity shocks would not affect equilibrium allocations in any way.

5.2 Goods Prices and Expenditure

The consumption goods price index is defined over a price index for the agricultural sector ($P_{Aj}$) and the prices of manufacturing ($P_{Mj}$) and services ($P_{Sj}$):

$$P_{Cj} = P_{Cj}(P_{Aj}, P_{Mj}, P_{Sj}).$$

The agricultural price index is defined over the prices of the arable and pastoral goods:

$$P_{Aj} = P_{Aj}(P_{Gj}, P_{Fj}).$$

The arable and pastoral agriculture good and the manufacturing good are assumed to be tradeable subject to iceberg trade costs. Therefore, no arbitrage with international markets determines the price of these goods as a function of exogenous international prices and iceberg trade costs:

$$p_{kj} = \tau_{kj}p_{k}^*, \quad \text{if } C_{kj} > Q_{kj} \quad \text{and} \quad p_{kj} = p_{k}^*/\tau_{kj}, \quad \text{if } Q_{kj} > C_{kj}, \quad k \in \{G, F, M\},$$

where $p_{k}^*$ is the international market price for good $k \in \{G, F, M\}$; $\tau_{kj}$ is the iceberg trade cost between location $j$ and international markets for good $g \in \{G, F, M\}$.

Housing and services are non-traded and hence their prices in each location are determined by the requirement that local demand for each of these goods equals local supply.

Total expenditure in each location $j$ ($X_j$) equals the sum of the income of workers ($w_jN_j$), the income of landlords ($r_jL_j$), and trade deficits ($D_j$):

$$X_j = w_jN_j + r_jL_j + D_j,$$

where $N_j$ is the measure of workers that choose to live in location $j$; $L_j$ is the supply of floor space; $r_j$ is the expected rental rate across all of the possible uses of floor space; and $D_j$ is the trade deficit. We follow the conventional approach in the quantitative international trade literature in treating the trade deficit as exogenous. We assign trade deficits to workers and allocate the observed economy-wide trade deficit ($\bar{D}$) across locations in proportion to labor income shares.


5.3 Production Technology

Production technologies are constant returns to scale and markets are perfectly competitive. Manufacturing, services and the disaggregated agricultural goods are produced using labor and floor space. We assume that the disaggregated agricultural goods are land intensive relative to manufacturing and services and that arable farming is more labor intensive than pastoral farming. For simplicity, we assume that production technologies are Cobb-Douglas, and hence can be written in the following intensive form:

\[
q_{Mi}(\varphi) = \kappa_M n_{Mi}(\varphi)^{1-\alpha_M} z_{Mi}(\varphi)^{\alpha_M}, \quad 0 < \alpha_M < 1, \tag{8}
\]

\[
q_{Si}(\varphi) = \kappa_S n_{Si}(\varphi)^{1-\alpha_S} z_{Si}(\varphi)^{\alpha_S}, \quad 0 < \alpha_S < 1,
\]

\[
q_{gi}(\varphi) = \kappa_g n_{gi}(\varphi)^{1-\alpha_g} z_{Ai}(\varphi)^{\alpha_g} a_{gi}(\varphi)^{\alpha_g}, \quad 0 < \alpha_g < 1.
\]

where \(q_{Mi}\) denotes manufacturing output per unit of floor space; \(n_{Mi}(\varphi)\) is manufacturing employment per unit of floor space; \(z_{Mi}(\varphi)\) captures manufacturing productivity; \(\kappa_M \equiv \alpha_M^{1-\alpha_M} (1-\alpha_M)^{-1}\); \((Q_{Si}(\varphi), n_{Si}(\varphi), z_{Si}(\varphi), \kappa_S, Q_{gi}(\varphi), n_{gi}(\varphi), z_{Ai}(\varphi), \kappa_g)\) are defined analogously; \(a_{gi}(\varphi)\) captures productivity differences across the disaggregated goods within the agricultural sector; we model productivity differences as land augmenting to simplify the algebra in the presence of factor intensity differences across sectors and goods.

Housing services are supplied competitively using floor space alone, such that the housing technology can be written in the following intensive form:

\[
q_{Hi}(\varphi) = z_{Hi}(\varphi), \tag{9}
\]

where \(q_{Hi}(\varphi)\) is the flow of housing services per unit of floor space and \(z_{Mi}(\varphi)\) is productivity (or quality) of floor space used to supply housing services.

We assume that land plots are heterogeneous in terms of their productivity for each potential use. In particular, productivity for each sector \((z_{Ai}, z_{Mi}, z_{Si}, z_{Hi})\) is drawn independently from the following Fréchet distribution: \(F_{ki}(z) = e^{-T_{ki} z^{-\theta}}\) for \(k \in \{A, M, S, H\}\). The scale parameter \(T_{ki}\) controls average productivity in each sector \(k\) in each location \(i\). The shape parameter \(\theta > 1\) regulates the dispersion of sectoral productivity across locations.

Similarly, productivity for each disaggregated agricultural good is drawn independently from the following Fréchet distribution: \(F_{gi}(a) = e^{-E_{gi} a^{-\epsilon}}\) for \(g \in \{G, F\}\). The scale parameter \(E_{gi}\) determines average productivity for each disaggregated good \(g\) in each location \(i\). The shape parameter \(\epsilon > 1\) controls the dispersion of agricultural productivity.

