Death or taxes? The political economy of sanitation expenditure in nineteenth-century Britain

Thesis by

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To Mum, who always fought for my education.

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Abstract

This thesis consists of three papers studying the relationship between democratic reform, expenditure on sanitation public goods and mortality in Britain in the second half of the nineteenth century. During this period decisions over spending on critical public goods such as water supply and sewer systems were made by locally elected town councils, leading to extensive variation in the level of spending across the country. This dissertation uses new historical data to examine the political factors determining that variation, and the consequences for mortality rates.

The first substantive chapter describes the spread of government sanitation expenditure, and analyzes the factors that determined towns' willingness to invest. The results show the importance of towns' financial constraints, both in terms of the available tax base and access to borrowing, in limiting the level of expenditure. This suggests that greater involvement by Westminster could have been very effective in expediting sanitary investment. There is little evidence, however, that democratic reform was an important driver of greater expenditure.

Chapter 3 analyzes the effect of extending voting rights to the poor on government public goods spending. A simple model predicts that the rich and the poor will desire lower levels of public goods expenditure than the middle class, and so extensions of the right to vote to the poor will be associated with lower spending. This prediction is tested using plausibly exogenous variation in the extent of the franchise. The results strongly support the theoretical prediction: expenditure increased following relatively small extensions of the franchise, but fell once more than approximately 50% of the adult male population held the right to vote.

Chapter 4 tests whether the sanitary expenditure was effective in combating the high mortality rates following the Industrial Revolution. The results show that increases in urban expenditure on sanitation—water supply, sewer systems and streets—was extremely effective in reducing mortality from cholera and diarrhea.

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Chapter 1

Introduction

Sanitation infrastructure is critical to public health. Yet, government investment in sanitation remains insufficient in many countries: in 2010 dirty water alone was estimated to have killed more people than all forms of violence, including war, combined (Corcoran, 2010). There is thus a pressing need to understand the political difficulties that impede government sanitation investment and how countries have been able to overcome those obstacles in the past.

This thesis examines the political economy of sanitation investment in Victorian Britain. Britain in the nineteenth-century faced challenges similar to those in developing countries today, with industrialization leaving a trail of deteriorating sanitary environments in its wake. A growing movement for sanitary reform faced intense opposition from taxpayers unwilling to fund much needed new infrastructure, leading to inefficiently low levels of investment in "social infrastructure" (Williamson, 2002). To understand the opposition to sanitation expenditure, we have to analyze local government, since it was locally elected town councils that held responsibility for maintaining sanitary environments. We often overlook the important role of local governments in building and maintaining infrastructure, in part due to the difficulty in collecting data when compared to well-developed national accounts, but by doing so we miss a key component of the development of the scope and size of the modern state. Further, local government data has the additional advantage of allowing political economy models to be tested within a single country setting, avoiding the difficulties associated with cross-country regressions.

The thesis is comprised of three separate papers, each of which utilizes a new annual dataset of town-level accounts for all urban areas in England and Wales between 1867 and 1910. In Chapter 2, I analyze whether the decentralization of spending authority to town councils increased sanitation investment. Critically, town councils had to rely on local taxes to fund their sanitation expenditure. This financial burden led to resistance from local tax-payers, with many towns spending nothing on key sanitation items as much as 40 years after town councils were given control of expenditure in the 1848 Public Health Act. I then show that democratic reforms in 1894, which implemented the secret ballot and removed multiple votes for wealthier citizens, did not overcome this unwillingness to spend. I implement a difference-in-difference analysis, using the fact that some town councils had been elected under this more democratic system since 1835 to construct a control group. I find that the extension of political power to poorer citizens reduced both the level of expenditure on water supply and revenue from taxes, suggesting that democratic reform inhibited the expansion of the role of state to encompass infrastructure investment.

In Chapter 3 I delve deeper into the effects of extending voting rights. Many theories of democratization suggest that extending the right to vote will lead to increased government expenditure (e.g., Meltzer and Richard, 1981; Lizzeri and Persico, 2004; Acemoglu and Robinson, 2000). However, these models frequently assume that government can engage in transfer expenditure, which is often not true for local governments, and was not the case in nineteenth-century Britain. I present and test a model of government expenditure on public goods where government does not hold power to implement redistributive transfers. The model predicts that the poor and the rich desire lower public goods expenditure than the middle class: the rich because of the relatively high tax burden, and the poor because of a high marginal utility of consumption. Consequently extensions of the franchise to the poor can be associated with declines in government expenditure on public goods. The empirical analysis exploits plausibly exogenous variation in the extent of the franchise in 150 towns to identify the effects of extending voting rights to the poor. The results show strong support for the theoretical prediction: expenditure increased following relatively small extensions of the franchise, but fell following extensions of the franchise beyond around 50% of the adult male population.

In Chapter 4 I test how effective sanitation expenditure was in reducing mortality from two waterborne diseases—cholera and diarrhea. Linking the financial data to registration information specifying mortality rates, I find that sanitation spending was very effective in reducing mortality from waterborne disease. This result suggests that the taxpayer opposition analyzed in the previous chapters had extremely costly effects on public health—it did not merely prevent wasteful or corrupt expenditure.

Chapter 2

The political economy of sanitation expenditure

2.1 Introduction

The role of the British state changed radically between 1848 and 1900. Over this period, government became responsible for provision of new urban infrastructure—including clean water supply, waste disposal and electric lighting—and for a growing range of public health services. However it was not the national government that built this critical infrastructure. Rather, it was locally elected town councils that were charged with both raising the funds to pay for sanitation, and deciding how those funds should be spent to best improve sanitary environments.

In this chapter I analyze whether the political decentralization in Britain was successful in increasing expenditure on sanitary public goods, including water supply, sewer systems and paved roads. The analysis shows that the central government faced considerable difficulties in convincing local councils to increase spending despite significant health benefits—as shown in Chapter 4, this infrastructure was critical to reducing mortality from waterborne disease. I then test whether these problems were a consequence of a local governance structure that was biased in favor of wealthy citizens in many towns. The results suggest that, in fact, the opposite was true: as democratic reform gave the poor greater political power there was a reduction in both important expenditure and in associated tax revenue. While democratic reform may contribute to the growth of social spending by national government (Lindert, 2004), this finding indicates that democratic change may have inhibited the expansion of the role of the state in other, equally important, ways.

To test the effects of democratic reform, I use a new dataset of sanitary expenditure in approximately 700 town councils between 1872 and 1904; plus earlier data regarding local government activities undertaken under the terms of the 1848 Public Health Act. This dataset allows me to identify the financial constraints faced by local governments and to analyze the success of attempts by the Westminster Parliament to encourage local governments to spend effectively. Many towns failed to make significant investments in infrastructure despite being granted significant powers—from 1848 onward towns were able, at a low cost, to obtain the authority to raise taxes and invest in improvements to their local environment. By 1872, fewer than 50% of towns were spending any money at all on sewer systems and even fewer were spending on water supply. The imposition of requirements that towns improve sanitary environments in the 1870s did lead to an increase in nationwide expenditure, but many towns continued to spend very small amounts on sanitation.

To test whether this failure to invest was a consequence of limited democracy—for instance due to elite capture—I use the fact that the governance structure of the councils that controlled sanitation expenditure varied across different towns and over time. While in some towns the system was relatively democratic, with a secret ballot and a system of one vote per head of household, in other towns the franchise was graduated, with wealthier citizens holding multiple votes. In 1894 this system was standardized by the 1894 Local Government Act, providing an exogenous institutional change. I use this Act of Parliament as the treatment event in a difference-in-difference analysis, where the control group consists of a matched sample of towns that had a democratic governance structure prior to this date. The results show little evidence that democratic governance led to greater expenditure on sanitation infrastructure. Rather, the findings suggest that in fact the move to a more democratic system, and hence the extension of political power to poorer citizens reduced per capita expenditure on water supply and per capita tax receipts.

What might explain this result? The answer may lie in the important financial constraints faced by town councils during this period and, in particular, their reliance on raising revenue through local taxation (Millward and Sheard, 1995). Taxpayers bore much of the burden of greater expenditure—the results show that the taxable wealth of the district was critical in determining the level of spending. In other words, an important barrier to investment was that citizens were limited in their ability to redistribute across the country. I find that significant growth in spending occurred once government grants gave towns greater ability to share the costs of maintaining and improving local roads.

Importantly, however, towns were also limited in their ability to redistribute between their own citizens since they were constrained in the scope of the taxes they could raise. Taxes could only be raised on property—not profits or income—and only a proportional tax rate could be used. As a result, the vast majority of households were expected to pay tax, meaning that poorer citizens had to "pay" for greater government spending on public goods. The fact they faced these costs could explain the negative effect of democratic reform—I analyze this argument in more detail in Chapter 3.

2.2 Data

I begin by describing the dataset that I use throughout the remainder of the paper. The data consists of two major parts: the financial data relating to annual town revenue and expenditure; and demographic information drawn from decennial censuses. I discuss each in turn below, and define some key variables used in the later empirical work.

2.2.1 Financial data

Data sources

The main part of the dataset relates to the annual accounts of all the urban councils responsible for sanitary expenditure between 1867 and 1904 reported in the *Local Taxation Returns* as part of the Parliamentary Papers.[1] These accounts were reported by Parliament in annual documents throughout this period, and provide a detailed disaggregation of the sources of revenue and types of expenditure in each town. A panel dataset was constructed by hand-matching towns between years to account for variations in place names over time. I also utilize information from other reports for specific purposes; these are cited in the appropriate location throughout the text. To construct the variables used in the analysis I transform the nominal financial values into real terms using the Rousseaux Price Index, obtained from Mitchell (1971, pp. 723–4), following Millward and Sheard (1995).

Variables

Sanitary expenditure

The focus of our analysis is "sanitary expenditure", defined as the combination of water supply, sewer systems and expenditure on streets and highways. This latter category is included for three reasons. First, the paving of streets can have a direct sanitary impact since it affects the ease of cleaning streets and because it was sometimes associated with slum clearance (Baird, 1886; Millward and Sheard, 1995). Further, this category of expenditure also included activities such as street cleaning and "scavenging" (collection of refuse). In places I group these categories together because it is not clear whether the towns are consistent in their separation between these different categories, and in some cases spending on (for instance) water and sewers is explicitly combined together. This is particularly true before

[1] A full list of the papers used is available from the author upon request.

1884, when the organization of the accounts improved significantly.

A further complication with the financial variables is that before 1884 loan expenditure is not distinguished from current expenditure and, consequently, it is not possible to separate investment expenditure from ongoing expenditure. As a result, in the regressions below I focus predominantly on the period after 1884. To account for both current and loan expenditure I spread expenditure out of loans over the period, by assuming an amortization of 1/25 of the loan each period. That is, our independent variable is:

$$OngoingExpend_{i,t} = CurrentExpend_{i,t} + \left(\sum_{s=1884}^{t} LoanExpend_{i,s} \right) /25$$

Revenue

I use three measures of receipts in the analysis. Tax receipts are measured as the total revenue from property taxes (the "rates") for each town. Towns varied according to the type of rate they levied for the same purpose, and as such I aggregate them into a single variable. Second, I include the revenue from property, including both rents and property sales.[2] The third revenue measure relates to the receipts from other authorities—including both the central government and county councils. Revenue from county councils is separated into two parts: those from the "Exchequer Account" and "Other"—predominantly consisting of payments for main roads. Since the latter is particularly interesting for our analysis, I would ideally separate between the two. Unfortunately the accounts do not do this for non-municipal boroughs from 1898 onward. As such, I estimate this variable by assuming that the percentage of the total receipts from the County Council accounted for by the "Other" category remains constant for each town after this point.

Rateable value per capita

The dataset includes the rateable value—that is the value of the property tax base—for the majority of years in the dataset. I use a three year rolling average to smooth changes due

[2] These sources of revenue are not consistently separated in the accounts.

to re-ratings, and linearly interpolate missing years.[3]

Loans outstanding and interest rates

From 1883 onwards the reports identify the stock of loans outstanding separated by category (water supply, sewers, etc.). This data can be used as a measure of the stock of investment by each local authority, given the importance of borrowing in funding investment (see discussion in the following section). In addition, we can use the total stock of loans outstanding to provide a crude estimate of the cost of borrowing to each local authority. In particular, I estimate the average interest rate using the following formula:

$$Average\_Interest_{i,t} = \frac{ExpendInterest_{i,t}}{(LoansOutstanding_{i,t} + LoansOutstanding_{i,t-1})/2}$$

That is, the average interest rate is calculated by dividing the expenditure on interest in year t by the estimated average value of loans outstanding during period t. Data on annual interest payments is available for the period 1887-1903 for all towns.[4]

This measure suffers from two concerns. First, the measure may include the interest rate paid on relatively old loans, and hence may not reflect the current interest cost facing a town. However, problems of this sort are likely to be small since towns could refinance loans at lower interest rate once the current cost of borrowing dropped (Bellamy, 1988). Secondly, the measure can only be estimated for towns that have loans outstanding at the end of the relevant year. This could lead to considerable selection bias since towns with higher average interest rates are likely to be less likely to borrow.

In order to separate trends specific to local governments from general changes in the cost of borrowing I also include a measure of the long run rate of interest—the adjusted yield on British consols reported in Mitchell (1971, p. 678).

[3]This information is missing for the year 1883 for municipal boroughs; and for isolated years for other towns. Municipal boroughs sometimes reported a separate rateable value as borough authorities and as sanitary authorities: I use the maximum of the two.

[4]For non-municipal boroughs it is also available for the year 1904.

2.2.2 Demographic data

Information regarding town population and the number of houses in each town is drawn from the reports of the decennial census between 1851 and 1911. Information for the years 1851–1901 was collected directly for the purposes of this project. For the 1911 census I use the parish-level data coded previously by Southall (2004) and stored at the UK data archive.

In addition to these demographic variables, I use information from the 1881 census to identify the occupational structure of each town. A 100% sample of the 1881 census is available from the North Atlantic Population Project (Minnesota Population Center, 2008; Schürer and Woollard, 2003). This dataset identifies the occupation, age, labor force status and place of birth for each resident. I use this dataset to identify the proportion of the work force in various occupations, including agriculture, textiles, domestic service, and mining; as well as the proportion of the population that are foreign born in each town.

Unfortunately, the census does not identify the current town of residence; rather it identifies the parish and registration sub-district in which each individual lives. I therefore match each town to registration sub-districts in the 1881 census. In some cases, the town falls entirely within a single sub-district, in which case I assign the value in that sub-district to that town. In others, towns were split across registration sub-district boundaries. In those cases I estimated town characteristics by weighting according to the proportion of the town in each of the registration sub-districts.

Sample

For the purposes of this paper I analyze towns that existed as sanitary authorities throughout the period 1875 to 1911. This allows us to assess the changes in spending and revenue patterns over time without worrying about major changes in the composition of the sample. By doing so, I exclude two sets of towns from our dataset. The first relates to those towns that became sanitary authorities after 1875; particularly newer industrial towns in the North-West. The second group relates to towns that stopped being sanitary authorities during this period; this group consists of sanitary authorities that were merged together after a certain point—in particular when large towns subsumed urban areas in its suburbs. In both cases the towns excluded reflect a relatively small part of the urban population.[5]

The sample then consists of a total of 691 towns, whose characteristics are summarized in Table 2.5 in the appendix. The towns vary significantly in size with the smallest town having a population of only approximately 200 throughout the period, but the largest towns (such as Manchester and Liverpool) having a population of several hundred thousand.

2.3 The development of the sanitary state

In this section I use the dataset to examine the growth and variation in the level of expenditure across towns and over time. I start by analyzing the effectiveness of the decentralized system implemented by the public health acts of 1848 and 1875; showing that providing powers to local governments was insufficient to induce towns to invest. As a prelude to the formal empirical analysis in the next section, I then investigate possible explanations for towns' reluctance to invest. First I identify differences in revenue sources available to towns, including variation in the size of the tax base available, revenue from property holdings, and revenue from other trading activities. I then provide new evidence as to costs of borrowing, and the government grants provided to towns available over time. Finally, I discuss the importance of changing governance structures on different towns.

[5]The included towns represent 79% of the population of urban areas reported in the 1881 census, and 73% of the urban population reported in the 1891 census.

2.3.1 Decentralization and expenditure on public goods

Parliament reacted to the growing sanitary movement in the 1840s by emphasizing the role of local action in combating insanitary conditions. Rather than taking direct action to improve sanitary environments, the national government "began a series of legislative measures in which the state became guarantor of standards of health and environmental quality and provided means for local units of government to make the structural changes to meet those standards" (Hamlin and Sheard, 1998, p.587). As a result the nineteenth-century saw a gradual broadening of both local governments' powers and responsibility for the maintenance of their local environment.

To examine the effectiveness of this decentralization movement, I examine the use of new powers by towns first under the 1848 Public Health Act, which provided towns with voluntary access to spending authority, and then under the 1872 and 1875 Public Health Acts, which gave towns greater obligations to maintain sanitary environments. As I will see, the Acts had some success in increasing expenditure on sanitary goods, but by no means were sufficient to ensure quality sanitary environments: even by the end of the century many areas were spending very small amounts on sanitary public goods.