We assume that landlords first observe the sectoral productivity draws \((z_{Ai}, z_{Mi}, z_{Si}, z_{Hi})\) and decide which land plots to allocate to agriculture, manufacturing, services or housing. Having chosen to allocate a land plot to agriculture, landlords observe the productivity draws for each
disaggregated agricultural good \((a_{Gi}, a_{Fi})\), and decide which agricultural land plots to allocate to arable and pastoral farming. We use this timing assumption to capture the idea that uncertainty about agricultural conditions (e.g., soil, climate etc) is typically only fully realized after land has been allocated to agricultural use.\(^{26}\)

A key implication of this heterogeneity in productivity across land plots is that locations will be incompletely specialized across sectors and across arable and pastoral farming for positive values of \(T_{Ki}\) and \(E_{gi}\), because there is a continuum of land plots in each location, and the support of the Fréchet productivity distribution is unbounded from above. We accommodate zero land use for a sector or disaggregated agricultural good by considering the limiting case in which these productivity parameters converge towards zero \((T_{Ki} \to 0 \text{ and } E_{gi} \to 0)\).

### 5.4 Production within Agriculture

We begin by characterizing the allocation of land between arable and pastoral farming conditional on having chosen to allocate land to agriculture. We then turn in the next section to the decision whether to allocate land plots to agriculture, manufacturing, services and housing.

Agricultural land plots are allocated to either arable or pastoral farming based on which use offers the highest rental rate \((r_{gi})\). Since labor is perfectly mobile across sectors and goods within locations, there is a single wage \((w_i)\) for each location. As a result, we can equivalently characterize the allocation of agricultural land based on which use has the lower wage-rental ratio \((\omega_{ig} \equiv w_i / r_{gi})\). The share of agricultural land allocated to disaggregated good \(g\) \((\ell^A_{gi})\) is:

\[
\ell^A_{gi} = \frac{L_{gi}}{\sum_{h \in \{G,F\}} L_{hi}} = \text{Prob} \left\{ g = \arg \min_{h \in \{G,F\}} \{ \omega_{hi} \} \right\},
\]

where the superscript \(A\) indicates that this share of land area and floor space is defined as a share of the land area and floor space allocated to agriculture.

Using the properties of the Fréchet distribution for agricultural productivity \((a_{gi})\), we can solve in closed-form for these agricultural land shares. The arable and pastoral agricultural land shares depend on relative prices \((P_{gi})\), relative productivities \((E_{gi})\), and wages \((w_i)\) because of the differences in land intensity \((\alpha_g)\):

\[
\ell^A_{gi} = \frac{E_{gi} (P_{gi} / w_i)^{\epsilon / \alpha_g}}{\sum_{h \in \{G,F\}} E_{hi} (P_{hi} / w_i)^{\epsilon / \alpha_h}}.
\]

We can also compute the expected wage-rental ratio in the agricultural sector, which plays a key role in the next section in determining the allocation of land plots across sectors. This expected

\(^{26}\)Although we make this timing assumption, an equivalent specification is to assume nested productivity shifters for the three aggregate sectors \((z_{Mi}(j), z_{Si}(j), z_{gi}(j))\) and the disaggregated agricultural goods \((a_{Gi}(j), a_{Pi}(j))\).
wage-rental ratio is an expectation across the distribution of idiosyncratic productivity \((a_{gi})\) for arable and pastoral farming and is given by:

\[
\frac{1}{\omega_{Ai}} \equiv E_a \left[ \frac{1}{\omega_{gi}} \right] = z_{Ai} \gamma_{\epsilon} \left[ \sum_{h \in \{G,F\}} E_{hi} (P_{hi}/w_i)^{\epsilon/\alpha_h} \right]^{1/\epsilon},
\]

where \(\gamma_{\epsilon} \equiv \Gamma (1 - 1/\epsilon)\); \(\Gamma (\cdot)\) is the Gamma function; and \(E_a\) is the expectation operator across the distribution of idiosyncratic agricultural productivity \((a_{gi})\); and \(\omega_{gi} \equiv w_i/r_{gi}\) is the equilibrium wage-rental ratio for disaggregated agricultural good \(g \in \{G, F\}\).

All other aggregate variables for the agricultural sector can be written in terms of this expected wage-rental ratio \((\omega_{Ai})\), including the expected agricultural rental rate \((r_{Ai})\):

\[
r_{Ai} = w_i E_a \left[ \frac{1}{\omega_{gi}} \right] = \frac{w_i}{\omega_{Ai}}.
\]

Employment in arable and pastoral farming is a multiple of the floor space allocated to each use that depends on factor intensity and relative factor prices:

\[
N_{gi} = \frac{1 - \alpha_g}{\omega_{gi}} L_{gi} = \frac{1 - \alpha_g r_{gi}}{\alpha_g w_i} L_{gi}, \quad g \in \{G, F\}.
\]

### 5.5 Production Across Sectors

The allocation of land between agriculture, manufacturing, services and housing is determined in a similar way. Each land plot \(\varphi\) in location \(i\) is allocated to the use that offers the lowest wage-rental ratio (or expected wage-rental ratio for the agricultural sector):

\[
\omega_i (\varphi) = \min_{k \in \{A,M,S,H\}} \{\omega_{ki} (\varphi)\},
\]

where the equilibrium wage-rental ratio for agriculture was determined above and those for manufacturing, services and housing are as follows:

\[
\omega_{ki} (\varphi) = \frac{1}{z_{ki} (\varphi)} \left( \frac{w_i}{P_{ki}} \right)^{\alpha_k}, \quad k \in \{M, S\},
\]

\[
\omega_{Hi} (\varphi) = \frac{1}{z_{Hi} (\varphi)} \frac{w_i}{P_{Hi}}.
\]