The 1848 Public Health Act established the principal of "localism" in sanitary affairs, offering local taxpayers ("ratepayers") the opportunity to establish a local board of health with responsibility for sewers and street cleaning, and the power to ensure a satisfactory water supply.[6] This provided towns with a low cost mechanism through which towns could gain the authority to spend on sanitary improvements. Before 1848 such powers were obtainable only on a case by case basis through private acts of Parliament ("Improvement Acts"), which imposed an often prohibitive cost on smaller and poorer towns (Wilson, 1997). But the 1848 Act was not enough, since many towns did very little, even if they chose to obtain the

[6]The 1848 Public Health Act was extended by the 1858 Local Government Act, and many authorities acquired their powers under the latter legislation. I refer to both as the 1848 Act for simplicity.

power to do so. Faced with the lack of response from town councils, Parliament imposed greater mandatory responsibilities on town councils. Public Health Acts of 1872 and 1875 established a network of urban and rural sanitary authorities covering the entire country, tasked with the responsibility to ensure the provision of sanitary services in their jurisdiction.

Crucially the 1848 Act was voluntary in nature; as such some areas adopted it and others did not. Table 2.1 displays the percentage of towns exercising different types of sanitary authority by 1871. The table indicates that at least in in one sense the Act was successful: almost three-quarters of towns held sanitary authority under either the 1848 Public Health Act or its successor the 1858 Local Government Act. Further, even larger towns that had not obtained authority under this Act had gained additional sanitary powers through other legislative routes. In fact all towns with a population of over 25,000 had some control over sanitary authority by 1871.

Table 2.1: Town population and local board adoption

	Type of Sanitary Authority in 1865					
Population	**Local Board**	**Improv. Comm.**	**Other local act**	**None**	**Total**	**N**
Under 10000	75%	3%	3%	19%	100%	515
10000-25000	71%	12%	4%	13%	100%	100
25000-50000	71%	7%	21%	0%	100%	42
50000-100000	57%	5%	38%	0%	100%	21
100000-250000	38%	0%	63%	0%	100%	8
Over 250000	20%	0%	80%	0%	100%	5
Total	73%	5%	6%	16%	100%	691

Note: Local Board relates to boards created under the 1848 Public Health Act or the 1858 Local Government Act. "Improv. Comm." relates to boards established as local improvement commissions. Other local act reports sanitary authority under a different form for municipal boroughs only. Towns were identified using the 1871 census and the 1903 Report from the Select Committee on Municipal Trading cited in footnote 16.

Table 2.1 suggests that a large number of towns had obtained at least the means to control sanitary expenditure by 1871. However, their motivation was not always to increase spending. In fact, many areas reportedly took up the act in order to *avoid* higher taxes for highway maintenance (Lumley, 1873).[7] In fact fewer than 35% of the 710 towns had received

[7]In particular the 1862 Highways Act gave Local Boards an opt out from becoming part of larger Highways

sanitary authority before this date.[8]

Further evidence of the limited success of the 1848 Public Health Act emerges from an analysis of town spending. By 1872 nearly all towns were spending money on streets and highways, but there was a much larger degree of variation in whether—and how much—towns were spending on either water supply or sewer systems. Figure 2.1 presents the changing proportion of towns spending at all in each of these categories between 1872 and 1904. As discussed above, the figures between 1872 and 1884 should be treated with some caution, since the disaggregation of activities by category is inconsistent prior to that date. Municipal boroughs, in particular, did not always separate spending categories at the beginning of the period, and so particularly for larger towns the proportions may be underestimates. Nevertheless this information provides some indication of the changing activities of the towns over time.

The figures for 1872—the last year of spending under the system established in 1848—indicate that most larger (defined as 1871 population of more than 50,000) towns had begun spending on sewer systems before the 1872 act. However only around 70% of mid-sized towns (10,000-50,000 population) and fewer than 50% of smaller towns had done so. For water supply, approximately 45% of large and mid-sized towns were spending on water supply as opposed to approximately 35% of small towns. Given the inaccuracies in the data this may underestimate the proportion of towns spending at this point, but it is clear that many towns were not devoting any money to these categories. Further, similar figures are provided by pre-1872 information indicating that in 1865 55% of towns had invested in drainage systems, and only 21% in water supply under the 1848 Public Health Act.[9] Interestingly, only 38% reported capital investments in highways, suggesting that much of this expenditure was likely

Districts.

[8]Figures based on Return of Districts where Public Health Act, 1848, or Local Government Act, 1858, or both, are in force,**1867**(80)LIX.141.

[9]Return of Districts under Public Health Act, 1848, and Local Government Act, 1858; Expenses for Works of Sewerage, Water Supply and other Sanitary Works, **1866**(176)LX.419.

ongoing maintenance and cleaning rather than investments.

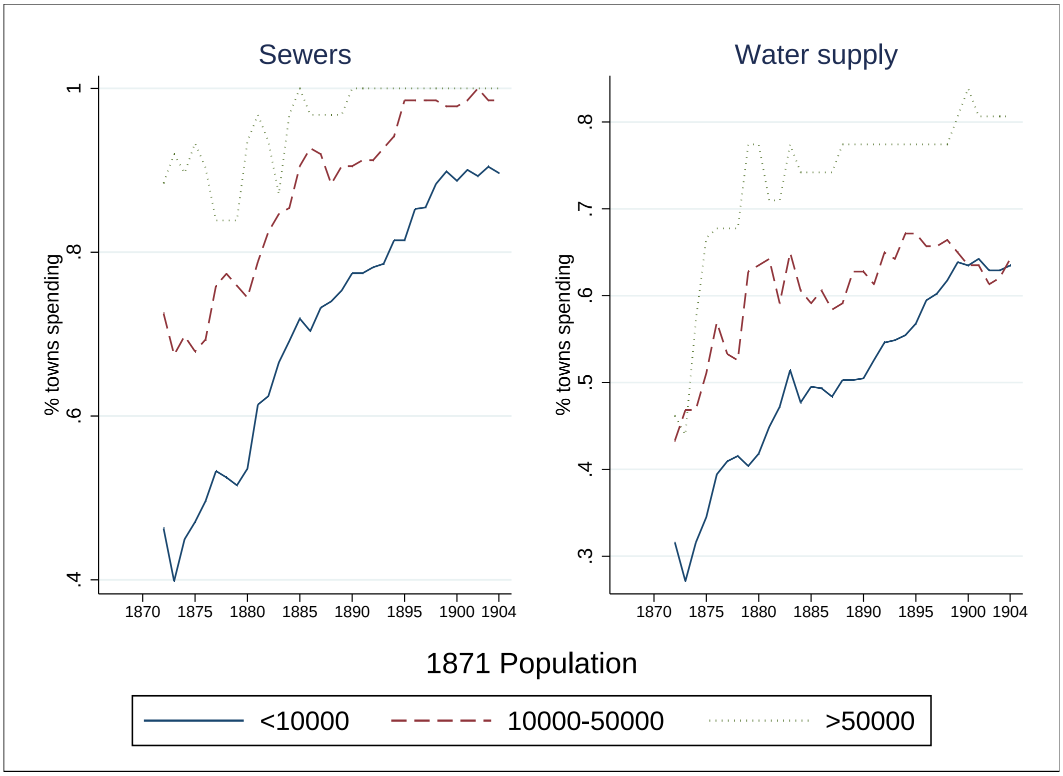
Were the 1870s Public Health Acts successful in increasing sanitary expenditure? Figure 2.1 suggests they were—to an extent. The number of towns involved in both sewer systems and water supply increased rapidly both between 1872 and 1877, and even more so between 1879 and 1885. These trends provide clear evidence of rapid changes following the imposition of the Public Health Acts, even accounting for the fact that some of the initial growth in the estimated proportion of towns involved in sewers and, particularly, water is likely to be a reflection of changes in town reporting (especially amongst the larger towns that tended to be municipal boroughs).

However it is also clear that the Public Health Acts had not achieved consistent expenditure across the country, for even in 1885 (ten years after the Act) one-quarter of towns were still spending nothing on sewers, and almost half were spending nothing on water supply. The challenge of enticing towns to spend was not resolved immediately, but remained a gradual process, with the proportion of towns spending continuing to increase until the mid-1890s. Similarly, much of the increase in the level of sanitary expenditure did not immediately follow the imposition of the Public Health Acts, but occurred after 1885 (see Appendix Figure 2.7).

In addition, the aggregate growth in expenditure masks large and persistent variation in the level of expenditure, as shown in Figure 2.2.[10] Despite clear growth in the level of expenditure nationally, great variation persisted throughout the nineteenth-century, with many towns spending very little on sanitation expenditure even in the mid-1890s.

[10] To provide comparability over time, the figure displays the density of nominal expenditure per capita in terms of the estimated national average (full employment) wage in each year. The average wage was calculated using the 1911 nominal wage reported in Feinstein (1990), deflated using the money wage index from Crafts and Mills (1994).

Figure 2.1: Steady increases in the proportion of towns involved in both water supply and sewer systems between 1872 and 1904.

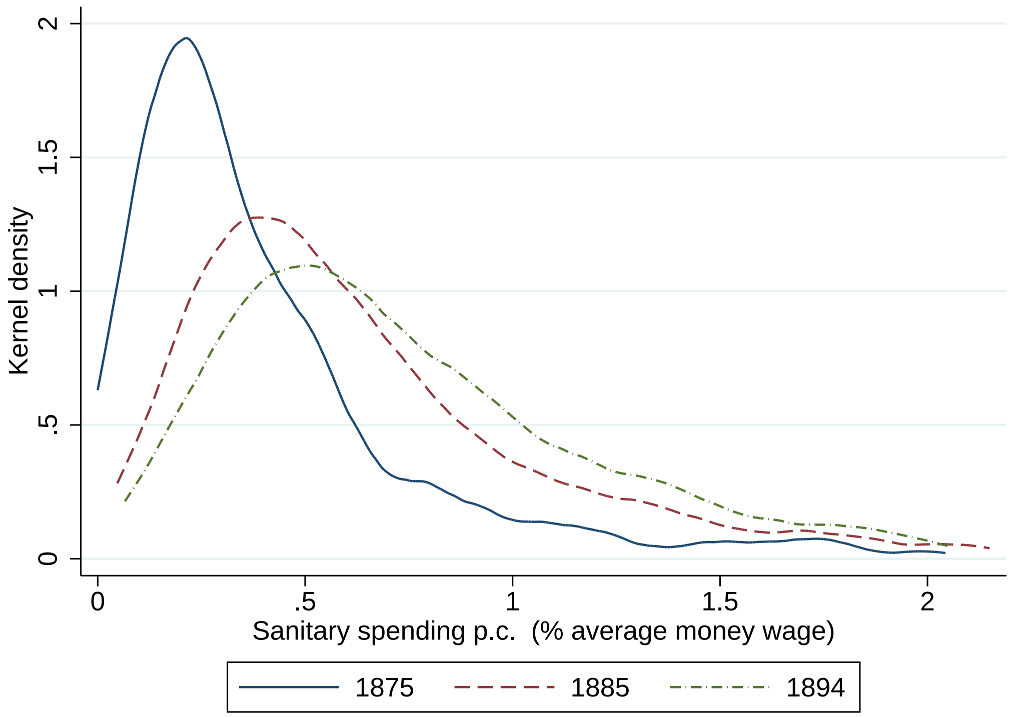


Note: Groups of towns are defined based on the 1871 town population. Each line portrays the proportion of towns reporting any expenditure on the relevant category in the given year.

2.3.2 Financing public goods expenditure

How can we explain this variation across towns? To answer that question, we must understand the financial constraints that towns faced in funding their spending. During this period towns were responsible for funding their own expenditure, with limited financial support from central government. Consequently towns' ability to invest was "closely circumscribed by local wealth and income" (Millward, 2004, p. 35). Further, capital investments had to be funded out of debt; making the cost of borrowing a potential disincentive to greater spending. In this subsection I analyze these constraints, and the extent to which they may have

Figure 2.2: Towns varied widely in their level of sanitary expenditure throughout the nineteenth-century.



Note: The x-axis plots the total nominal spending on sanitation per capita (streets, sewers and water supply) divided by the estimated national average money wage in each year. See text for details of the sources. The figure excludes a small number of towns with sanitary expenditure greater than £1 p.c. for illustrative purposes.

varied over towns and across time, as well as the extent of government support in the form of grants. In the following section I then test the importance of these different factors in explaining the level of public goods expenditure.

Constraints on revenue

The primary source of revenue available to towns was local taxation. Limitations on local authority powers, in place throughout the period, meant that tax could only be raised on "immovable" property, and as such towns were constrained by the "rateable value" of the property in their district, defined according to the rental value of land and buildings in the district.[11] Millward and Sheard (1995) find that, using a small sample of urban areas, a 1% increase in the per capita rateable value of the district was associated with a 1% increase in the level of per capita expenditure (see also Aidt et al. (2010) and, in the German case, Brown (1988)). Figure 2.3 illustrates the wide variation in the level of per capita rateable value across towns: in 1875 the per capita rateable value of the median town was approximately half that of the town at the 95th percentile. Notably, however, although there were great increases in the rateable value per capita over time, it did not increase significantly when compared to nominal wages: the increases in spending necessitated either higher tax rates or alternative sources of revenue.

Towns did, however, have access to some other sources of revenue. Faced with significant opposition to higher taxation, councils began to search for alternative means of funding expenditure (Hennock, 1973, 1963; Wohl, 1983; Millward, 2000; Aidt et al., 2010). Millward and Sheard (1995) and Millward (2000) highlight two particular sources. The first was income from estates, which provided income in the form of rents and property sales. The second was profits from municipal involvement in activities such as gas supply, markets or, from the end of the nineteenth-century, tramways and electric light undertakings. The classic example of the latter route is Birmingham, where Joseph Chamberlain advocated strongly for the use of gas profits to subsidize urban improvements. Our analysis will assess the extent to which this was a special case or a more widespread funding mechanism.

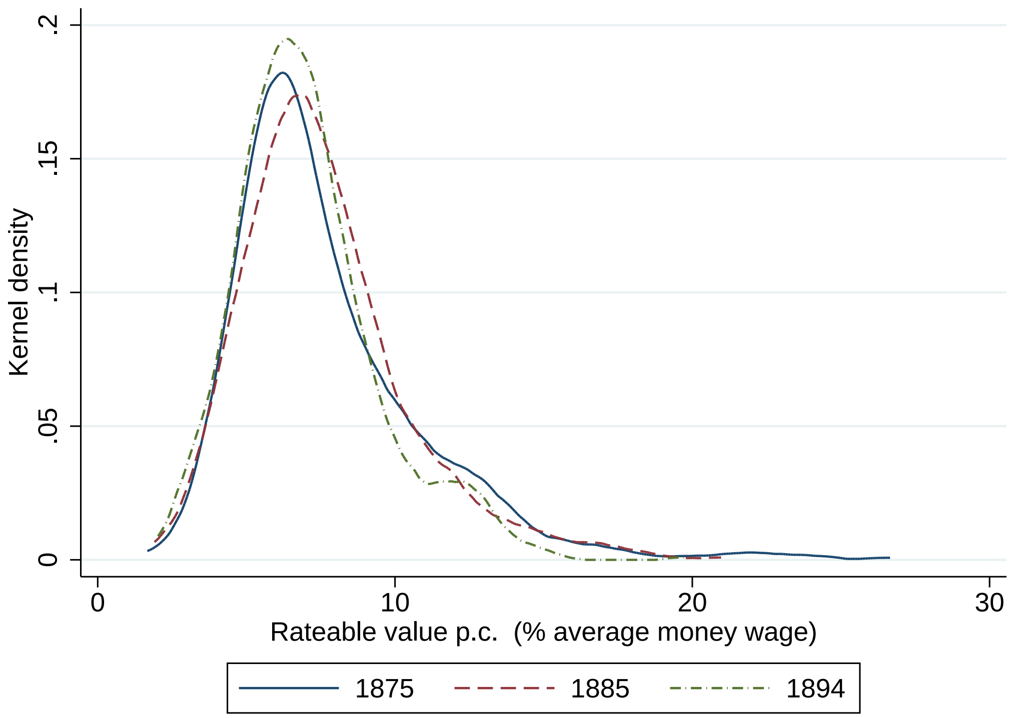
Government grants

Councils received some additional revenue from central government grants during this period. However, the grants were limited to those services deemed "national" in character, such as policing and maintenance of lunatics.[12] Further, grants remained small compared to the size

[11] The details of the rating system are somewhat complex, since discounts could apply depending on both the use of the land, and the way in which rent was paid. For further information see Offer (1981) and the final report of the Royal Commission on Local Taxation cited in footnote 12.

[12] For further discussion of the rationale and use of central government grants during this period see the

Figure 2.3: Towns varied widely in the size of their tax base.



Note: The x-axis plots the total nominal ratable value per capita divided by the estimated national average money wage in each year. Rateable value data was collected from the *Local Taxation Returns*; see text for the sources used to calculate the money wage. The figure excludes towns with rateable value per capita more than £10 for illustrative purposes.

of town revenue, with many towns receiving nothing at all and few receiving an amount exceeding 5% of their rate revenue. As a result, the economic literature has generally seen grants as having a limited role.[13]

However, there were some important changes in the grant system after 1890 that may have received too little focus in the existing literature.[14] In 1890 new county councils, created by the 1888 Local Government Act, gained responsibility for maintaining "main roads" within their jurisdiction. As a result they had to bear some of the cost of maintenance and repair

Final Report of the Royal Commission on Local Taxation, **1901** [Cd. 638]XXIV.413.

[13]See Millward and Sheard (1995), for instance, who group central government grants along with all other "non-trading" income.

[14]See however the discussion in Waller (1983).

of roads within their district, necessitating transfers to town councils within their area. The size of these transfers, while not huge, were much larger than other forms of external revenue. Once transfers from the counties is included, the median town received grants worth more 20% of their rate revenue in 1895—of which by far the largest component related to funding of roads. These grants amounted to 40% of the median town's expenditure on roads.[15]

These transfers were funded largely by sources outside of each individual town, through either a county-wide tax or funding from central government. As such, these grants allowed spending on roads to be funded from a wider tax base than the town's own property. However, often this funding was essentially conditional on towns also spending their own tax revenue: they would often access this funding through cost-sharing agreements where, for instance, the County Council would agree to fund a fixed amount of maintenance cost per year for a fixed term. Alternatively, towns could seek to broaden the scope of the funding they received by petitioning for more roads to be recognized as "main roads".

Borrowing and access to loans

While these revenue sources formed the long-term basis for investment in public goods, the high up-front capital costs of infrastructure investment had to be met through loans. Local authority borrowing was considered the key benchmark of the progress in developing sanitary infrastructure by contemporaries, and access to affordable capital was seen as major obstacle to investment (Bellamy, 1988). In 1902 on average over 95% of capital invested in trading authorities had been borrowed.[16] By 1904, the total borrowing of all urban districts amounted to 35% of the total national debt.[17]

[15] These figures exclude the "county boroughs"—consisting mainly of towns with population above 50,000, who acted as independent counties and so did not receive these transfers.

[16] Author's calculation based on figures in *Report from the Joint Select Committee of the House of Lords and the House of Commons on Municipal Trading*, **1903** (270)VII.1.

[17] Calculated as the sum of borrowing of borough councils and urban sanitary districts for all purposes in 1903–1904, divided by the nominal amount of unredeemed capital of the UK public debt. The sources of the information are the 1903-04 *Local Taxation Returns* and Mitchell (1971, p. 600).

Ensuring access to finance thus became a critical part of the central government's attempts to encourage local authorities to improve the sanitary environment.[18] Urban improvement loans were available from Public Works Loan Commissioners from the 1860s onward, ensuring that all towns did have access to loans throughout this period. However, the appropriate terms of repayment (including the interest rate, the repayment method and repayment term) remained an issue of debate into the twentieth-century, and were not always overly favorable to towns seeking to invest.

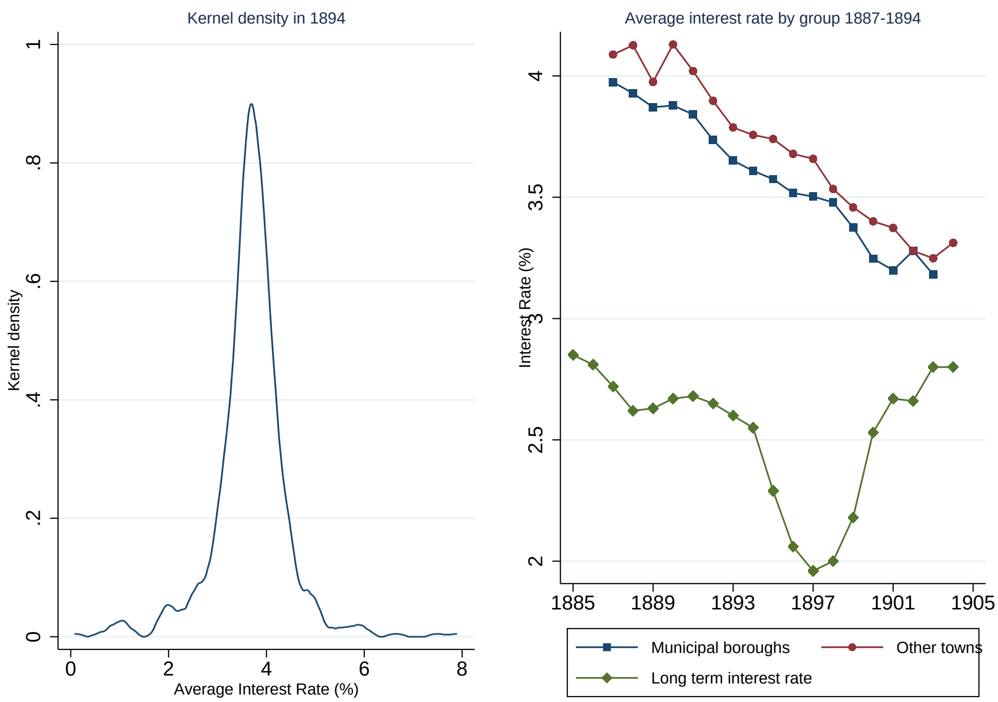
As a result, councils tended to opt for borrowing from alternative sources where possible. This may have led to barriers to investment for smaller towns, but "the big towns and cities experienced little difficulty in raising finance for their ambitious projects...revealing a comparative advantage in their access to loans which after 1870 they extensively exploited" (Wilson, 1997, p.39).

Our data allows us to directly test the extent to which larger towns gained this comparative advantage. As shown in the left hand panel of Figure 2.4 there was wide variation in the average interest rate being paid across towns. Further, there was a considerable decline in the average level of the interest rate over time, as shown in the right hand panel of the figure. For comparison purposes, I also include the yield on consols which serves as an approximation to the long-term interest rate (Mitchell, 1971, pp.649–640).

To explore the characteristics of towns affecting the cost of borrowing, in the appendix I undertake a simple regression analysis with the average interest rate as the dependent variable. The results show consistent evidence that, as suggested by Wilson (1997), larger, wealthier towns had a lower interest rate. Further, as expected, the yield on consols is strongly significant and positive, indicating that towns' cost of borrowing was reacting to changes in the money markets. This is notable, as it suggests that towns were not purely dependent on government loans in this period.

[18]The discussion in this paragraph is based on Wohl (1983); Bellamy (1988); Wilson (1997).

Figure 2.4: Cost of town borrowing fell between 1887 and 1904.



Note: Interest rate for municipal boroughs (that is, the incorporated towns) and other towns is the "average interest rate" defined in Section 2.2. Yield on consols from (Mitchell, 1971, p.678).

2.3.3 Governance of sanitary authorities

In addition to changing town funding, Westminster also intervened in local affairs through alternations to the electoral system under which town councils were governed. While the powers of the sanitary authorities were standardized across the country, the structure of the governing bodies varied across the county, and over time. The sanitary authorities in the incorporated towns—the so called "municipal boroughs"—were constituted by the existing borough council. In non-incorporated towns, in contrast, the sanitary authorities were governed by a newly elected local board or (after 1872) council. As a result the electoral system varied across the two groups of towns. Following the 1835 Municipal Corporations

Act, incorporated towns had been governed by a standardized system of locally elected councils. These councils were elected annually (with one-third of councilors replaced each year) on the basis of one-man-one-vote, by an electorate consisting of all male heads of household subject to residence and tax-paying requirements.[19]

Non-municipal boroughs, on the other hand, were elected under a graduated franchise. Under this system voters could receive up to twelve votes depending on the amount of property occupied and owned. The secret ballot was instituted in municipal boroughs—but not other towns—as part of the 1872 Ballot Act (which also implemented the ballot in parliamentary elections.) This distinction in electoral practice was maintained until the 1894 Local Government Act, which standardized a system of one-man-one-vote, with the secret ballot, across all towns.

We might expect that extensions of political power to the poor would be associated with increases in expenditure if poorer citizens vote for higher government spending to achieve redistribution (as in the classic Meltzer-Richard (1981) model). Alternatively, removing the power of elites might lead to greater spending through preventing pork barrel spending (Lizzeri and Persico, 2004). Lindert (2004) suggests that, in fact, this mechanism was important in increasing social spending after 1880. If investment in public goods were driven by extensions of political power to the poor, we would expect that (all else being equal) municipal boroughs would be more involved in sanitary activity until 1894 for two reasons. First because prior to this date wealthier citizens received multiple votes in non-municipal boroughs and, secondly, the lack of a secret ballot might allow landlords to intimidate their tenants.

I test this proposition formally in Section 2.4. However, a simple examination of the data suggests that the democratic governance structure in municipal boroughs was neither a

[19] It is these councils that are discussed extensively in Lizzeri and Persico (2004), with the authors arguing that the imposition of wider franchise in these municipal boroughs resulted from growing demand for public goods following industrialization.

necessary or sufficient condition for investment in sanitation. Although the left hand panel of Figure 2.5 shows that municipal boroughs as a whole were more likely to be spend on water and sewers than non-municipal boroughs, this difference disappears if we take into account the characteristics of municipal boroughs, which tended to be larger and less industrial on average than other towns. As a crude comparison group, I limit the sample to the towns of comparable size in 1851 in the right hand panel of the figure.[20] With that simple control for size and town occupation, the towns spending on water supply are approximately similar across the two groups. Strikingly, the proportion of towns spending on sewers is actually much higher in the non-incorporated group of towns for much of the period. I consider the comparability of the two groups of towns further in the empirical analysis.

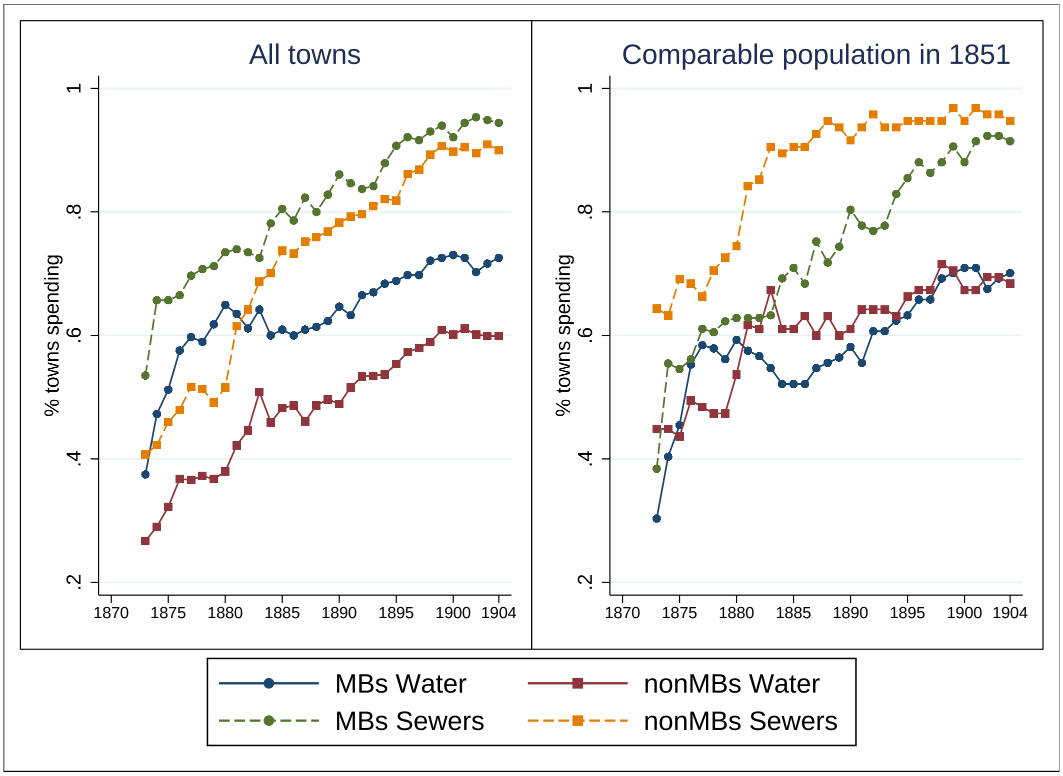
An alternative way to understand whether the democratic governance in municipal boroughs was associated with greater investment in public goods and services is to investigate the timing of investments by towns that became incorporated over this period. Fifty-four towns became municipal boroughs between 1871 and 1904, providing the opportunity to identify whether they began spending on various public goods before or after incorporation. To do this, I combine the information from the *Local Taxation Returns* regarding annual spending on water supply and sewer spending, combined with additional information from the 1903 Report of the Select Committee on Municipal Trading which provides the date municipal boroughs began trading in other public goods and services—including burial, baths, gas and markets.[21]

The results, presented in Table 2.2, indicate that incorporation was neither necessary or sufficient for investment in these public goods. In general these towns began spending on each of these public goods *before* they became incorporated rather than afterward. Nearly all

[20] Towns were included in the 1851 were census if they were "principal towns", including particularly market towns. This excludes many of the newer industrial towns in Yorkshire and the North-West.

[21] The Select Committee Report also identifies when towns began trading activities in water supply (as distinguished from any expenditure). The findings are similar indicating that 50% of towns had begun trading before incorporation and only 8% afterward. See footnote 16 for the full reference of the report.

Figure 2.5: Municipal boroughs were not more active in sanitary expenditure once differences in population size are accounted for.



Note: Both panels exclude towns incorporated between 1872 and 1904. Right hand panel includes only towns within common support of town population in 1851.
Source: *Local Taxation Returns.*

(94%) of the towns spent money on sewers before they were incorporated, while 76% of towns were engaged in water supply. Further, a higher proportion of towns were involved in all but one of the activities in Table 2.2 before incorporation than afterward. The exception—relating to burial activities, saw only a small difference, with 24% of towns starting activities after incorporation as opposed to 22% beforehand.

2.3.4 Differences in demand and cost of provision

Aside from local politics and the requirements imposed by central government, there may have been significant differences across towns in both the cost of provision and level of de-

Table 2.2: Towns incorporated between 1872 and 1903 were more likely to start providing public goods and services before incorporation than afterwards.

Activity	**Before incorporation**	**After incorporation**	**Not before 1904**
Burial	22%	24%	54%
Bath	38%	24%	38%
Gas	30%	12%	58%
Markets	42%	12%	46%
Sewers	94%	4%	2%
Water	76%	11%	13%

Note: Based on 54 towns incorporated between 1872 and 1903, except for figures for burial and baths which are based on 50 towns incorporated between 1872 and 1899. Information for water, gas, and sewers is drawn from the *Local Taxation Returns*, based on the first year of spending. Information for burial and baths is drawn from the 1903 Report of the Select Committee on Trading, cited in footnote 16.

mand for public goods. Large, densely populated cities are more likely to suffer from disease since cramped living conditions lend themselves to easy spread of disease. Further, the demand for sanitary infrastructure is driven, partly, by the understanding of their importance to public health which may be dependent on the size of sanitary movement within a city.

Aside from sanitary concerns, there may be other sources of demand for some of the public goods examined here. Water supply, for instance, was in demand for industrial as well as consumer needs (Hassan, 1985). We might also think that sewer systems (particularly drainage) might be in greater demand in more agricultural areas.

On the cost side of the analysis, we must consider the fact that there may be important economies of scale in the provision of many of these sanitary investments. Larger cities may have lower costs of provision per capita; since the fixed costs of (for instance) a water plant would be spread over a wider area. Similarly, there may be cost savings associated with densely populated areas, since there pipes and streets need to be laid for a smaller difference. Higher numbers of people per house mean that several people can be reached for the cost of a single connection to a water main.

2.4 Empirical analysis

How then do these differences in costs, demand and political structure affect the growth and variation in the size of expenditure on sanitary public goods after 1870? In this section I test the importance of these different factors in determining the level of spending and also revenue sources. I first examine the relationship between different funding sources and demographic characteristics on the level of expenditure on public goods. I then use the imposition of the 1894 Local Government Act to address the effects of democratic reform on expenditure patterns.

2.4.1 Determinants of public goods expenditure

In this section I analyze the observable characteristics associated with local government expenditure on each of the sanitation public goods. In particular, I estimate the following specification using includes twenty-one cross sections covering the period 1884-1904:

$$y_{i,t} = \alpha + \beta_1 DEMOGRAPHIC_{i,t} + \beta_2 OCCUPATION_i + \beta_3 FINANCE_{i,t} + \delta year + \epsilon_{i,t}$$

where i indexes a town, t indexes a year, and $y_{i,t}$ represents either the level of spending per capita or the outstanding loan stock per capita. I run separate regressions for the aggregate sanitary public goods category, and the three component parts of sewers, water supply and streets. $DEMOGRAPHIC$, $OCCUPATION$, and $FINANCE$ are vectors of control variables that we might expect to be associated with the demand for public goods expenditure—I explain these further in the following paragraph. I include year fixed effects to account for trend growth in the town over time and, in some specifications, town fixed effects.

The first set of variables, $FINANCE_{i,t}$ are used to test the importance of financial constraints. These constraints include both the rateable value per capita in the town—in other words, the tax base available to the district—and two non-tax sources of revenue: receipts from property and receipts from "tolls and dues".[22] In addition, I test whether trading profits from gas supply subsidized public goods expenditure by including a dummy variable indicating whether the town was involved in gas supply. Finally, in specifications (2), (4), (6) and (8) the estimated average interest rate is included to test the importance of variation in financing costs.

To address different potential sources of demand for sanitary public goods, the second set of control variables capture the occupational make-up of the town, using data from the 1881 census. In particular, I include dummy variables to identify whether the town contains a large (defined as more than 10%) share of the total workforce in textiles, minerals (i.e., mining and related concerns), or agriculture. I also include the percentage of "white collar" workers—defined as either commerce or the professions—as a measure of the strength of the new professional middle class that are often associated with the sanitary reform movement. Since these variables are measured in only one period they are excluded when town fixed effects are included.

The final set of variables, $DEMOGRAPHIC_{i,t}$, includes population, population density, population growth, and urban crowding (defined as the number of people per house). As discussed above, these characteristics may affect both the demand for and cost of sanitation infrastructure. For example, more crowded or denser cities could have higher need for sanitation expenditure to combat differences to maintain the quality of the urban environment. On the other hand, they might be correlated with differences in costs due to economies of scale. To capture these potentially competing effects I include these demographic variables

[22]Receipts from property includes both rents and receipts from property sales. Tolls and dues include, for instance, market fees.

in bins, rather than as linear variables.