Using the fact that sectoral productivity \((z_{Ai}, z_{Mi}, z_{Si}, z_{Hi})\) also has a Fréchet distribution, we can solve in closed-form for land use across sectors. The shares of land used for agriculture, manufacturing, services and housing depend on relative prices \((P_{ki}, P_{gi})\), relative productivities
(T_{Ki}, E_{gi}), and wages (w_i) because of the differences in land intensity (\alpha_K, \alpha_g):

\ell_{Ai} = \frac{\gamma_i^\theta \left[ \sum_{g \in \{G,F\}} E_{gi} \left( \frac{w_i}{P_{gi}} \right)^{-\epsilon/\alpha_g} \right]^{\theta/\epsilon}}{\Psi_i}.

(17)

\ell_{ki} = \frac{T_{ki} \left( \frac{w_i}{P_{ki}} \right)^{-\theta/\alpha_k}}{\Psi_i}, \quad k \in \{M, S\}

(18)

\ell_{Hi} = \frac{T_{Hi} \left( \frac{w_i}{P_{Hi}} \right)^{-\theta}}{\Psi_i},

(19)

\Psi_i \equiv T_{Hi} \left( \frac{w_i}{P_{Hi}} \right)^{-\theta} + \sum_{k \in \{M,S\}} T_{Ki} \left( \frac{w_i}{P_{Ki}} \right)^{-\theta/\alpha_M} + \gamma_i^\theta \left[ \sum_{g \in \{G,F\}} E_{gi} \left( \frac{w_i}{P_{gi}} \right)^{-\epsilon/\alpha_g} \right]^{\theta/\epsilon}.

where the absence of a superscript for these land and floor space shares indicates that they are defined as a share of all land area and floor space (e.g., \ell_{Ai} \equiv L_{Ai}/L_i).

Employment in manufacturing and services is a multiple of the floor space allocated to each use that depends on factor intensity and relative factor prices:

N_{ki} = \frac{1 - \alpha_k}{\alpha_k} \frac{1}{\omega_{ki}} L_{ki} = \frac{1 - \alpha_k}{\alpha_k} \frac{r_{ki}}{w_i} L_{ki}, \quad k \in \{M, S\},

(20)

where we solved for agricultural employment above, and housing services are supplied using floor space alone.

5.6 Migration

Workers born in each location choose their preferred location given bilateral migration costs and their idiosyncratic amenity draws. Using the Fréchet distribution of idiosyncratic amenities, the probability of migrating from origin i to destination j depends on relative amenities (B_{ji}), wages (w_i), consumption prices (P_{Ci}), housing prices (P_{Hi}) and migration costs (\kappa_{ji}):

\lambda_{ji} = \frac{(B_{ji}w_j)^\chi \left( \kappa_{ji} P_{Cj}^{1-\beta_H} P_{Hj}^{\beta_H} \right)^{-\chi}}{\sum_{m \in J} (B_{mi}w_m)^\chi \left( \kappa_{mi} P_{Cm}^{1-\beta_H} P_{Hm}^{\beta_H} \right)^{-\chi}},

(21)

Multiplying this migration choice probability (\lambda_{ji}) by the measure of workers born in location i (\bar{N}_i), a key prediction of the model is that bilateral migration flows (N_{ji}) satisfy a gravity equation, as observed empirically in our data. The probability of migrating from location i to location j depends on characteristics of the origin i, attributes of the destination j and bilateral migration costs and amenities (“bilateral resistance”). Additionally, this probability depends on the characteristics of all destinations m and all bilateral migration costs and amenities (“multilateral resistance”). Each location faces an upward-sloping supply function for workers, such that it
must offer a higher real wage net of amenities in order to attract additional workers with lower idiosyncratic preferences for that location.

The expected utility of workers born in location $i$ is a weighted average of real income net of amenities in each destination, where the weights are bilateral migration costs ($\kappa_{ji}$):

$$
\bar{u}_i = \mathbb{E}_i [u] = \gamma \chi \left[ \sum_{m \in J} (B_{mi} w_m)^{\chi} \left( \kappa_{mi} P_{Cm}^{1-\beta_H} P_{Hm}^{\beta_H} \right)^{-\chi} \right]^{\frac{1}{\chi}}, \quad \gamma \chi \equiv \Gamma \left( \frac{\chi - 1}{\chi} \right),
$$

(22)

where recall that $\Gamma (\cdot)$ is the Gamma function.

Another key prediction of the model is that for workers born in a given location $i$, expected utility conditional on choosing a destination $j$ is the same across all destinations $j$, and equal to overall expected utility in equation (22). Intuitively, destinations with attractive economic characteristics (e.g. high wages, high amenities, a low cost of living, and low migration costs) attract workers with lower idiosyncratic draws for preferences. Under our assumption of a Fréchet distribution for amenities, this composition effect exactly offsets the more attractive economic characteristics, with the result that expected utility is the same across all destinations $j$ for a given location of birth $i$. Nevertheless, expected utility differs across birth locations $i$, because some locations have better access to attractive destinations through the geography of bilateral migration costs ($\kappa_{ji}$). Therefore, workers born in different locations $i$ will be unevenly affected by international trade shocks that have heterogeneous effects across destinations $j$.