The results of the pooled cross section regressions related to ongoing sanitary expenditure are presented in Table 2.3. In the discussion I focus predominantly on these results since the findings are very similar to those in other specifications—both those using the outstanding loan stock as the dependent variable, and those including town fixed effects. As such, the detailed results of those other specifications are relegated to the appendix.[23] Both the dependent variable and the independent variables are standardized in all specifications (with the exception of the dummy variables and the average interest rate), and as such the results can be read as the effect of a one standard deviation increase in the independent variable in terms of a standard deviation of the dependent variable.

The strongest and most consistent result is that the coefficient related to the rateable value per capita is, as expected, positive and very statistically significant. This provides strong evidence that wealthier towns spent more on each of the three categories of sanitary public goods. The evidence regarding the importance of other sources of revenue is, however, more mixed: increased revenue from market tolls and involvement in gas supply are both associated with greater sanitary expenditure, but there is no evidence that greater revenue from property led to towns spending more. Trading in gas was associated with greater spending on water, which provides some corroboration for the claim that towns beyond Birmingham used "trading profits" to fund other investment. Further analysis, contained in the appendix, indicates that these trading profits were used to reduce taxes as well as increase expenditure.

There is clear evidence of the effect of reduced borrowing costs on the level of expenditure: the coefficient on the average interest rate indicates that a 1% decrease in the cost

[23]The only major exception is that the many of the coefficients related to the demographic variables become statistically insignificant once town fixed effects are included, which is likely to reflect that these variables are not well identified in these specifications due to the limited extent of changes within towns over time in these variables.

Table 2.3: Determinants of adjusted expenditure per capita: pooled cross section regressions.

	Standardized dependent variables							
	Sanitary spend p.c.		Water spend p.c.		Sewers spend p.c.		Streets spend p.c.	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Rateable value p.c.	0.40***	0.40***	0.11***	0.11**	0.21***	0.26***	0.38***	0.36***
	(0.03)	(0.04)	(0.04)	(0.05)	(0.05)	(0.06)	(0.03)	(0.03)
Property receipts p.c.	0.01	0.01	0.00	0.00	-0.01	-0.01	0.01	0.01
	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)
Tolls receipts p.c.	0.10***	0.09***	0.04	0.04	0.20***	0.17***	0.02	0.02
	(0.02)	(0.02)	(0.03)	(0.03)	(0.05)	(0.05)	(0.02)	(0.02)
Transfers p.c.: county roads	0.36***	0.35***	0.03	0.03	0.03**	0.04**	0.47***	0.44***
	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.04)	(0.05)
Transfers p.c.: other	0.03	0.02	0.01	0.00	-0.02	-0.01	0.04***	0.03**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
Involved in Gas	0.15***	0.16***	0.38***	0.36***	0.01	0.02	-0.03	-0.00
	(0.05)	(0.05)	(0.07)	(0.08)	(0.06)	(0.06)	(0.04)	(0.04)
Average interest rate		-0.06***		-0.08***		-0.04***		-0.02
		(0.01)		(0.01)		(0.02)		(0.01)
Municipal Borough	-0.07	-0.03	0.17**	0.20***	-0.14*	-0.15*	-0.13***	-0.09**
	(0.05)	(0.06)	(0.07)	(0.08)	(0.08)	(0.09)	(0.04)	(0.04)
Occupational characteristics								
>10% Textiles	0.13**	0.07	0.09	0.03	0.14**	0.15**	0.06	0.00
	(0.05)	(0.06)	(0.07)	(0.08)	(0.06)	(0.07)	(0.05)	(0.05)
>10% Agriculture	0.04	0.06	0.04	0.02	0.17***	0.17**	-0.05	-0.01
	(0.05)	(0.05)	(0.06)	(0.07)	(0.06)	(0.07)	(0.05)	(0.04)
>10% Minerals	-0.12***	-0.11**	0.05	0.06	-0.07	-0.09	-0.16***	-0.14***
	(0.05)	(0.05)	(0.06)	(0.07)	(0.05)	(0.06)	(0.04)	(0.04)
% White Collar	0.07***	0.08**	-0.01	-0.03	0.12***	0.11***	0.05**	0.07**
	(0.03)	(0.03)	(0.04)	(0.04)	(0.03)	(0.04)	(0.02)	(0.03)
% Foreign Born	-0.13***	-0.15***	-0.07	-0.08*	-0.13***	-0.14***	-0.08***	-0.09***
	(0.03)	(0.03)	(0.04)	(0.04)	(0.03)	(0.03)	(0.02)	(0.02)
Population								
Popn 10k-25k	0.07	0.04	0.10	0.06	0.11	0.09	-0.01	-0.02
	(0.05)	(0.05)	(0.07)	(0.08)	(0.07)	(0.07)	(0.04)	(0.04)
Popn 25k-50k	0.18**	0.15*	0.15	0.11	0.03	-0.03	0.15***	0.15**
	(0.08)	(0.09)	(0.14)	(0.15)	(0.12)	(0.13)	(0.06)	(0.06)
Popn 50k-100k	0.34***	0.31***	0.30*	0.27	0.02	0.01	0.28***	0.26***
	(0.11)	(0.12)	(0.16)	(0.17)	(0.15)	(0.16)	(0.08)	(0.09)
Popn 100k-250k	0.26**	0.22*	0.23	0.20	-0.10	-0.15	0.27***	0.25***
	(0.12)	(0.13)	(0.19)	(0.20)	(0.18)	(0.20)	(0.08)	(0.08)
Popn over 250k	0.51***	0.49**	0.72**	0.76**	-0.04	-0.08	0.29	0.27
	(0.18)	(0.22)	(0.32)	(0.33)	(0.19)	(0.20)	(0.29)	(0.32)
Population growth								
Quartile 2	0.00	0.01	0.05	0.04	0.08*	0.08	-0.07*	-0.05
	(0.04)	(0.04)	(0.05)	(0.06)	(0.05)	(0.06)	(0.04)	(0.04)
Quartile 3	0.08*	0.09**	0.12**	0.11*	0.15***	0.14**	-0.03	0.00
	(0.04)	(0.04)	(0.05)	(0.06)	(0.05)	(0.06)	(0.04)	(0.04)
Quartile 4	0.09*	0.11**	0.05	0.02	0.19***	0.19***	0.01	0.06
	(0.05)	(0.06)	(0.07)	(0.08)	(0.06)	(0.07)	(0.05)	(0.05)
Urban crowding								
Quartile 2	0.09**	0.11**	0.11**	0.11*	0.13***	0.15***	-0.01	0.01
	(0.04)	(0.04)	(0.05)	(0.06)	(0.05)	(0.06)	(0.04)	(0.04)
Quartile 3	0.15***	0.17***	0.06	0.08	0.21***	0.24***	0.07	0.08
	(0.05)	(0.06)	(0.07)	(0.08)	(0.06)	(0.07)	(0.05)	(0.05)
Quartile 4	0.07	0.09	0.07	0.09	0.11	0.11	0.01	0.01
	(0.06)	(0.07)	(0.09)	(0.10)	(0.07)	(0.08)	(0.05)	(0.06)
Population density								
Quartile 2	-0.01	0.01	0.22***	0.17**	0.34***	0.32***	-0.30***	-0.23***
	(0.05)	(0.06)	(0.07)	(0.08)	(0.06)	(0.07)	(0.05)	(0.06)
Quartile 3	-0.09	-0.07	0.14**	0.07	0.40***	0.37***	-0.39***	-0.31***
	(0.06)	(0.06)	(0.07)	(0.08)	(0.07)	(0.08)	(0.06)	(0.06)
Quartile 4	-0.07	-0.05	0.15	0.07	0.45***	0.47***	-0.39***	-0.33***
	(0.07)	(0.08)	(0.09)	(0.10)	(0.13)	(0.15)	(0.06)	(0.07)
Town FE	N	N	N	N	N	N	N	N
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
No. obs	14429	10944	14429	10944	14433	10946	14435	10948
R-squared	0.54	0.52	0.13	0.11	0.24	0.23	0.62	0.60

Standard errors are clustered by town, and displayed in parentheses. All variables are standardized except for dummy variables and the average interest rate. "Transfers p.c. county roads" is the estimated revenue received from county councils for maintenance of main roads; "transfers p.c. other" captures all other transfers from both county councils and central government.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

of borrowing was associated with an increase in sanitary expenditure of approximately 0.06 standard deviations. This result is strong in both the pooled cross section and also the fixed effects regressions. The size of this effect might initially seem small, but we should consider that this is likely an underestimate of the actual effect since our measure of the interest rate necessarily excludes all towns that did not borrow in any period. Further, there may well be an element of reverse causality, in that towns with easy access to credit may have been willing to borrow more, leading to higher (average) interest rates on the loans they did have outstanding.

We can also see that there is strong evidence that the direct subsidies to town councils to improve main roads were effective in increasing the level of expenditure. The coefficient relating to the variable "transfers p.c. county roads" has a large and strongly statistically significant effect on spending on streets and, as a result, sanitary expenditure as a whole. Further, it appears that the grants for roads may have targeted towards areas which had underinvested (relatively) in the past, since there is a strong negative correlation between increased county grants for roads spending and the stock of loans outstanding for streets (see Table 2.9 in the appendix).

The results relating to the occupational characteristics of the towns also shed some light on the groups driving demand for public goods. The findings show some evidence that textiles towns (defined as having a greater than 10% of the workforce employed in textiles) had higher levels of loans outstanding in both water supply and sewer systems.[24] Notably, however, there is consistent evidence that "minerals towns" (defined as having a greater than 10% of the workforce employed in minerals), such as mining areas, had *lower* expenditure on sanitary public goods, particularly streets. Interestingly also, a greater share of "white collar" workers is associated with higher levels of expenditure on sewer systems and streets, but not water supply (in fact there appears to be a negative relationship with the stock of

[24] See Table 2.8 in the appendix for the full results of these specifications.

outstanding water supply loans). To the extent that this variable captures the existence of a sanitary movement, it provides further evidence that the push for clean water was for industrial rather than sanitary purposes. Similarly, as hypothesized in the previous section, agricultural towns are found to have had a higher level of expenditure on sewers, which may capture farmers' needs for drainage.

The final set of results relate to the correlations between the level of expenditure and demographic characteristics. The results indicate that spending was generally high in larger cities, but that this effect is driven largely by expenditure on streets. Expenditure on water supply was highest in the very largest cities, but there is no evidence of any difference in the level of expenditure at lower levels of population.

There is, however, evidence of economies of scale when looking at the results regarding urban crowding and population density. Expenditure on sanitary expenditure is highest in the middle two quartiles of urban crowding, consistent with there being a reduction in costs due to the need for fewer house connections. Similarly, denser towns spent less per capita on streets, reflecting the need for fewer roads in a smaller area.

2.4.2 Democratic institutions and sanitary expenditure

The previous section has highlighted some key characteristics of the towns that chose to spend on public goods. In this section I build on those results by exploring whether democratic institutions were key to achieving local government investment in sanitary public goods. As discussed previously, the governance structure of the towns controlling sanitary authority varied significantly across the country and across time. The incorporated towns, or "municipal boroughs" were governed under a system of one-man-one-vote throughout the period. The non-incorporated towns, in contrast, were governed by a council elected under a graduated franchise, whereby citizens could receive up to twelve votes dependent on the value of property they owned or occupied.

In 1894 this latter system was changed, with all towns placed under councils elected on the one-man-one-vote principle. In this section, I use this change to test the effects of democratic reform on town expenditure. As national legislation this can be thought of as exogenous to any individual town, particularly since the Act was motivated predominantly by the effect on Poor Law Unions rather than sanitary authorities. I use a difference-in-difference approach to test the effects of this institutional change on spending in the non-municipal boroughs. The treatment group in this case are the non-municipal boroughs ("Non-MBs"); while the control group are the incorporated towns, or municipal boroughs ("MBs"). In essence then I compare the non-municipal boroughs to a group of "already treated" towns. Our approach then involves testing whether the difference in spending on different types of public service changed after the 1894 reforms. In particular, I estimate the following specifications for the period 1884-1904:

$$y_{i,t} = \alpha + \beta_1 POST\_1894 + \beta_2 NONMB * POST\_1894 + \beta_3 X_{i,t} + \gamma_1 T_i + \gamma_2 year$$

where i indexes towns and t indexes years. $NONMB$ is a dummy variable equaling 1 if the town is not incorporated in 1894, $POST\_1894$ is a dummy variable equaling one for the period after 1894, X is a vector of control variables, $year$ is a vector of year fixed effects and T is a vector of town fixed effects.[25] The effect of the Local Government Act is then measured by the sign of the coefficient β_2. If democratic reform led to greater sanitation expenditure , then $\beta_2 > 0$.

For this approach to be appropriate it must be the case that in the absence of the 1894 Act, the change in the level of spending amongst the non-MBs would have been the same as that amongst the municipal boroughs (the "parallel trends" assumption). While there may be differences in time-invariant characteristics between the two groups, there should

[25] Note that the vector of town fixed effects absorbs the effect of being within a treatment or the control group.

not be differences that change over time or mean that towns react differently to other time-changing factors (such as the state of the economy). This is a concern in our case for two reasons. First, it is clear that there are large differences in the observable characteristics of the group of municipal boroughs and the non-incorporated towns, as shown in the top panel of Table 2.6 in the appendix. Municipal boroughs tended to be larger on average, and included all the very large towns. They also tended to be wealthier and denser. Both of these differences are concerning, since they may be correlated with other unobserved factors—such as access to credit—that imply different trends in spending growth.

The second concern in comparing the two groups of towns is that the group of municipal boroughs includes a number of towns that opted for incorporation in the period near to the 1894 LGA. This is concerning since incorporation often reflected a desire for town growth, or demand for town prestige that we might expect to be associated with more rapid increases in spending.

To address these concerns, I undertake a two-step matching process to generate a sample with more balanced covariates. The first step trims the sample by removing towns that chose to incorporate during the period, and by restricting the towns to a sub-group that overlaps in size and occupational characteristics. By limiting the control group to those towns incorporated as early as 1835, I address concerns regarding the selection effect, since these towns were incorporated as a result of charters granted in previous centuries (often granted in the Elizabethan era, for instance) and so there is no reason that their democratic status should be related to their spending on the public goods of concern in the nineteenth-century. Removing towns with very different characteristics—the very large municipal boroughs, and non-municipal boroughs that had a very large share of their workforce in either agriculture, textiles or minerals compared to the municipal boroughs—addresses some of the concern that the towns are fundamentally different in their demand for sanitation.[26]

[26]Specifically, I remove all towns larger than the largest non-MB in 1881, and also all non-MBs with a

The results of this exercise are displayed in the central panel of Table 2.6. Trimming the sample reduces the differences between the groups of municipal boroughs and non-municipal boroughs, but does not remove them. I therefore match municipal boroughs with similar non-municipal boroughs. To do so, I use nearest-neighbor propensity score matching using the 1883 (i.e., pre-analysis) covariates, including population, urban crowding, population growth, population density, per capita rateable value and the percentage of the workforce in textiles, minerals, white collar and agriculture. Under this process, a propensity score is estimated for each of the towns, and each of the municipal boroughs is matched to the closest non-municipal borough based on the propensity score. To ensure no single town overly affects the results I do not allow for replacement: each town is only matched once.

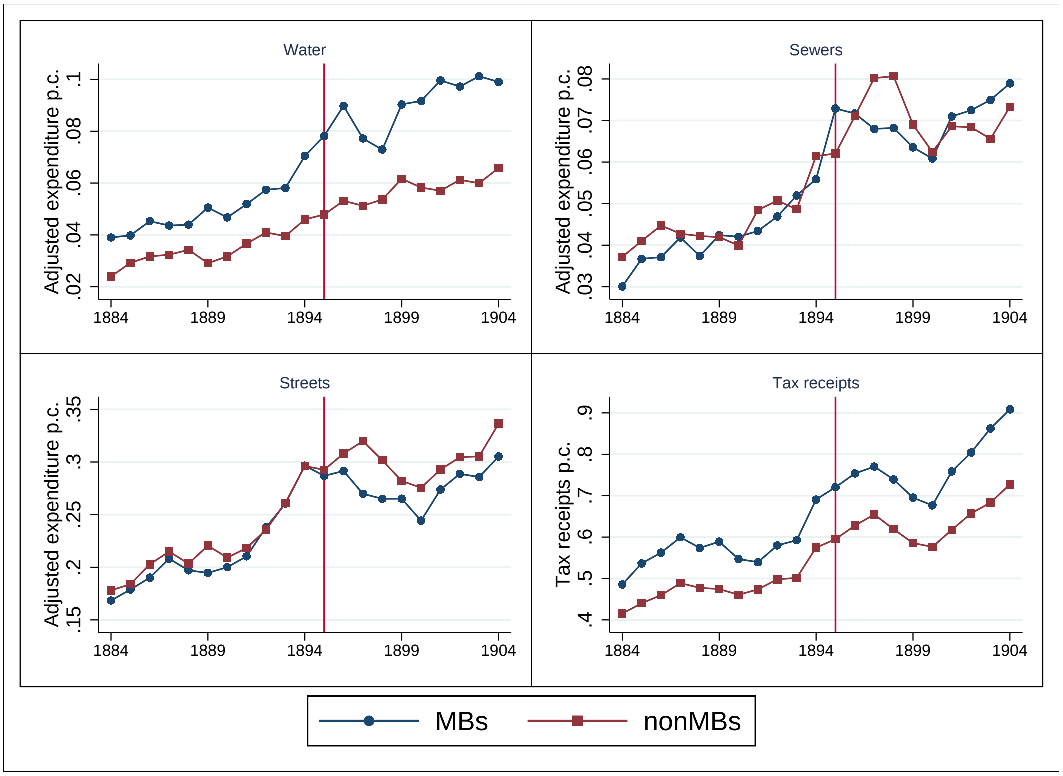
This exercise leaves us with a sample of 256 towns in total (128 in each group). The bottom panel displays the characteristics of the municipal boroughs and non-municipal boroughs within this group. The characteristics of the group are much closer than in the unmatched sample; however there remain significant differences. In particular, the non-municipal boroughs remain both larger and more agricultural on average than the municipal boroughs. Given this it is important to check that any results are robust to the inclusion of control variables capturing changes in town characteristics over time.

To provide reassurance that the parallel trends assumption holds, I graph the path of changes in the level of spending on water, sewers and streets in Figure 2.6. The trends are generally very similar until 1894, but after this date there is some divergence in terms of both per capita expenditure on water supply, and also streets expenditure. In the former case, the figure shows that actually non-incorporated towns spent *less* on water supply after democratic reform; while the latter shows an increase in their expenditure on streets per capita.[27]

higher share of their workforce in either agriculture, minerals or textiles than any municipal borough.

[27]Note that the decline in expenditure displayed in the figure is a reflection of the fact that the graph is in real terms and there was significant inflation between 1896 and 1900.

Figure 2.6: Similar pre-trends between incorporated and non-incorporated towns in matched sample.



Note: Estimates based on matched sample of 256 towns. Red line represents financial year 1894–95, the first financial year the 1894 LGA was in place.

Table 2.4 presents the results of the regression analysis. The left hand column presents the estimated coefficients of the interaction term when no control variables are included, while the right hand column is the results when the control variables are included. As suggested by Figure 2.6, there is evidence that the 1894 democratic reform led to statistically significant decreases in both the level of expenditure per capita on water supply and the level of per capita taxation. Further, these effects were relatively large, consisting of approximately 0.22 and 0.14 standard deviations respectively. Rather than drive sanitary expenditure, this suggests that democratic change may, in fact, have inhibited spending on water supply.

The only evidence that suggests democratic reform may have increased expenditure comes from per capita expenditure on streets. However the statistical significance is both weak and dependent on the inclusion of control variables—particularly the measure of transfers for streets. But that effect can be interpreted as democratic reform leading to greater expenditure *given the level of county roads transfers*. This finding is concerning, since the level of transfers was partly determined by requests from town councils. As such this finding could reflect either an unwillingness to seek support from county councils, or difficulties in convincing them to invest in roads. As such, we should treat this result with caution.

What might explain the surprising finding that increasing the political power of the poor was associated with lower spending on water supply and lower taxes? One possibility is that when town councils were governed by elites they over-invested in water supply for industrial purposes; after the switch to democratic government, the town populace did not wish to invest any more in water. Alternatively, it may be that the poor were opposed to higher taxes because of their low income. I will explore this explanation further in the following chapter.

Table 2.4: Both water supply and tax receipts fell relatively to the control group after the 1894 Local Government Act

Standardized Dependent variable	**No controls**	**Controls**
Sanitary spend p.c.	-0.02	-0.05
	(0.07)	(0.06)
Water spend p.c.	-0.19***	-0.22***
	(0.07)	(0.07)
Sewers spend p.c.	-0.04	-0.08
	(0.08)	(0.08)
Streets spend p.c.	0.11	0.10**
	(0.08)	(0.05)
Tax receipts p.c.	-0.11**	-0.14***
	(0.05)	(0.05)

Coefficients relate to the NONMB_x_Post1894 interaction term. Control variables include population (in six bins), urban crowding, population growth, per capita rateable value, per capita property receipts, per capita tolls revenues, per capita county road receipts and other per capita transfers. Clustered standard errors are displayed in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

2.5 Conclusion

This paper has provided new evidence as to the success—or otherwise—of the decentralized provision of sanitary public goods in nineteenth-century England. The findings have shown that merely passing responsibility to town councils was insufficient to overcome opposition to expenditure. Our findings highlight the failings of the Westminster Parliament in encouraging greater expenditure: by constraining towns to rely on their own taxes they limited towns' ability to invest. Further, I present new evidence as to the importance of capital markets to supporting investment; the provision of higher subsidies could have induced greater levels of expenditure.

Second, the results of the paper indicate that democratic reform was not critical to investment in urban infrastructure. Many towns were able to successfully invest with town councils elected under a graduated franchise, and in the absence of the secret ballot. Further, there is little evidence that the removal of these restrictions led to greater expenditure. In fact there is evidence of a reduction in spending on water supply and tax revenue after these democratic reforms. This suggests that the poorer citizens granted political power by these institutional changes may have opposed greater expenditure and, in particular, taxation.

2.A Appendix

2.A.1 Descriptive statistics of the full sample

Table 2.5: Characteristics of towns in sample

	N	Min	Mean	Median	Max	SD
Population						
1851 Population	327	1,707	15,593	5,775	375,955	34,833
1861 Population	507	311	13,470	4,648	443,938	34,261
1871 Population	691	197	13,035	4,888	493,405	34,089
1881 Population	691	187	15,892	5,804	552,508	39,709
1891 Population	691	199	18,622	6,298	517,980	46,407
1901 Population	691	219	21,949	7,283	684,958	55,323
Occupation (% 1881 labor force)						
% Agriculture	691	0%	12%	9%	58%	11%
% Textiles	691	0%	12%	2%	64%	19%
% Minerals	691	2%	13%	6%	69%	15%
% White Collar	691	1%	5%	5%	24%	3%
% Domestic Service	691	4%	17%	17%	43%	8%

Note: Sample includes towns acting as urban sanitary authorities throughout the period 1875–1904. Number of observations is reduced in 1851 and 1861 because not all towns were reported in the census in these years. Percentage of workforce is estimated based on the "occupational order" of individuals reported in the 1881 census. The "white collar" category includes both the orders of "commerce" and "professionals". See the text for further estimation.

2.A.2 Additional empirical results

Tables 2.7–2.9 present the results of the additional specifications discussed in section 2.4.1. Table 2.7 includes the results of the specifications using the spending per capita as the dependent variable and including town fixed effects. Tables 2.8 and 2.9 report the results with the outstanding loan stock per capita as the dependent variable, presenting the pooled cross section and fixed effects specifications, respectively.

Table 2.6: Propensity score matching: sub-samples are more similar after matching exercise, but still significant differences in average population and agriculture.

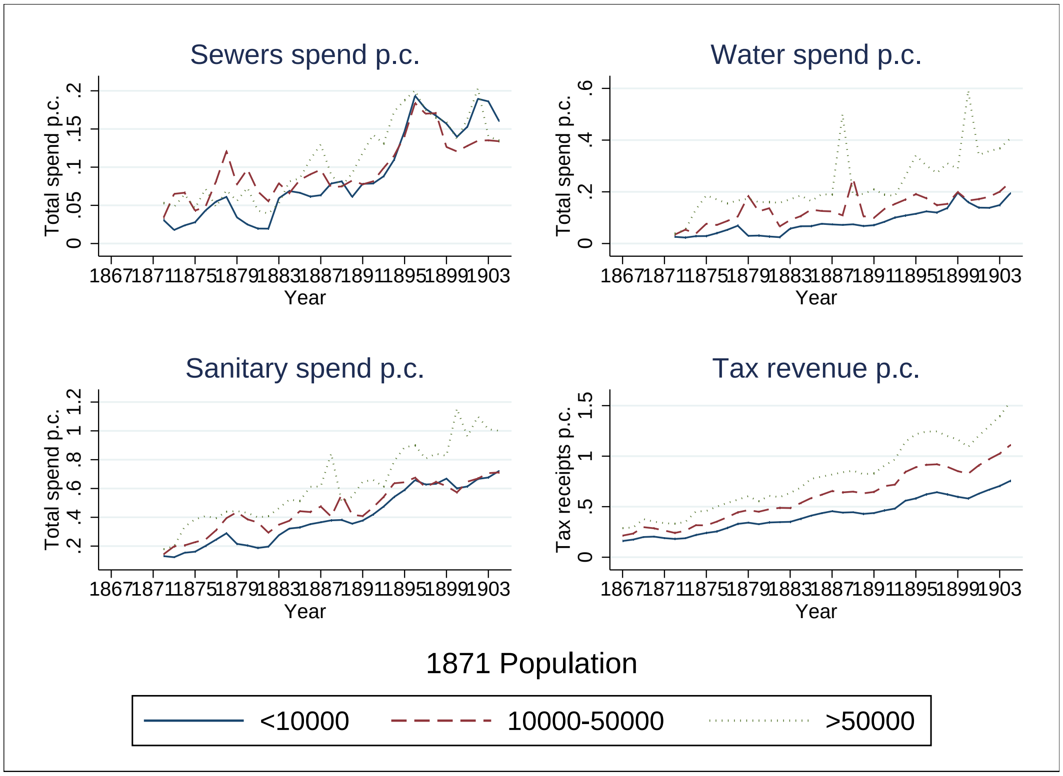
	Non-MBs		MBs		Diff.	SE	p-val
	N	Mean	N	Mean			
All observations							
Population	468	6482	223	36932	-30450	3084	0.000
Urban crowding	468	5.06	223	5.17	-0.10	0.06	0.098
Population growth	468	1.0	223	1.0	0.0	0.0	0.089
Population density	468	5	223	14	-9	1	0.000
% Agriculture	468	14	223	10	3	1	0.000
% Textiles	468	13	223	9	4	2	0.005
% Minerals	468	15	223	9	7	1	0.000
% White Collar	468	5.1	223	6.1	-1.1	0.2	0.000
Rateable value p.c.	468	3.6	223	3.7	-0.1	0.1	0.321
Trimmed based on size and occupation							
Population	317	5033	128	10146	-5113	539	0.000
Urban crowding	317	5.05	128	4.97	0.07	0.07	0.314
Population growth	317	1.0	128	1.0	0.0	0.0	0.000
Population density	317	5	128	9	-5	1	0.000
% Agriculture	317	15	128	15	0	1	0.704
% Textiles	317	10	128	5	6	1	0.000
% Minerals	317	13	128	7	6	1	0.000
% White Collar	317	5.4	128	6.0	-0.6	0.2	0.018
Rateable value p.c.	317	3.6	128	3.6	0.0	0.1	0.888
Matched observations							
Population	128	6066	128	10146	-4080	796	0.000
Urban crowding	128	4.90	128	4.97	-0.07	0.08	0.368
Population growth	128	1.0	128	1.0	-0.0	0.00	0.769
Population density	128	6	128	9	-3	1.8	0.097
% Agriculture	128	19	128	15	4	1.3	0.001
% Textiles	128	4	128	5	-0	1.1	0.784
% Minerals	128	7	128	7	-0	0.9	0.773
% White Collar	128	5.7	128	6.0	-0.29	0.20	0.160
Rateable value p.c.	128	3.4	128	3.6	-0.13	0.15	0.363

"Trimmed sample" reflects the restriction to towns incorporated in 1835 or never incorporated, and in common support of population, and of percentage labor force in each of agriculture, minerals, and textiles in 1881. "Matched observations" refers to the sample created based on propensity score matching. Population, urban crowding, population growth and per capita rateable value refer to estimated values in 1883.

Determinants of tax burden

The results from the spending regressions indicate the importance of different types of revenue stream—such as trading profits, or government grants—in stimulating expenditure. In this appendix I look more closely at whether alternative revenues were, in fact, associated with lower levels of tax revenue. If towns were using these sources of income as a replacement for tax expenditure we would expect that these non-tax revenues would be associated with lower tax rates for a given level of expenditure on sanitary public goods. However if they purely led to higher expenditure, then we would expect that the relationship on taxation

Figure 2.7: Steady increases in sanitary expenditure and tax revenue between 1872 and 1904.



Note: Groups of towns are defined based on the 1871 town population. Each line reflects the average expenditure and revenue per capita within the group in each year.
Source: ***Local Taxation Returns.***

would be negative, conditional on the level of town expenditure or infrastructure stock.

To test these relationships, I run specifications similar to those in Section 2.4 but using per capita tax revenue as the dependent variable. To control for the fact that higher expenditure would entail higher tax receipts, I also include the per capita loan maintenance expenses (including both principal and interest payments). I use this measure as it will be largely determined by past expenditure, and so will not lead to spurious correlation whereby a town raises receipts and expenditure simultaneously.

The results of this analysis are presented in Table 2.10. Columns (1) and (2) display the results of the pooled analysis, while (3) and (4) contain the fixed effects specifications. In

Table 2.7: Determinants of adjusted expenditure per capita: fixed effect regressions.

	Standardized dependent variables							
	Sanitary spend p.c.		Water spend p.c.		Sewers spend p.c.		Streets spend p.c.	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Rateable value p.c.	0.36***	0.44***	0.16**	0.15	0.29***	0.33***	0.26***	0.35***
	(0.07)	(0.10)	(0.07)	(0.10)	(0.06)	(0.07)	(0.05)	(0.07)
Property receipts p.c.	0.01	0.01	0.01	0.01	-0.00	-0.00	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)
Tolls receipts p.c.	-0.00	-0.01	-0.07	-0.08	0.06***	0.06***	0.01	0.01
	(0.03)	(0.03)	(0.06)	(0.07)	(0.02)	(0.02)	(0.01)	(0.01)
Transfers p.c.: county roads	0.27***	0.21***	0.01	0.01	0.01	0.01	0.36***	0.28***
	(0.03)	(0.03)	(0.02)	(0.02)	(0.01)	(0.02)	(0.04)	(0.04)
Transfers p.c.: other	0.02*	0.01	0.00	-0.01	0.00	0.01	0.03***	0.02**
	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
Involved in Gas	0.11	0.14*	0.15	0.19	0.09	0.04	0.02	0.07
	(0.07)	(0.08)	(0.12)	(0.15)	(0.08)	(0.09)	(0.04)	(0.05)
Average interest rate		-0.04***		-0.05***		-0.05***		-0.01
		(0.01)		(0.01)		(0.01)		(0.01)
Municipal Borough	-0.10	-0.08	0.01	0.03	-0.01	0.03	-0.14***	-0.14**
	(0.07)	(0.09)	(0.15)	(0.20)	(0.08)	(0.10)	(0.05)	(0.06)
Population								
Popn 10k-25k	0.07	0.02	0.10	0.07	0.15*	0.05	-0.04	-0.04
	(0.06)	(0.07)	(0.10)	(0.11)	(0.08)	(0.09)	(0.04)	(0.04)
Popn 25k-50k	0.09	0.07	-0.01	-0.04	0.22*	0.11	0.03	0.06
	(0.10)	(0.10)	(0.16)	(0.17)	(0.13)	(0.13)	(0.07)	(0.08)
Popn 50k-100k	0.21	0.14	0.28	0.10	0.20	0.15	0.02	0.06
	(0.14)	(0.15)	(0.23)	(0.23)	(0.16)	(0.16)	(0.10)	(0.09)
Popn 100k-250k	0.27	0.20	0.25	0.03	0.25	0.26	0.11	0.13
	(0.18)	(0.19)	(0.23)	(0.23)	(0.23)	(0.25)	(0.15)	(0.15)
Popn over 250k	0.25	0.17	0.00	-0.22	0.19	0.21	0.25	0.26
	(0.19)	(0.20)	(0.23)	(0.23)	(0.27)	(0.29)	(0.16)	(0.16)
Population growth								
Quartile 2	-0.01	0.01	-0.01	-0.03	0.01	0.05	-0.01	0.01
	(0.03)	(0.03)	(0.04)	(0.04)	(0.03)	(0.04)	(0.02)	(0.02)
Quartile 3	0.01	0.03	0.05	0.03	-0.02	0.00	-0.01	0.02
	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)	(0.05)	(0.03)	(0.03)
Quartile 4	0.03	0.05	0.04	0.03	-0.01	0.03	0.03	0.04
	(0.04)	(0.04)	(0.06)	(0.05)	(0.05)	(0.06)	(0.03)	(0.03)
Urban crowding								
Quartile 2	0.04	-0.01	0.06	0.05	-0.06	-0.06	0.04	-0.02
	(0.03)	(0.04)	(0.05)	(0.06)	(0.04)	(0.05)	(0.03)	(0.03)
Quartile 3	0.06	0.03	0.04	0.06	-0.13*	-0.08	0.12***	0.04
	(0.05)	(0.06)	(0.07)	(0.08)	(0.07)	(0.08)	(0.04)	(0.05)
Quartile 4	0.02	0.01	0.13	0.19*	-0.32***	-0.24**	0.10	0.02
	(0.07)	(0.07)	(0.09)	(0.10)	(0.10)	(0.11)	(0.06)	(0.06)
Population density								
Quartile 2	-0.01	0.10	0.12	0.14	0.12	0.19	-0.13	-0.03
	(0.07)	(0.10)	(0.08)	(0.12)	(0.11)	(0.18)	(0.09)	(0.12)
Quartile 3	-0.10	-0.02	0.13	0.18	0.10	0.12	-0.26**	-0.18
	(0.09)	(0.14)	(0.10)	(0.15)	(0.14)	(0.22)	(0.13)	(0.18)
Quartile 4	-0.22**	-0.15	-0.06	-0.06	0.07	0.08	-0.29**	-0.21
	(0.10)	(0.15)	(0.12)	(0.19)	(0.15)	(0.23)	(0.13)	(0.17)
Town FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
No. obs	14429	10944	14429	10944	14433	10946	14435	10948
No. towns	691	660	691	660	691	660	691	660

Standard errors are clustered by town and displayed in parentheses. All variables are standardized except for dummy variables and the average interest rate. "Transfers p.c. county roads" is the estimated revenue received from county councils for maintenance of main roads; "transfers p.c. other" captures all other transfers from both county councils and central government. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

(2) and (4) I add the variable measuring the loan maintenance costs per capita.