### 5.7 Labor Market Clearing

Labor market clearing requires that total employment in each destination ($N_j$) equals the sum across origins for the flow of workers choosing to migrate to that location ($N_{ji}$):

$$
N_j = \sum_{i \in J} N_{ji} = \sum_{i \in J} \lambda_{ji} \bar{N}_i,
$$

(23)

where total employment is the sum of employment by sector: $N_j = N_{Gi} + N_{Fi} + N_{Mi} + N_{Si}$.

### 5.8 Floor Space

Floor space ($L_j$) is produced using land ($K_j$) and capital ($M_j$) by a competitive construction sector using a Cobb-Douglas production technology:

$$
L_j = K_j^\eta M_j^{1-\eta}, \quad 0 < \eta < 1,
$$

(24)

where capital is assumed to be in perfectly elastic supply at a constant and common rental rate $\Xi$. From the first-order condition for profit maximization, we obtain the following relationship
between equal capital use and land area:

\[ M_j = \left[ \frac{(1 - \eta) r_j}{\Xi} \right]^\frac{1}{\eta} K_j, \]  

(25)

where recall that \( r_j \) is the price of floor space. Substituting equilibrium capital use (25) into the floor space production technology (24), we obtain a constant elasticity supply function for floor space as in Saiz (2010):

\[ L_j = h K_j r_j^\mu, \quad \mu = \frac{1 - \eta}{\eta}, \quad h = \left[ \frac{1 - \mu}{\Xi} \right]^\frac{1-\eta}{\eta}, \]  

(26)

where this supply of floor space takes the same value across all land plots within a given location.

### 5.9 Floor Space Market Clearing

Floor space market clearing implies that the income of landlords is equal to total payments for residential and commercial use of floor space. Using our assumptions of Cobb-Douglas preferences, this floor space market clearing condition can be written as follows:

\[ r_j L_j = \beta_H r_j L_j + \beta_H [w_j N_j + D_j] + \sum_{k \in \{G,F,M,S\}} \alpha_k w_j N_{kj}, \]  

(27)

where the first term on the right-hand side captures payments for residential floor space from landlords; the second term corresponds to payments for residential floor space from workers (incorporating trade deficits); and the third term represents payments for commercial floor space.

### 5.10 General Equilibrium

The exogenous variables of the model are world prices and trade costs for the traded goods \( \{P_G^*, P_F^*, P_M^*, \tau_{Gn}, \tau_{Fn}, \tau_{Mn}\} \), exogenous location characteristics \( \{E_{Gi}, E_{Fi}, T_{Mi}, T_{Si}, T_{Hi}\} \), exogenous bilateral migration costs and amenities \( \{\kappa_{ji}, B_{ji}\} \) and the number of workers born in each location \( \{N_i\} \). Given these exogenous variables, the general equilibrium of the model can be referenced by the following endogenous variables: (i) the local prices of traded goods \( \{P_{Gi}, P_{Fi}, P_{Mn}\} \), (ii) the local prices on non-traded services and housing \( \{P_{Sn}, P_{Hn}\} \), (iii) the shares of arable and pastoral farming in agricultural land area \( \{\ell_A^{Gi}, \ell_A^{Fi}\} \); (iv) the shares of manufacturing, services and housing in total land area \( \{\ell_M, \ell_Si, \ell_{Hi}\} \); (v) the expected rental rate \( (r_i) \); (vi) the supply of floor space \( (L_i) \); (vii) the wage \( (w_i) \); (viii) bilateral migration probabilities \( (\lambda_{ji}) \).

### 6 Quantification

We now show how the model can be used to rationalize the observed data and recover unobserved values of endogenous variables in the initial equilibrium observed in the data. We use the values
of some of these unobserved endogenous variables in our counterfactuals for the Repeal of the Corn Laws and the Grain Invasion in the next section. Our quantitative analysis proceeds in a number of steps, where each step imposes the minimal additional assumptions required, before proceeding to the next step. From now onwards, we make explicit the time subscript $t$.

### 6.1 Step 1: Price and Supply of Floor Space ($r_{it}, L_{it}$)

Observed rateable values ($R_{it}$) are the product of the price ($r_{it}$) and quantity ($L_{it}$) of floor space. Combining this definition of rateable values ($R_{it} = r_{it}L_{it}$) with our assumption of a constant elasticity supply function for floor space in equation (26), we can recover the unobserved price ($r_{it}$) and quantity ($L_{it}$) of floor space, as the following constant elasticity functions of observed rateable values ($R_{it}$) and land area ($K_i$):

$$L_{it} = hK_i \left( \frac{R_{it}}{hK_i} \right)^{\frac{1}{1+\mu}} \quad r_{it} = \left( \frac{R_{it}}{hK_i} \right)^{\frac{1}{1+\mu}},$$

where $h$ corresponds to a choice of units in which to measure floor space.

We calibrate the value of the floor space supply elasticity as $\mu = 1.83$, based on data on the contributions of new buildings and changes in the value of existing buildings to observed changes in rateable values, as in Heblich, Redding, and Sturm (2020).

### 6.2 Step 2: Agricultural Floor Space Payments Share ($\alpha_{Ait}$)

We next solve for the aggregate share of payments for floor space in agricultural revenue ($\alpha_{Ait}$), which is a key input into our solution for unobserved wages ($w_{it}$) in Step 3 below. This share of payments for floor space in agricultural revenue is defined as:

$$\alpha_{Ait} = \frac{\sum_{g \in \{G,F\}} r_{git}L_{git}}{\sum_{g \in \{G,F\}} w_{it}N_{git} + r_{git}L_{git}}.$$

We can re-write this aggregate floor space payments share as a weighted average of the floor space payments shares for arable ($\alpha_G$) and pastoral ($\alpha_F$) farming:

$$\alpha_{Ait} = \sum_{g \in \{G,F\}} \alpha_g \frac{w_{it}N_{git} + r_{git}L_{git}}{\sum_{g \in \{G,F\}} w_{it}N_{git} + r_{git}L_{git}},$$

where the weights are the share of arable and pastoral farming in agricultural revenue.

From the Cobb-Douglas production technology for each disaggregated agricultural good, payments for labor are a constant multiple of payments for floor space, as in equation (13) above. Using this result in the previous equation, we obtain the following closed-form solution for the
aggregate share of payments for floor space in agricultural revenue ($\alpha_{Ait}$) in terms of observed agricultural land shares ($\ell^A_{Git}$, $\ell^A_{Fit}$):

$$\alpha_{Ait} = \alpha_G \left( \frac{1}{\alpha_G \ell^A_{Git}} + \frac{1}{\alpha_F \ell^A_{Fit}} \right) + \alpha_F \left( \frac{1}{\alpha_G \ell^A_{Git}} + \frac{1}{\alpha_F \ell^A_{Fit}} \right).$$  \tag{29}$$

We calibrate the parameters $\alpha_G$ and $\alpha_F$ using data on the share of land and buildings in farm income and data on farm labor intensity from the individual-level population census of 1851. From Feinstein (1972), the share of land and buildings in farm income for the economy as a whole was 0.31 in 1855. From the data on farm acreage and employment reported in the population census of 1851, we find that farms in parishes with the highest levels of wheat suitability (which we associate with arable farming) are 1.5 times as labor-intensive as farms in parishes with the lowest levels of wheat suitability (which we associate with pastoral farming). We choose $\alpha_G$ and $\alpha_F$ to match these empirical moments, which yields values of 0.25 and 0.34, respectively.

6.3 Step 3 : Wages ($w_t$)

We next use this solution for the aggregate agricultural land payments share ($\alpha_{Ait}$) to solve for wages ($w_{it}$). Re-arranging the floor space market clearing condition (27), we can recover unobserved wages ($w_{it}$) from the observed data on rateable values ($R_{it}$), employment in each sector ($N_{kit}$), and the aggregate land payments share for each sector ($\alpha_{Ai}$, $\alpha_{M}$, $\alpha_{S}$):

$$w_{it} = \frac{(1 - \beta_H) R_{it}}{\beta_H N_{it} + \alpha_{Ait} \frac{\alpha_{Ait}}{1 - \alpha_{Ait}} N_{Ait} + \sum_{k \in \{M,S\}} \alpha_k \frac{\alpha_k}{1 - \alpha_k} N_{kit}}. \tag{30}$$

We calibrate the share of land payments in manufacturing and services ($\alpha_{M}$, $\alpha_{S}$) using data on the share of payments for land and buildings in aggregate domestic income and the share of non-agricultural sectors in domestic income. We set $\alpha_{M} = \alpha_{S} = 0.09$.

6.4 Step 4 : Floor Space Shares by Sector ($\ell_{Ait}$, $\ell_{Mit}$, $\ell_{Sit}$, $\ell_{Hit}$)

We observe employment in agriculture, manufacturing and services ($N_{Ait}$, $N_{Mit}$, $N_{Sit}$, but do not observe the shares of floor space and land area allocated to manufacturing, services and housing ($\ell_{Mit}$, $\ell_{Sit}$, $\ell_{Hit}$). Therefore, we now use the structure of the model, the observed data, and our solutions for wages ($w_{it}$) and floor prices ($r_{it}$) from previous steps to solve for these unobserved endogenous variables.

From our assumptions of Cobb-Douglas preferences and production technologies, we have the following closed-form solutions for floor space use in each sector in terms of employment in each sector ($N_{kit}$), wages ($w_{it}$) and the price of floor space ($r_{it}$):

$$L_{Hit} = \beta_H L_{it} + \beta_H \sum_{k \in \{A,M,S\}} \frac{w_{it}}{r_{it}} N_{kit},$$
\[ L_{Ait} = \frac{\alpha_{Ait}}{1 - \alpha_{Ait}} \frac{w_{it}}{r_{it}} N_{Ait}, \]
\[ L_{Mit} = \frac{\alpha_{M}}{1 - \alpha_{M}} \frac{w_{it}}{r_{it}} N_{Mit}, \]
\[ L_{Sit} = \frac{\alpha_{S}}{1 - \alpha_{S}} \frac{w_{it}}{r_{it}} N_{Sit}. \]

Dividing the solution for floor space for each sector by its sum across sectors, we immediately obtain the share of floor space used in each sector \((\ell_{Hiit}, \ell_{Ait}, \ell_{Mit}, \ell_{Sit})\).