As expected, the results in columns (1) and (3) are similar to the previous regressions. In particular, the coefficients on rateable value, tolls receipts and involvement in gas supply are associated with *greater* taxation. However this picture changes once the measure of

Table 2.8: Determinants of outstanding loan stock per capita: pooled cross-section regressions.

	Standardized dependent variables							
	Sanitary loans p.c.		Water loans p.c.		Sewers loans p.c.		Streets loans p.c.	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Rateable value p.c.	0.22***	0.27***	0.09***	0.10***	0.31***	0.40***	0.13***	0.16***
	(0.04)	(0.05)	(0.03)	(0.04)	(0.09)	(0.12)	(0.04)	(0.05)
Property receipts p.c.	-0.02	-0.02	-0.02	-0.02	-0.01	-0.01	0.01	0.01
	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)
Tolls receipts p.c.	0.07***	0.06**	0.04	0.03	0.05*	0.02	0.13***	0.12***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)
Transfers p.c.: county roads	-0.02	-0.02	-0.02	-0.02	0.03	0.03	-0.05***	-0.06***
	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.03)	(0.01)	(0.02)
Transfers p.c.: other	0.15***	0.15***	0.18***	0.18***	0.01	0.01	0.02	0.02
	(0.03)	(0.03)	(0.04)	(0.04)	(0.02)	(0.02)	(0.02)	(0.02)
Involved in Gas	0.41***	0.36***	0.43***	0.40***	0.11	0.06	0.11	0.10
	(0.08)	(0.09)	(0.09)	(0.10)	(0.07)	(0.07)	(0.08)	(0.08)
Average interest rate		-0.11***		-0.07***		-0.12***		-0.04***
		(0.01)		(0.01)		(0.02)		(0.01)
Municipal Borough	0.03	0.00	0.07	0.05	-0.05	-0.08	-0.02	-0.04
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.08)	(0.06)	(0.07)
Occupational characteristics								
>10% Textiles	0.26***	0.25**	0.22**	0.22*	0.15**	0.14*	0.11	0.10
	(0.09)	(0.10)	(0.10)	(0.11)	(0.07)	(0.08)	(0.07)	(0.08)
>10% Agriculture	0.01	-0.03	0.06	0.06	-0.09	-0.16**	-0.05	-0.07
	(0.06)	(0.06)	(0.06)	(0.07)	(0.07)	(0.08)	(0.06)	(0.07)
>10% Minerals	-0.02	-0.03	0.05	0.05	-0.06	-0.07	-0.16***	-0.18***
	(0.06)	(0.07)	(0.07)	(0.08)	(0.07)	(0.08)	(0.05)	(0.06)
% White Collar	-0.00	-0.03	-0.07**	-0.08***	0.12***	0.08	0.03	0.03
	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.05)	(0.03)	(0.04)
% Foreign Born	0.05	0.06	0.07**	0.08**	-0.07**	-0.06	0.07**	0.08**
	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)	(0.04)
Population								
Popn 10k-25k	0.05	0.00	0.02	-0.01	0.06	0.01	0.05	0.02
	(0.06)	(0.06)	(0.06)	(0.07)	(0.07)	(0.07)	(0.05)	(0.06)
Popn 25k-50k	0.31**	0.23	0.26	0.21	-0.03	-0.13	0.50***	0.45***
	(0.15)	(0.15)	(0.16)	(0.16)	(0.13)	(0.14)	(0.14)	(0.15)
Popn 50k-100k	0.53**	0.48**	0.51**	0.48**	0.05	0.00	0.46***	0.40**
	(0.21)	(0.22)	(0.23)	(0.24)	(0.15)	(0.17)	(0.18)	(0.20)
Popn 100k-250k	0.63***	0.57**	0.38	0.35	-0.03	-0.08	1.49***	1.43***
	(0.24)	(0.25)	(0.26)	(0.27)	(0.18)	(0.20)	(0.36)	(0.36)
Popn over 250k	1.39***	1.36***	1.34***	1.36***	-0.42**	-0.48**	2.14***	2.01***
	(0.33)	(0.34)	(0.33)	(0.35)	(0.18)	(0.19)	(0.49)	(0.48)
Population growth								
Quartile 2	0.12**	0.10*	0.07	0.05	0.13**	0.11*	0.09**	0.09*
	(0.05)	(0.06)	(0.05)	(0.06)	(0.05)	(0.06)	(0.04)	(0.05)
Quartile 3	0.16***	0.12**	0.07	0.04	0.20***	0.15**	0.13***	0.14***
	(0.05)	(0.06)	(0.05)	(0.06)	(0.06)	(0.07)	(0.04)	(0.05)
Quartile 4	0.11*	0.08	-0.02	-0.05	0.27***	0.25***	0.12*	0.12*
	(0.06)	(0.07)	(0.06)	(0.07)	(0.07)	(0.08)	(0.07)	(0.07)
Urban crowding								
Quartile 2	0.01	-0.01	0.00	-0.02	0.06	0.05	-0.06	-0.08
	(0.05)	(0.06)	(0.05)	(0.06)	(0.05)	(0.06)	(0.05)	(0.06)
Quartile 3	-0.05	-0.08	-0.08	-0.10	0.07	0.05	-0.08	-0.09
	(0.07)	(0.08)	(0.08)	(0.09)	(0.07)	(0.09)	(0.07)	(0.08)
Quartile 4	-0.16*	-0.19**	-0.11	-0.11	-0.15*	-0.21**	-0.09	-0.11
	(0.09)	(0.10)	(0.10)	(0.11)	(0.08)	(0.09)	(0.09)	(0.10)
Population density								
Quartile 2	0.21***	0.14**	0.08	0.04	0.33***	0.24**	0.09*	0.06
	(0.06)	(0.07)	(0.06)	(0.07)	(0.08)	(0.10)	(0.05)	(0.06)
Quartile 3	0.19***	0.12*	0.09	0.06	0.25***	0.17*	0.10*	0.08
	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)	(0.10)	(0.06)	(0.06)
Quartile 4	0.27***	0.19*	0.15	0.09	0.28***	0.20*	0.21**	0.20**
	(0.09)	(0.10)	(0.09)	(0.10)	(0.09)	(0.11)	(0.08)	(0.10)
Town FE	N	N	N	N	N	N	N	N
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
No. obs	14437	10949	14437	10949	14437	10949	14437	10949
R-squared	0.38	0.37	0.30	0.29	0.20	0.21	0.36	0.35

Standard errors are clustered by town and displayed in parentheses. All variables are standardized except for dummy variables and the average interest rate. "Transfers p.c. county roads" is the estimated revenue received from county councils for maintenance of main roads; "Transfers p.c. other" captures all other transfers from both county councils and central government. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.9: Determinants of outstanding loan stock per capita: fixed effects regressions.

	Standardized dependent variables							
	Sanitary loans p.c.		Water loans p.c.		Sewers loans p.c.		Streets loans p.c.	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Rateable value p.c.	0.16***	0.18***	0.09***	0.10**	0.22***	0.28***	0.02	-0.00
	(0.04)	(0.06)	(0.03)	(0.05)	(0.06)	(0.09)	(0.04)	(0.05)
Property receipts p.c.	0.01	0.01	0.00	0.00	0.01***	0.01***	0.01	0.01
	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Tolls receipts p.c.	-0.03	-0.04	-0.07	-0.06	0.03*	0.02	0.03*	0.03
	(0.05)	(0.05)	(0.06)	(0.06)	(0.02)	(0.02)	(0.02)	(0.02)
Transfers p.c.: county roads	0.00	0.00	-0.01	-0.01	0.03	0.02	-0.01	-0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)
Transfers p.c.: other	0.02**	0.02*	0.01	0.01	0.02**	0.02**	0.03**	0.02**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Involved in Gas	0.14	0.16	0.18	0.22	0.02	0.00	-0.04	-0.07
	(0.10)	(0.13)	(0.11)	(0.15)	(0.12)	(0.14)	(0.06)	(0.06)
Average interest rate		-0.09***		-0.05***		-0.11***		-0.02***
		(0.01)		(0.01)		(0.01)		(0.01)
Municipal Borough	0.11	0.06	0.04	0.01	0.19	0.19	0.05	-0.05
	(0.09)	(0.10)	(0.10)	(0.10)	(0.15)	(0.17)	(0.08)	(0.09)
Population								
Popn 10k-25k	0.09	0.07	0.03	0.04	0.19*	0.14	-0.04	-0.06
	(0.07)	(0.08)	(0.05)	(0.06)	(0.12)	(0.13)	(0.06)	(0.06)
Popn 25k-50k	-0.09	-0.10	-0.09	-0.06	-0.02	-0.08	-0.05	-0.12
	(0.15)	(0.17)	(0.17)	(0.19)	(0.16)	(0.16)	(0.15)	(0.15)
Popn 50k-100k	0.15	0.10	0.26	0.25	-0.08	-0.11	-0.09	-0.25
	(0.25)	(0.25)	(0.28)	(0.28)	(0.18)	(0.18)	(0.22)	(0.21)
Popn 100k-250k	0.26	0.06	0.24	0.11	-0.06	-0.10	0.41	0.04
	(0.29)	(0.28)	(0.31)	(0.29)	(0.21)	(0.21)	(0.35)	(0.31)
Popn over 250k	-0.01	-0.26	-0.04	-0.17	-0.07	-0.11	0.22	-0.36
	(0.35)	(0.37)	(0.32)	(0.32)	(0.23)	(0.23)	(0.63)	(0.66)
Population growth								
Quartile 2	0.01	0.01	0.02	0.01	-0.02	0.00	0.04	0.04
	(0.03)	(0.03)	(0.02)	(0.02)	(0.04)	(0.05)	(0.03)	(0.03)
Quartile 3	-0.04	-0.04	0.03	0.01	-0.11**	-0.09*	-0.09**	-0.08**
	(0.03)	(0.03)	(0.03)	(0.03)	(0.05)	(0.05)	(0.04)	(0.04)
Quartile 4	-0.07*	-0.08**	-0.01	-0.02	-0.09	-0.10	-0.11***	-0.10***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.07)	(0.07)	(0.04)	(0.04)
Urban crowding								
Quartile 2	0.03	0.03	0.04	0.04	0.03	0.04	-0.05	-0.06
	(0.04)	(0.04)	(0.03)	(0.03)	(0.06)	(0.06)	(0.05)	(0.05)
Quartile 3	0.05	0.07	0.05	0.06	0.05	0.09	-0.03	-0.05
	(0.05)	(0.06)	(0.05)	(0.05)	(0.08)	(0.09)	(0.05)	(0.06)
Quartile 4	0.12*	0.18**	0.13**	0.15**	0.08	0.18	-0.04	-0.03
	(0.07)	(0.08)	(0.06)	(0.07)	(0.11)	(0.12)	(0.07)	(0.08)
Population density								
Quartile 2	0.04	0.09	0.04	0.06	0.02	0.10	0.03	0.02
	(0.06)	(0.08)	(0.06)	(0.07)	(0.11)	(0.16)	(0.05)	(0.07)
Quartile 3	-0.01	0.05	0.05	0.11	-0.12	-0.05	-0.03	-0.06
	(0.07)	(0.10)	(0.06)	(0.08)	(0.15)	(0.22)	(0.06)	(0.09)
Quartile 4	-0.09	-0.07	-0.04	-0.03	-0.09	-0.05	-0.11	-0.12
	(0.10)	(0.14)	(0.09)	(0.13)	(0.17)	(0.25)	(0.11)	(0.15)
Town FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
No. obs	14437	10949	14437	10949	14437	10949	14437	10949
No. towns	691	660	691	660	691	660	691	660

Standard errors are clustered by town and displayed in parentheses. All variables are standardized except for dummy variables and the average interest rate. "Transfers p.c. county roads" is the estimated revenue received from county councils for maintenance of main roads; "transfers p.c. other" captures all other transfers from both county councils and central government. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

loan maintenance is included. The coefficients on toll receipts and gas involvement become negative and statistically significant, while the coefficient on county road transfers is also significantly negative in specifications (3) and (4). This suggests that these towns were using these revenue sources partly to reduce their tax burden.

Determinants of interest rate

To explore the characteristics of towns affecting the cost of borrowing, I undertake a simple regression analysis with the average interest rate as the dependent variable. The results are displayed in Table 2.11. In specification (1) and (2) I pool the data across years, whereas in specifications (3) and (4) I include town fixed effects. The first approach allows us to control for the effects of time-invariant characteristics of towns that may have affected the cost of borrowing. This includes town occupational structure (for which I only have data for 1881), but also town size which would (generally) not change significantly over a twenty year period. The fixed effects specification, on the other hand, allows us to control flexibly for time-invariant characteristics that I cannot measure and focus on the *within* town changes over time.

As control variables I include the town population, and town tax base, property income per capita and revenue from tolls and dues. I also include the principal payments per capita as a control variable in all specifications. This controls for the fact that interest rates may be higher in towns with higher stocks of loans outstanding, and since the actual outstanding loan stock was used in the calculation of the interest rate and so will be spuriously correlated. I also include a dummy variable indicating whether the town was a municipal borough to control for differences due to different governance structures or potentially prestige (Bellamy, 1988). Specifications (1) and (3) include the consol rate as a control variable, while specifications (2) and (4) include year fixed effects. The latter allows us to control for time specific effects on the cost of borrowing not related to the consol rate. I include the consol rate as a lagged value to account for the fact that it would take time to borrow following a fall in the consol rate.

The results indicate that, as suggested by Wilson (1997), larger, wealthier towns had a lower interest rate. The coefficient on town population is consistently negative, with the exception of specification 4 (including both town and year fixed effects). This insignificance may reflect the limited change in population within a town over this period, or that town size is capturing other characteristics (e.g., prestige) which are slow moving. The coefficient on rateable value per capita is also statistically significant in all four specifications, which is likely to reflect the fact that loans were generally secured on the potential income from rates. There is also evidence that income from tolls and dues—an alternative to tax revenue—was associated with lower town interest rates once time trends are accounted for. There is also strong evidence that textiles towns also had a lower cost of borrowing, although the reason for this is not clear. Finally, as expected, the yield on consols is strongly significant and positive, indicating that towns' cost of borrowing was reacting to changes in the money markets. This is important, as it suggests that towns were not purely dependent on government loans in this period.

Table 2.10: Determinants of tax receipts per capita.

	DV=Tax receipts per capita (standardized)			
	(1)	(2)	(3)	(4)
Rateable value p.c.	0.46***	0.35***	0.36***	0.29***
	(0.03)	(0.02)	(0.06)	(0.05)
Property receipts p.c.	-0.05	-0.05	0.00	-0.01
	(0.03)	(0.03)	(0.00)	(0.01)
Tolls receipts p.c.	0.05***	-0.02*	0.01	-0.01
	(0.02)	(0.01)	(0.02)	(0.01)
Transfers p.c.: county roads	-0.01	-0.01	-0.03***	-0.03***
	(0.02)	(0.02)	(0.01)	(0.01)
Transfers p.c.: other	0.02**	-0.03**	0.02**	-0.01
	(0.01)	(0.01)	(0.01)	(0.02)
Involved in Gas	0.01	-0.39***	0.12**	-0.15***
	(0.04)	(0.04)	(0.06)	(0.04)
Loan maintenance p.c.		0.45***		0.38***
		(0.03)		(0.03)
Occupations				
>10% Textiles	0.04	-0.03		
	(0.04)	(0.04)		
>10% Agriculture	-0.05	-0.04		
	(0.04)	(0.03)		
>10% Minerals	-0.18***	-0.15***		
	(0.04)	(0.03)		
% White Collar	0.13***	0.11***		
	(0.03)	(0.02)		
% Foreign Born	-0.07***	-0.08***		
	(0.02)	(0.01)		
Population				
Popn 10k-25k	0.11***	0.09**	0.02	-0.06
	(0.04)	(0.03)	(0.05)	(0.04)
Popn 25k-50k	0.30***	0.20***	0.20*	0.10
	(0.08)	(0.06)	(0.11)	(0.08)
Popn 50k-100k	0.54***	0.47***	0.59***	0.50***
	(0.09)	(0.07)	(0.15)	(0.13)
Popn 100k-250k	0.66***	0.47***	0.96***	0.89***
	(0.09)	(0.09)	(0.17)	(0.15)
Popn over 250k	1.17***	0.71***	1.65***	1.71***
	(0.14)	(0.16)	(0.28)	(0.28)
Population growth				
Quartile 2	0.10***	0.04*	-0.01	-0.02
	(0.03)	(0.03)	(0.02)	(0.02)
Quartile 3	0.09**	0.01	-0.10***	-0.09***
	(0.04)	(0.03)	(0.03)	(0.02)
Quartile 4	0.13***	0.05	-0.16***	-0.13***
	(0.05)	(0.04)	(0.04)	(0.03)
Urban crowding				
Quartile 2	0.05	0.04	0.04	0.02
	(0.03)	(0.03)	(0.03)	(0.03)
Quartile 3	0.08*	0.10***	0.05	0.02
	(0.05)	(0.04)	(0.05)	(0.04)
Quartile 4	0.05	0.09**	0.00	-0.03
	(0.06)	(0.04)	(0.06)	(0.05)
Population density				
Quartile 2	0.21***	0.09**	0.01	-0.04
	(0.05)	(0.04)	(0.05)	(0.05)
Quartile 3	0.21***	0.08**	0.00	-0.07
	(0.05)	(0.04)	(0.07)	(0.06)
Quartile 4	0.27***	0.13***	0.03	-0.04
	(0.06)	(0.05)	(0.08)	(0.07)
Municipal Borough	0.17***	0.20***	0.24***	0.20***
	(0.05)	(0.04)	(0.09)	(0.07)
Town FE	N	N	Y	Y
Year FE	Y	Y	Y	Y
No. obs	14437	14437	14437	14437
No. towns			691	691

Standard errors are clustered by town, and displayed in parentheses. All variables are standardized except for dummy variables. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.11: Interest rates lower in larger and wealthier towns.