### 6.5 Step 5: Arable and Pastoral Employment \((N_{Git}, N_{Fit})\)

We observe land area allocated to arable and pastoral farming \((L_{Git}, L_{Fit})\), but do not observe employment in arable and pastoral farming \((N_{Git}, N_{Fit})\). Therefore, we follow a similar procedure of using the structure of the model, the observed data, and our solutions for wages \((w_{it})\) and floor prices \((r_{it})\) from previous steps to solve for these unobserved endogenous variables.

From our assumptions of Cobb-Douglas preferences and production technologies, we have the following closed-form solutions for employment in arable and pastoral farming in terms of floor space \((L_{git})\), wages \((w_{it})\) and the price of floor space \((r_{it})\):

\[ N_{Git} = \frac{1 - \alpha_G}{\alpha_G} \frac{r_{it}}{w_{it}} L_{Git}, \]
\[ N_{Fit} = \frac{1 - \alpha_F}{\alpha_F} \frac{r_{it}}{w_{it}} L_{Fit}, \]  \( (31) \)

where we solved for the floor space allocated to agriculture \((L_{Ait})\) in the previous step. We observe the shares of agricultural land area allocated to arable and pastoral farming \((\ell^A_{Git}, \ell^A_{Fit})\), which equal the shares of agricultural floor space allocated to these two goods. Therefore, combining these two pieces of information, we can compute floor space allocated to arable and pastoral farming \((L_{Git}, L_{Fit})\), and hence recover employment in arable and pastoral farming \((N_{Git}, N_{Fit})\).

### 6.6 Step 6 : Parameter Calibration

We determined the shares of land payments in revenue \((\alpha_G, \alpha_F, \alpha_M, \alpha_S)\) and the floor space supply elasticity \((\mu)\) in previous steps. We assume standard values for the remaining model parameters from the existing empirical literature. The parameter \(\epsilon\) that controls the dispersion of agricultural productivity draws determines the elasticity of the arable and pastoral shares of agricultural land with respect to changes in the relative prices of these goods. Given the mild climate of England and Wales, which permits both these agricultural activities, we assume a relatively high elasticity of \(\epsilon = 3\), close to the value of 3.176 estimated in *Fajgelbaum and Redding (2022)* using spatially-disaggregated data for Argentina during the 19th century.
The parameter $\theta$ that regulates the dispersion of sectoral productivity determines the elasticity of the agricultural, manufacturing, services and housing land shares with respect to changes in the relative prices of these goods. Given the substantial heterogeneity in the characteristics of land that are advantageous for each of these sectors, we assume a lower elasticity of $\theta = 2$, which also ensures that arable and pastoral farming are more substitutable with one another than with each of the other economic activities.

Finally, the parameter $\chi$ that captures the dispersion of idiosyncratic amenities determines the elasticity of population with respect to real income in each location. We assume a value of $\chi = 2$ for this migration elasticity, which lies broadly in the center of the range of estimates of this parameter in Bryan and Morten (2019), Fajgelbaum, Morales, Suárez-Serrato, and Zidar (2019) and Galle, Rodríguez-Clare, and Yi (2022).

7 Counterfactuals

In this section, we show how the model can be used to undertake counterfactuals for the impact of the Grain Invasion, as captured by the observed decline in the relative price of arable products from 1871-1901. We treat this change in relative prices as exogenous, as driven by improvements in transatlantic shipping technology and the opening up of the American mid-west, Canadian prairies and Argentinian pampas for large-scale cultivation of wheat and other cereal grains.

We start at the observed equilibrium in the data in 1871 and undertake a counterfactual for the observed relative decline in the price of arable products from 1871-1901. We use an exact-hat algebra approach, in which we use the observed values of the endogenous variables and our solution for unobserved endogenous variables in the initial equilibrium to capture unobserved location characteristics, such as productivity, amenities and migration costs. We denote the values of variables in the initial equilibrium without a prime, the values of variables in the counterfactual equilibrium with a prime, and the relative changes in variables between the actual and the counterfactual equilibria with a hat (such that $\hat{x}_i = x'_i/x_i$). Using this notation, we write the counterfactual equilibrium conditions of the model in terms of the observed values of variables in the initial equilibrium and these relative changes in variables.

In particular, we solve for a counterfactual equilibrium using the following shooting algorithm. We start by guessing a relative change in the price of floor space $\hat{r}_i$ and the wage $\hat{w}_i$ and solve for the relative change in all other endogenous variables of the model. We next check whether demand equals supply in the market for floor space, the labor market, the market for non-traded services and the market for housing. If demand equals supply in all four markets, we have found an equilibrium. If not we update our guess for the relative change in the price of floor space $\hat{r}_i$ and the wage $\hat{w}_i$ until convergence to an equilibrium.
Given each guess for the relative change in the price of floor space $\hat{r}_i$ and the wage $\hat{w}_i$, we solve for the relative change in all the endogenous variables of the model using the following system of equations:

\[
\hat{e}_{Gi} \ell_{Gi} = \frac{\ell_{Gi} \hat{P}_{/Gi}^{\rho/\alpha G} \hat{w}_i^{1-\rho/\alpha G}}{\ell_{Gi} \hat{P}_{/Gi}^{\rho/\alpha G} \hat{w}_i^{1-\rho/\alpha G} + \ell_{F_i} \hat{w}_i^{1-\rho/\alpha F}},
\]  

(32)

\[
\hat{e}_{F_i} \ell_{F_i} = 1 - \hat{e}_{Gi} \ell_{Gi},
\]  

(33)

\[
\hat{P}_{Ai} = \left[ \ell_{Gi} \hat{P}_{/Gi}^{\rho/\alpha G} \hat{w}_i^{1-\rho/\alpha G} + \ell_{F_i} \hat{w}_i^{1-\rho/\alpha F} \right]^{1/2},
\]  

(34)

\[
\hat{e}_{Hi} \ell_{Hi} = \frac{\ell_{Hi} \hat{P}_{/Hi}^{\rho/\alpha H} \hat{w}_i^{1-\rho/\alpha H} + \ell_{Si} \hat{P}_{/Si}^{\rho/\alpha S} \hat{w}_i^{1-\rho/\alpha S} + \ell_{Mi} \hat{w}_i^{1-\rho/\alpha M} + (1 - \ell_{Hi} - \ell_{Hi} - \ell_{Hi}) \hat{P}_{Ai}^\rho}{\hat{P}_{Ai}^\rho},
\]  

(35)

\[
\hat{e}_{Ai} \ell_{Ai} = \frac{(1 - \ell_{Hi} - \ell_{Si} - \ell_{Hi}) \hat{P}_{Ai}^\rho}{\hat{P}_{Ai}^\rho},
\]  

(36)

\[
\hat{e}_{Mi} \ell_{Mi} = \frac{\ell_{Hi} \hat{P}_{/Hi}^{\rho/\alpha M} \hat{w}_i^{1-\rho/\alpha M} + \ell_{Si} \hat{P}_{/Si}^{\rho/\alpha S} \hat{w}_i^{1-\rho/\alpha S} + \ell_{Mi} \hat{w}_i^{1-\rho/\alpha M} + (1 - \ell_{Hi} - \ell_{Hi} - \ell_{Hi}) \hat{P}_{Ai}^\rho}{\hat{P}_{Ai}^\rho},
\]  

(37)

\[
\hat{e}_{Si} \ell_{Si} = \frac{\ell_{Hi} \hat{P}_{/Hi}^{\rho/\alpha S} \hat{w}_i^{1-\rho/\alpha S} + \ell_{Si} \hat{P}_{/Si}^{\rho/\alpha S} \hat{w}_i^{1-\rho/\alpha S} + \ell_{Mi} \hat{P}_{/Mi}^{\rho/\alpha M} \hat{w}_i^{1-\rho/\alpha M} + (1 - \ell_{Hi} - \ell_{Hi} - \ell_{Hi}) \hat{P}_{Ai}^\rho}{\hat{P}_{Ai}^\rho},
\]  

(38)

\[
\hat{L}_i = \hat{r}_i, \quad \hat{L}_{Hi} = \hat{r}_i \hat{L}_i, \quad \hat{L}_{Mi} = \hat{r}_i \hat{L}_i, \quad \hat{L}_{Si} = \hat{r}_i \hat{L}_i, \quad \hat{L}_{Ai} = \hat{r}_i \hat{L}_i, \quad \hat{w}_i N_{Mi} = \hat{r}_i \hat{L}_{Mi}, \quad \hat{w}_i N_{Si} = \hat{r}_i \hat{L}_{Si}, \quad \hat{w}_i N_{Ai} = \hat{r}_i \hat{L}_{Ai}, \quad \hat{w}_i N_i = \hat{r}_i \hat{L}_i \quad \hat{w}_i N_{Mi} = \hat{r}_i \hat{L}_{Mi}, \quad \hat{w}_i N_{Si} = \hat{r}_i \hat{L}_{Si}, \quad \hat{w}_i N_{Ai} = \hat{r}_i \hat{L}_{Ai}, \quad \hat{w}_i N_i = \hat{r}_i \hat{L}_i \quad \hat{w}_i N_{Mi} = \hat{r}_i \hat{L}_{Mi}, \quad \hat{w}_i N_{Si} = \hat{r}_i \hat{L}_{Si}, \quad \hat{w}_i N_{Ai} = \hat{r}_i \hat{L}_{Ai}, \quad \hat{w}_i N_i = \hat{r}_i \hat{L}_i
\]  

(47)

\[
\hat{N}_i = \hat{w}_i N_i, \quad \hat{N}_{Si} = \hat{w}_i N_i \quad \hat{N}_{Ai} = \hat{w}_i N_i
\]  

(48)

\[
\hat{P}_{Ai} = \hat{P}_{/Ai}^{\rho/\alpha A} \hat{P}_{/Ai}^{\rho/\alpha M}, \quad \hat{P}_{Ci} = \hat{P}_{/Ci}^{\rho/\alpha C} \hat{P}_{/Ci}^{\rho/\alpha M}, \quad \hat{\lambda}_i \lambda_i = \frac{\hat{w}_i \hat{P}_{/Ci}^{\rho/\alpha C} \hat{P}_{/Ci}^{\rho/\alpha M} \hat{P}_{/Hi}^{\rho/\alpha H} \hat{P}_{/Hi}^{\rho/\alpha M} \hat{w}_i}{\sum_{n \in N} \hat{w}_n \hat{P}_{/Cn}^{\rho/\alpha C} \hat{P}_{/Cn}^{\rho/\alpha M} \hat{w}_n \hat{w}_n \hat{w}_n},
\]  