	DV=Average interest rate			
	Pooled	Pooled	Fixed Effects	Fixed Effects
	(1)	(2)	(3)	(4)
Population	-0.05***	-0.03**	-0.43***	-0.01
	(0.01)	(0.01)	(0.12)	(0.06)
Principal payments p.c.	0.01	0.03	0.05**	0.09***
	(0.02)	(0.02)	(0.02)	(0.02)
Rateable value p.c.	-0.11***	-0.09***	-0.24***	-0.11***
	(0.02)	(0.02)	(0.04)	(0.04)
Property receipts p.c.	0.01	0.01	-0.01***	-0.00
	(0.01)	(0.01)	(0.00)	(0.00)
Tolls receipts p.c.	-0.00	-0.04***	0.04***	-0.02**
	(0.01)	(0.01)	(0.01)	(0.01)
Municipal Borough	-0.06	-0.05		
	(0.04)	(0.04)		
>10% Textiles	-0.21***	-0.22***		
	(0.04)	(0.04)		
Yield on Consols	0.43***		0.34***	
	(0.04)		(0.03)	
No. obs	10499	10499	10499	10499
No. towns	660	660	660	660
Town Fixed Effects	N	N	Y	Y
Year Fixed Effects	N	Y	N	Y
Occupation controls	Y	Y	N	N
R-squared	0.05	0.13	-	-

Standard errors are clustered by town, and displayed in parentheses. All variables are standardized except for dummy variables and the yield on consols. "Occupational controls" include the percentage of population foreign born, and dummy variables indicating whether more than 10% of the town workforce was working in agriculture or minerals. "Municipal Borough" is a dummy variable indicating whether the town was a municipal borough in 1886—the year prior to the analysis period. Regression uses data for the years for which interest payment data is available (1887–1903). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Chapter 3

How did the extension of the franchise affect expenditure on local public goods?

3.1 Introduction

Most theories of democratization predict that extensions of the right to vote to the poor will be associated with increases in government expenditure (e.g., Meltzer and Richard, 1981; Lizzeri and Persico, 2004; Acemoglu and Robinson, 2000). Poorer citizens demand greater levels of redistribution, hence government spending increases once they are granted the franchise. However the same argument may not apply to expenditure on public goods: if public goods are normal goods then the poor may prefer lower taxes and *lower* government expenditure than the middle class (Epple and Romano, 1996; Bursztyn, 2013).

This distinction is particularly important for local governments, whose powers are often limited to public good expenditure rather than redistributive spending (Shah and Shah, 2009). In recent years development agencies have had increasing interest in passing responsibility for key infrastructure projects—such as clean water supply—to local governments on the basis that encouraging local participation will encourage more efficient levels of investment (Bonfiglioli, 2003). If the poor must pay for public goods, through higher taxes or foregone transfers, devolution of power may lead to unanticipated opposition to government expenditure.

I propose a model of the relationship between the franchise and the size of government where government expenditure is restricted to investment in public goods. The model predicts that, if the marginal utility of consumption is high at low levels of income, the poor will oppose increased spending on public goods. The rich will also oppose increased spending since they bear a relatively high share of the tax burden. Demand for public goods is thus driven by the middle class: the relationship between the franchise and government expenditure is inverted-U-shaped. As a result, an extension of the franchise to the poor may lead to a reduction in public goods provision.

To test this prediction I construct a new dataset of local government expenditure and the extent of the local franchise in England and Wales between 1867 and 1910. This approach offers three advantages over the cross-country analyses undertaken in many previous studies of franchise extension (e.g., Husted and Kenny, 1997; Lott and Kenny, 1999; Aidt et al., 2006; Aidt and Dallal, 2008; Abrams and Settle, 1999; Lindert, 2004). First, by using local government data I am able to capture the effects of extending the franchise on important infrastructure spending not measured in national government accounts. Second, because the municipalities all operated in a common institutional and cultural environment, I am able to isolate the effect of franchise extension from other confounding factors. Third, this period is of particular interest since, following the Industrial Revolution, town councils were faced with demands for new public goods—such as clean water and sewer systems—similar to those required in developing countries today (Günther and Fink, 2011). Further, the analysis in Chapter 4 shows that this sanitation expenditure made a large contribution to the reduction in mortality from waterborne disease in this period. The political obstacles that councils faced in providing these key infrastructure investments are thus of continuing relevance.

To identify the effects of extending the franchise to the poor I use plausibly exogenous variation in the level of the franchise across time and across towns. While town councils were elected under a common electoral framework, there remained substantial variation in the extent of the franchise across towns. This variation resulted partly from nationally imposed registration requirements, which granted the vote only to heads of household who had met residence and tax-paying requirements. In addition, the poor law authorities also maintained some control over which individuals held the right to vote, particularly when considering the claims of female residents (partially enfranchised in 1869) or renters. Over time, however, national reforms to the electoral system led to convergence in the extent of the franchise across towns, providing a further source of exogenous variation that is exploited in the empirical analysis.

The main specifications test the effect of the franchise on two dependent variables: tax receipts per capita and public goods expenditure per capita. I estimate panel regressions with linear and quadratic terms in the franchise, and including time and year fixed effects. The results show strong and consistent evidence of the proposed relationship: extensions of the franchise beyond 50% were associated with a decline in both the level of per capita public goods spending and per capita tax receipts. The results are robust to the inclusion of time-varying demographic controls, including potential sources of spurious correlation such as population growth and urban crowding. They are also robust to removing subsets of towns with very high or low levels of observable characteristics (e.g., very small or very large towns). Two placebo tests, using variables that we would not expect to be related to the franchise, show that the relationship is not a spurious artifact of the dataset. Finally, the results are robust to limiting the analysis to the period immediately before and immediately after major national reforms to the franchise.

One concern might be that opposition to government expenditure was driven by the fact that the poor did not understand the health benefits associated with sanitation investments, rather than a preference for consumption. To test this I examine how the relationship between the franchise and different types of public goods changed over time. The results show that the effect of the franchise on sanitary public goods diminished over time, suggesting that either growing wealth or knowledge of the benefits of sanitation infrastructure overcame taxpayer opposition. But the extent of the franchise continued to have the same effect on other public goods, such as tramways and electric lighting, that became widely available in the 1890s. This supports the hypothesis that opposition to public goods was based on income, rather than specific features of sanitation infrastructure.

3.2 Related literature

Local public goods such as sewer systems and clean water had a large impact on mortality in the nineteenth- and early twentieth-century, and they continue to do so in developing countries.[1] Yet investment in these key public goods remains insufficient in many countries (Günther and Fink, 2011). In recent years, there has been increasing interest in devolving power over the provision of these public goods to local, democratically elected, institutions in order to ensure that the interests of all citizens are represented in decision-making (Olken, 2010). However, we do not know how effective democratic governments are in providing these goods (Ponce-Rodríguez et al., 2012).

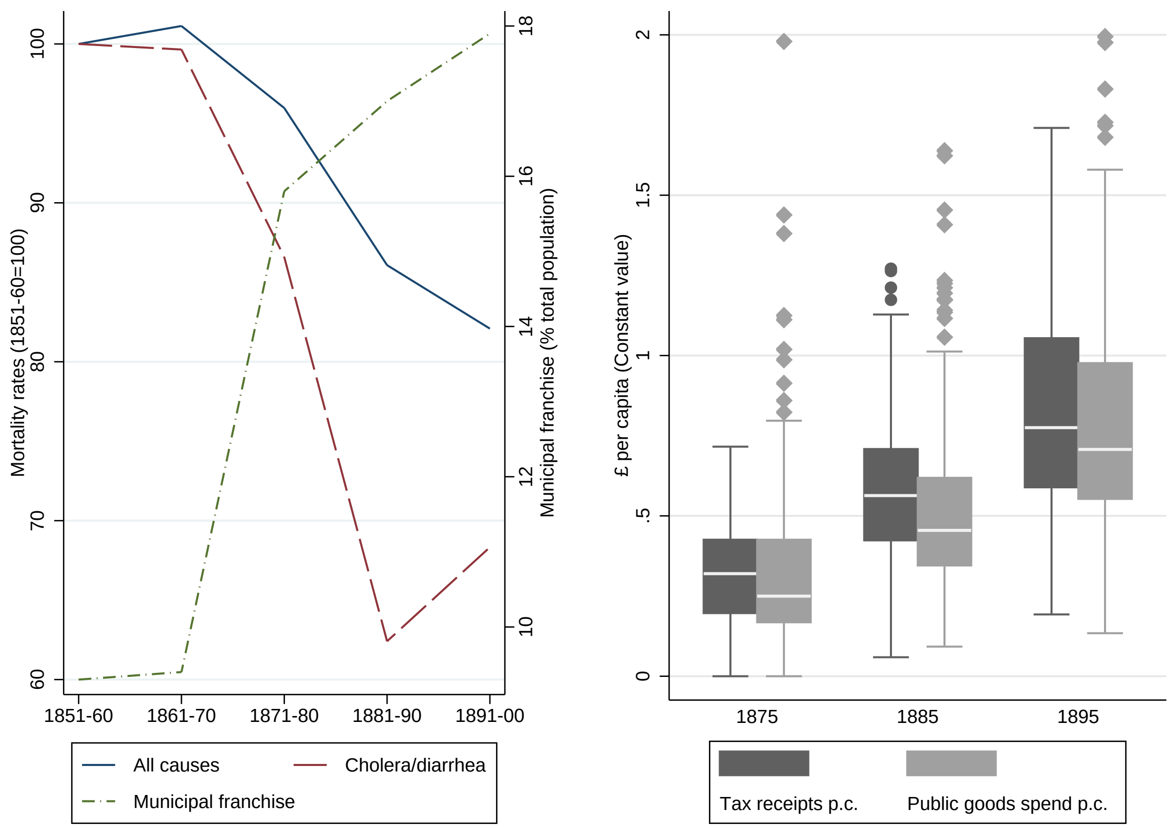
Most theories of franchise extension imply that extending the right to vote to the poor will be associated with an increase in the size of government (e.g., Meltzer and Richard, 1981; Lizzeri and Persico, 2004; Acemoglu and Robinson, 2000, 2001, 2005).[2] A cursory look at the British data (see Figure 3.1) supports this prediction. Between 1860 and 1900 the average municipal franchise approximately doubled from 9% to 18% of the entire population

[1] For examples of historical studies see Szreter (2005); Cain and Rotella (2001); Cutler and Miller (2005); Troesken (2002); Ferrie and Troesken (2008); Kesztenbaum and Rosenthal (2013). For more contemporary evidence see Zwane and Kremer (2007); Ahuja et al. (2010); Fink et al. (2011); Zhang (2012) and many others.

[2] See also Toscani (2012); Conley and Temimi (2001); Justman and Gradstein (1999); Jack and Lagunoff (2006); Bertocchi (2011); Borck (2007).

(including children)—coinciding with an even greater increase in public goods expenditure per capita, and a 30% decline in deaths from cholera and diarrhea.

Figure 3.1: Large decline in mortality coincided with rapid increase in local expenditure on public goods after 1870. However there remained large variation in the scale of variation in the size of local government expenditure.



Source: Mortality statistics from Dicennial Returns of Registrar General, and digitized by Woods (1997). For details of franchise and financial variables see Appendix 3.A. Right hand panel excludes values above £2 per capita in 1895 for illustrative purposes.

However, as shown in Figure 3.1, this rapid increase was accompanied by great variation across different areas, with some towns spending less in 1895 than the median level of expenditure 20 years previously. Only two-thirds of incorporated towns supplied water in 1900 and the extent of the investment in water supply also varied significantly across towns

(Wohl, 1983; Millward and Sheard, 1995). This is particularly surprising given the high rates of social return to these public goods—clean water technologies had a social rate of return of 23 to 1 in major US cities in the early twentieth-century (Cutler and Miller, 2005). The results in Chapter 4 indicate that the expenditure that occurred in England and Wales accounted for between 20% and 40% of the reduction in waterborne mortality between 1871 and 1890.

This paper examines how this variation can be explained by the extent of the franchise in different towns. The studies cited above generally rely on the assumption that local governments have control over transfer payments.[3] However in practice this is often not true of local governments, which can face nationally-imposed constraints on their expenditure powers. This is important, since whereas higher transfers are unambiguously beneficial to recipients, higher government expenditure on public goods can be subject to a trade-off between government public good provision and consumption. If all citizens must pay part of the cost of public goods—as in standard political economy models—the poor may prefer lower taxes than richer citizens (Epple and Romano, 1996).[4]

Empirical studies of the effects of the extension of the franchise have focused on national- or state-level expenditures, and so overlook many of the key infrastructure investments undertaken at city- or town-level. This limitation has led to a focus on redistributive government expenditure (e.g., Husted and Kenny, 1997; Lott and Kenny, 1999; Aidt et al., 2006; Aidt and Dallal, 2008; Abrams and Settle, 1999) or nationally-funded education services (e.g., Stasavage, 2005; Brown and Hunter, 2004; Baum and Lake, 2003). The evidence that is available does not identify a clear cut effect of franchise extension on the provision of public

[3] In Meltzer and Richard (1981), for instance, government expenditure is limited only to transfer payments. In Lizzeri and Persico (2004) government is able to choose from a full schedule of transfer payments and public goods expenditure.

[4] Another possibility is that the value (real or perceived) of public goods varies across income groups, due to differing effects on productivity across industrial sectors (Llavador and Oxoby, 2005) or by increasing the return to capital and hence wage income (Aidt et al., 2010).

goods. Female enfranchisement had no effect on investment in sanitation infrastructure between 1905 and 1930, although this may reflect the fact that by this point large towns had already invested in these public goods (Miller, 2008). Specifically in the British context, this paper contradicts the argument of Aidt et al. (2010) that the poor drove the late nineteenth growth in government expenditure, by utilizing the new comprehensive data set comprising town finances in all municipal boroughs from 1867 onwards. Outside Britain, there is some evidence that poorer citizens sometimes oppose government expenditure both historically and today (Brown, 1988; Harding and Stasavage, 2014; Bursztyn, 2013). More generally, it does not appear that democratization is associated with lower mortality rates once sample selection is accounted for (Ross, 2006).[5]

3.3 Model

This section presents a simple model showing that, if local governments impose linear taxes and cannot utilize transfer payments, the poor and the rich will desire lower tax rates than the middle class. In contrast to many previous models, I assume that towns controlled expenditure over public goods, but could not undertake redistributive transfer payments. I also impose the standard assumption that councils use linear tax rates. In Section 4.3 I show that these assumptions closely match the institutional constraints faced by town councils in nineteenth-century Britain.

The model predicts that, if the franchise is extended first to the rich, then to the middle class, and then to the poor, the relationship between municipal expenditure and the extent of the franchise will be inverted-U-shaped. This prediction results from assumptions relating to the shape of citizens' utility functions, particularly the fact that the poor have a relatively

[5] For evidence of a positive relationship between democratization and health outcomes, much of which is addressed by Ross, see Besley and Kudamatsu (2006); Kudamatsu (2012); Navia and Zweifel (2003); Zweifel and Navia (2000).

high marginal utility of consumption. Those assumptions are particularly plausible in a low income economy, where poorer citizens may struggle to pay for a sufficient food intake or be forced to live in extremely cramped living quarters. The rich, on the other hand, oppose higher tax rates because they face a relatively high tax burden.

3.3.1 Framework

Consider an individual i who receives utility from consumption c_i and from expenditure on a local public good g. Utility from the public good is decreasing in the size of the population N. For instance, a fixed investment in clean water supply may only be able to serve a certain number of citizens. As such, utility is given by:

$$U_i = u(c_i) + v\left(\frac{g}{N}\right)$$

Individuals receive an income y_i, with aggregate income denoted by Y. The public good is funded through a linear tax rate $\tau \in [0, 1]$, leading to a government budget constraint of $g = \tau Y$.

Assume u and v are strictly concave, continuous, twice differentiable and satisfy the Inada conditions with $u(0) = v(0) = 0$. In addition, I assume the follow conditions on the coefficient of relative risk aversion for $u(c)$, $r_R(c, u) = -c\frac{u''(c)}{u'(c)}$.

1. $\frac{\partial r_R(c,u)}{\partial c} < 0$.

2. $\lim_{c \to 0} r_R(c, u) > 1$ and $\lim_{c \to \infty} r_R(c, u) < 1$.

These assumptions state, essentially, that poor individuals are very sensitive to reductions in consumption, but that this is less true of the wealthy. Intuitively, poor households may be unwilling to gamble, since any loss means more to them. Ogaki and Zhang (2001) provide evidence that this form of utility is appropriate in modern-day developing societies with low income households.