(51)
\[ \hat{N}_i = \hat{\lambda}_i, \]  
\[ \hat{w}_i = \left[ \hat{w}_i \hat{N}_i \left( \frac{1}{r_i} w_i \right) + \hat{w}_i \hat{N}_M \left( \frac{1}{w_i} N_i \right) + \hat{w}_i \hat{N}_S \left( \frac{1}{w_i} N_i \right) \right], \]  
\[ \hat{r}_i = \frac{\hat{w}_i \hat{N}_i \frac{1}{r_i} w_i \beta H + \sum_{k \in \{A, M, S\}} \hat{w}_i \hat{N}_k \beta H w_i N_k}{\hat{N}_i}, \]  
\[ \hat{P}_{Hi} = \frac{\hat{r}_i \hat{L}_i \frac{1}{r_i} w_i \beta H + \hat{w}_i \hat{N}_i \beta H w_i N_i}{X_{Hi}}, \]  
\[ \hat{P}_{Si} = \frac{\hat{r}_i \hat{L}_i \frac{1}{r_i} w_i \beta S + \hat{w}_i \hat{N}_i \beta S w_i N_i}{X_{Si}}, \]  
\[ \text{where } X_{Hi} \text{ denotes expenditure on housing such that } X_{Hi} = P_{Hi} z_{Hi} \ell_{Hi} L_i = \beta_H \left[ r_i L_i + w_i N_i \right]; \]  
\[ X_{Si} \text{ captures expenditure on services such that } X_{Si} = P_{Si} (N_{Si})^{1-\alpha_S} (z_{Si} \ell_{Si} L_i)^{\alpha_S} = \beta_S \left[ r_i L_i + w_i N_i \right]; \]  
we assume Cobb-Douglas preferences across sectors and across disaggregated goods within the agricultural sector.

In Figures 12-13, we show some aggregate moments for the economy-wide impact of this decline in the relative price of arable products, and compare the model’s counterfactual predictions to the observed moments in the data. Whereas the model’s counterfactual predictions hold all else constant, the observed moments in the data capture the impact of not only the decline in the relative price of arable products, but the impact of all other shocks over time (including for example changes in relative productivity across sectors). In Figures 14-15, we show the distributional consequences of this decline in the price of arable products, and relate these distributional consequences to the initial land share of cereals in 1871.
Figure 12: Actual and Counterfactual Changes in Aggregate Share of Arable Land

![Change in Aggregate Arable Land Share](image)

Note: Counterfactual for the observed decline in the relative price of arable products from 1871-1901.

Figure 13: Actual and Counterfactual Changes in Aggregate Agricultural Employment Share

![Double-Differenced Agricultural Employment Share](image)

Note: Counterfactual for the observed decline in the relative price of arable products from 1871-1901.
Figure 14: Distributional Consequences of the Grain Invasion Across Locations

Note: Counterfactual for the observed decline in the relative price of arable products from 1871-1901. Histograms of counterfactual relative changes in the model’s endogenous variables across locations. Relative changes in variables in each panel are normalized to have a mean of one across locations.

Figure 15: Distributional Consequences of the Grain Invasion Across Locations and Initial Specialization in Arable Farming in 1871

Note: Counterfactual for the observed decline in the relative price of arable products from 1871-1901. Binscatter of relative change in land price against initial land share of cereals in 1871. Relative change in land price normalized to have a mean of one across all locations.
8 Conclusion

The distributional consequences of trade is one of the most central questions in international economics. We provide new theory and evidence on this question using one of the most influential trade shocks in history; the 1846 Repeal of the Corn Laws and the subsequent “grain invasion” of European markets from the new world. Whereas traditional research has emphasized the distributional consequences of this trade shock across factors and industries, we highlight its uneven incidence across geographical locations.

We make use of a newly-created, spatially-disaggregated dataset on population, employment by sector, rateable values (land and property value), and poor law (welfare transfers) disbursement for around 11,000 parishes in England and Wales from 1801–1901. The key idea behind our approach is that locations were unevenly affected by this trade shock, depending on the extent to which they were suitable for arable (primarily grain) farming versus pastoral (primarily sheep and cattle) farming. We use this idea to develop an exogenous measure of exposure to this trade shock based on the suitability of agroclimatic conditions for wheat cultivation.

Using quasi-experimental reduced-form regression methods, we show that this trade shock led to a population redistribution from rural to urban areas, structural transformation away from agriculture, and a substantial change in the relative price of land and buildings. In the first half of the 19th century, rural locations with high and low wheat suitability exhibit similar population growth trajectories over time. Following the grain invasion in the second half of the 19th century, we observe a sharp decline in rates of population growth in rural locations with high wheat suitability relative to those with low suitability. By the end of our sample period in 1901, we find a cumulative reduction in the relative population of these high wheat suitability locations by around 20 percent.

We next develop a quantitative spatial model of the distribution of economic activity across sectors and locations. Given the observed data on employment, the value of land and buildings and agricultural land shares, we show how the model can be used to recover the unobserved values of other endogenous variables. Undertaking counterfactuals for the observed decline in the relative price of arable products from 1871-1901, we find sizeable impacts on the aggregate share of arable land and the aggregate share of agriculture in employment. We find that geography is an important dimension along which the distributional consequences of international trade occur, with large relative changes in wages, land prices and real wages across locations within England and Wales, depending on their initial specialization in arable farming.
References


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