One type of utility function that meets these conditions is a subset of Hyperbolic Absolute Risk Aversion (HARA) models (Merton, 1971). In particular, if:

$$u(c_i) = \frac{1-\gamma}{\gamma}\left(\frac{\beta c_i}{(1-\gamma)} - s\right)^{\gamma}$$

then the conditions are satisfied for $s > 0$ and $0 < \gamma < 1$. The value s here can be interpreted as a subsistence level of consumption, from which individuals receive no utility (that is below this level they are essentially unable to meet their basic needs).

3.3.2 Results

Individual's optimal tax rates

The assumptions over u and v, combined with assumptions 1 and 2 are sufficient to give the following proposition.[6]

Proposition 1. *Denote τ_i^* as the optimal tax rate for an individual with income y_i. Then there exists $\tilde{y}$ such that:*

1. $\frac{\partial \tau_i^*}{dy_i} \geq 0$ *for* $y_i \leq \tilde{y}$
2. $\frac{\partial \tau_i^*}{dy_i} < 0$ *for* $y_i > \tilde{y}$

This proposition states that the optimal tax rate is inverted-U-shaped in income: the rich and poor desire a lower tax rate (and hence lower government spending per capita) compared with those with medium levels of income. The preferred tax rate is increasing in income until a point, $\tilde{y}$, after which the preferred tax rate decreases in income. Intuitively, this is because at low levels of income citizens cannot "afford" spending on the public good,

[6]All proofs are contained in the appendix.

since an increase in taxation moves them to very low levels of disposable income. As income rises, this cost is reduced, increasing the preferred tax rate. However, at the same time, the marginal cost of taxation increases since richer citizens have a greater income to be taxed. Thus eventually demand for per capita public expenditure declines.

Extension of the franchise and public goods expenditure

The discussion above has characterized how citizens' preferences over taxation change with income. I now identify the translation of these preferences into the implemented tax rate. In particular, assume that the tax rate is set by a politician chosen through a standard two-candidate simple majority election, in which candidates' promises are binding.

Denote the most limited (that is the initial) electorate as E_0 and suppose the right to vote is extended sequentially in decreasing order of income, such that a citizen i is only enfranchised once all citizens with $y_j > y_i$ are already enfranchised. Let $\tilde{\tau}$ denote the median level of τ_i^* for all individuals for whom $y_i \geq \tilde{y}$. That is the median tax rate desired by individuals who are on the decreasing part of the optimal tax function.

I make the following assumptions on the distribution of income in the town:

3. $|\{i|y_i \geq \tilde{y},\ i \notin E_0\}| \geq 2$; and

4. $|\{i|y_i < \tilde{y},\ \tau_i < \tilde{\tau}\}| \geq 2$.

These conditions ensure the electorate will consist first of very rich citizens, then be extended to some middle income citizens, and finally to very poor citizens. The first condition states that there are some middle class individuals who are not initially enfranchised. The second states that there are some individuals sufficiently poor to want a lower tax rate than the rich.

Proposition 2. *Let N and E_0 be odd and assume $y_i \neq y_j$ for $i \neq j$. Then, given assumptions 3 and 4, the tax rate and amount of government spending per capita will be inverted-U-shaped in the level of the franchise.*

This proposition states that extensions of the franchise will initially lead to higher tax rates but then, eventually, lower tax rates.

Growth in town wealth

The final proposition considers the effects of growing town wealth on public goods expenditure. This is likely an important factor in explaining the diffusion of public goods over time, regardless of the extent of the franchise. The effect of increases in average income can vary depending on how the additional income is distributed, since this will affect the identity of the median voter. As such, I consider increases in aggregate town income that are distributed equally across all citizens: i.e., the income of all individuals increases proportionally to average income. For instance, a 10% increase in average income would be associated with a 10% increase in every individual's income.

Proposition 3. *Increases in average municipal income are always associated with increases in expenditure per capita.*

This proposition reflects the fact that an increase in average income leads to an increase in the tax revenue collected (i.e., the tax rate multiplied by aggregate income) at any given tax rate. As such expenditure in public goods may increase independently of the level of the franchise.

3.4 Data and identification strategy

I use data from nineteenth-century local governments in England and Wales to test the model. In this section I first outline the data sources used for this analysis—further detail is provided in Appendix 3.A. I then discuss the identification strategy underlying the empirical analysis in three parts. First, I explain how the spending and taxation powers held by town councils during this period matched the model assumptions. Second, I discuss the exogeneity of the franchise variable. Finally, I provide quantitative evidence that extensions of the franchise led to the enfranchisement of the poor.

3.4.1 Data

Sample

The focus of the empirical analysis will be on incorporated towns in England and Wales—the so called "municipal boroughs"—which possessed the broadest range of expenditure powers and were governed under a standardized council system from 1835 onwards. This group included nearly all the largest towns (except London, which was governed under its own set of councils). However, it also included a number of small market towns, due to historical charters obtained prior to the Industrial Revolution. The main specifications focus on a subset of these towns. In particular, the sample is limited to municipal boroughs that were both incorporated (i.e., had councils elected under the system described here) and had control of sanitary expenditure in 1867 (i.e., the start of the study period). A total of 214 towns had been incorporated by 1867; however only 154 had control of sanitary expenditure prior to this date. A further four towns are excluded due to either franchise data that appeared implausibly high (above 90% in some cases) or (in one case) because of difficulties identifying boundary changes.[7] The remaining 150 towns include 92% of the 1881 population of the 214 municipal boroughs incorporated by 1867. Further, it includes all towns with population above 100,000 in 1881, and 35 of 41 towns with population above 50,000 in 1881.[8] The findings are unchanged using a broader sample—see the discussion of robustness tests in Section 3.5.3.

[7]The results are not dependent on the exclusion of these towns.

[8]These figures exclude West Ham and Croydon, which are suburbs of London and became London Boroughs at a later date.

Financial data

The analysis uses a new annual panel dataset for the years 1867 to 1904. The dataset was constructed from the *Local Taxation Returns* contained in the Parliamentary Papers collection. These financial accounts detail the sources of revenue and types of expenditure in each town. Financial values are then translated into constant values using the Rousseaux Price Index (Mitchell, 1971, pp. 723-4) following Millward and Sheard (1995).

I use this dataset to construct three measures of government revenue and expenditure. The first is the level of tax revenue per capita. Second, I construct two measures of public goods expenditure. The first includes all public goods expenditure. This has the advantage of being available for the whole period from 1867 onwards—expenditure was not generally disaggregated before 1872. However, given the importance of sanitary infrastructure to economic development, I also construct a measure of expenditure on sanitary public goods from 1872 onwards. This measure includes spending on "water supply", "sewers and sewerage", and "highways, scavenging and watering".[9]

One concern is that the financial accounts do not differentiate between investment and ongoing (e.g., maintenance) expenditure on public goods. As a result, it is clear from inspection of the dataset that there are a large number of extremely high one time expenditures. To deal with this issue, I construct a measure of ongoing expenditure. To separate ongoing expenditure from investment expenditure, I first identify "investment periods" by analyzing deviations in trend expenditure for each type of expenditure. In non-investment periods, the level of ongoing expenditure is simply the per capita expenditure in that period. In investment periods, the level of ongoing expenditure is the level of expenditure in the next non-investment period. For instance, if 1873 and 1874 were investment periods, but 1875

[9]These categories are those identified as having a sanitary aspect in Millward and Sheard (1995). Note that the measure of highways includes cleaning of the streets and "scavenging"—which refers to emptying of privy middens. I combine the measures into a single variable, since some towns did not distinguish between them in the financial reports.

was not, then the level of per capita expenditure in 1873 and 1874 is set equal to that in 1875.

Investment periods are identified using both the level and year-on-year increase in expenditure.[10] An investment period is identified as starting when either a town begins spending for the first time, when year-on-year expenditure increases by more than 100%, or if the town's per capita expenditure is higher than twice the median of per capita expenditure in the town in future years. An investment period is then identified as continuing until expenditure falls significantly again, relatively both to other towns and future expenditure in the same town. Prior to the existence of disaggregated data in 1872, investment periods are also identified if expenditure is more than twice the aggregated 1872 ongoing expenditure. The results are robust to alternative ways of identifying these periods.[11]pover

Measuring the franchise

My measure of the franchise is the *male* franchise, since the key prediction of the model relates to the extension of voting rights to poorer citizens. This is important since using the total franchise could conflate two (potentially very different) sources of changes in the franchise: the broadening of the male franchise, and the extension (for the first time) of the franchise to women. As discussed in detail in Section 4.3, it is reasonable to assume that growth in the male franchise involves extensions of the right to vote to poorer citizens. However, this is not necessarily the case for women, since their right to vote depended on being a head of household, and it is not clear how the preponderance of female household heads may have varied across income groups.

[10] See the appendix for more detail on the identification of these investment periods.

[11] An alternative approach is to simply remove the observations with very high values from the analysis as outliers: there is still strong support for the inverted-U-relationship, for instance, when excluding the highest 1% or 5% of observations of expenditure per capita on public goods in year. However this approach has the difficulty that it may be biased against towns with generally high expenditure, and may lead to bias by excluding periods when important expenditure did occur.

I measure the level of municipal franchise for each sex as follows:

$$\text{Male (female) franchise} = \frac{\text{Number of male (female) electors}}{\text{Male (female) population of voting age}}$$

The numerator of the measure is calculated using the number, and gender breakdown, of municipal electors reported in a number of parliamentary papers for ten cross sections between 1864 and 1897. The franchise in intervening years is interpolated using a compound average growth rate. The denominator is calculated using total male and female municipal population collected from dicennial censuses, adjusted by the estimated proportion of male and female citizens of voting age, using information from the 1881 census.

To account for potential delays between the date of registration and actual change in expenditure, I use the value of the franchise lagged by three years. This time lag reflects the fact that municipal councils were elected across a three year period; the results, however, are robust to different lag periods (including no lags). To ensure that the results are not driven exclusively by the tails of the franchise distribution, I also exclude the top and bottom 1% of franchise values. The results are unchanged when including these observations.

3.4.2 Identification

Historical context fits model assumptions

The powers allocated to local authorities closely mirror the assumptions of the model. First, towns were governed by locally elected councils, established by the 1835 Municipal Corporations Act. Councils were chosen under a system of annual elections, with one-third of councilors replaced each year. Further, it was the town councils that financed and provided local public goods. These public goods included, in particular, the key sanitary public goods—including water supply, street cleaning and sewer systems—required to combat the deterioration in sanitary environments following industrialization. By 1867 the vast majority of the municipal boroughs had the authority to undertake these large scale public works, with the remainder receiving such authority in 1872.

Second, municipal governments did *not* have authority to undertake transfer payments and did not control welfare (that is poor relief) expenditure (Lizzeri and Persico, 2004). Welfare expenditure was controlled by Boards of Poor Law Guardians, who were elected separately on a graduated franchise, with district boundaries which often differed substantially from those of the municipalities.

Third, towns' taxation power was limited to the use of proportional property taxes, rather than business or income taxation. Because of this limitation, the tax burden was approximately proportional to household income, as assumed in the model. Further, the need for increased taxation was a key issue in local political debate. The new demands for expenditure led to intense taxpayer opposition, often leading to referenda and petitions in opposition to investment (Hennock, 1973, 1963; Wohl, 1983). This was often true amongst a "shopocracy" of small property owners (e.g., Yasumoto, 2011; Aidt et al., 2010) and poorer citizens, who opposed government expenditure since they cared more about their immediate income than an improved living environment (Hamlin, 1998).

Variation in the municipal franchise

Elections in municipal boroughs occurred under the "municipal franchise", which was determined under different legislation to the parliamentary franchise. As shown in Figure 3.2 the extent of this franchise, measured as a percentage of the adult population, varied considerably across towns and over time.[12] In this subsection I explain this variation and argue that the variation is plausibly exogenous to expenditure on public goods, particularly since much of the change resulted from national legislation.

The franchise grew significantly between 1865 and 1895, as shown in Figure 3.2, although

[12] The construction of the franchise measure is discussed in Section 4.3 and in detail in Appendix 3.A.

with continued variation in the size of the electorate across towns. This growth resulted partly from the enfranchisement of women, who gained the right to vote (if they were heads of household) in 1869. The male franchise also grew over time, with the median level increasing from around 34% of the adult male population in 1854 to approximately 60% in 1885.

In considering Figure 3.2 it is important to note that the right to vote was only given to heads of households—rather than to individuals. Since multiple men of voting age could share a residence (e.g., fathers and sons), the proportion of households enfranchised was higher than the proportion of voting-age men. This suggests that by the 1880s a very high proportion of households had the right to vote in these towns. This also explains the comparatively low level of the female franchise since few women were heads of household (fewer than 7% of adult women in the 1881 census).[13]

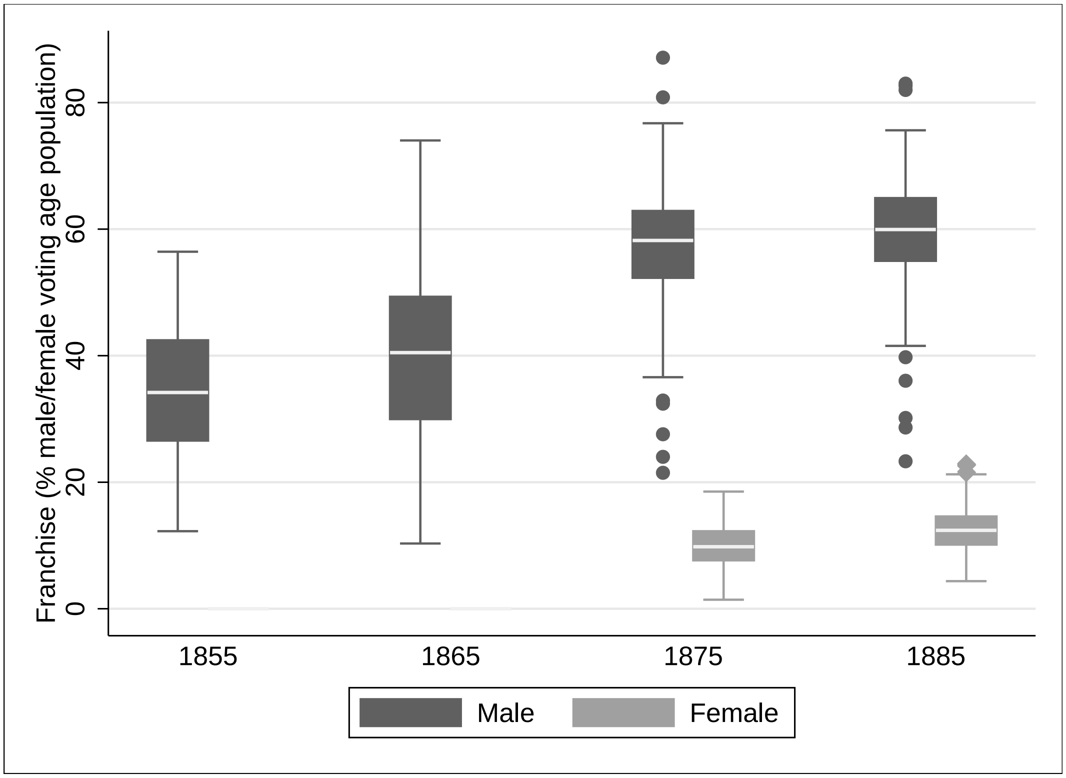
National legislation provided the basic framework under which the municipal electorate was determined.[14] From 1835 the electorate consisted of all male householders subject to residence and tax-paying requirements. However, while in theory this electorate was very broad, in practice the number of voters was frequently significantly below the "theoretical franchise" (Keith-Lucas, 1952). Poor voters in particular were frequently excluded for two major reasons. First, the legislation imposed the requirement that voters must have been resident for at least three years and had to have paid local taxes for at least two and a half years. Second, citizens also lost the right to vote if they had recently received poor relief.

The requirement that the right to vote was determined by having paid taxes was a particular source of variation across towns, since it meant that local decisions over whom to tax determined the size of the electorate. In particular, towns varied in their approach to assessing occupiers of small dwellings. The low value of these houses often made it costly to tax them directly, and so in some areas tax collectors collected taxes from landlords, who

[13] Author's calculation based on analysis of individual-level census data.

[14] Interested readers are referred to the appendix for the discussion of the specific Acts that affected the municipal franchise: for the sake of brevity I refer to legislative changes only by the dates when they occurred.

Figure 3.2: The extent of the municipal franchise varied across place and grew over time.



Source: Author's calculations based on data from parliamentary papers and decennial censuses. See Section 4.3 and Appendix 3.A for details.

paid on behalf of their tenants in return for a discount of around of 20–25%. Prior to 1869, however, the law did not clearly specify whether tenants who did not pay their taxes directly had the right to vote. Whether these tenants were actually enfranchised thus depended on the actions of the local authorities: in many cases only the landlord's name was entered on the ratebook—and hence the voting register—leading to significant disenfranchisement. Tenants were able to insist on paying taxes themselves but rarely did so since it required re-registering around 4 to 6 times each year.

The variation in the franchise resulting from differences in tax policy are plausibly exogenous to the level of public goods expenditure, since decisions over who was taxed and how were decided not by the municipal council, but by the authorities responsible for poor relief. These authorities were elected under a separate franchise under which the rich had multiple votes, and with different jurisdictional boundaries (Lizzeri and Persico, 2004).

An even stronger cause of exogeneity in the franchise is provided by two national reforms to the male franchise that occurred in 1869. The first enshrined the right of tenants to vote even when paying their taxes indirectly through their landlord. The second significantly reduced the length of residence and tax-paying requirements. The period of residency was reduced from three years to one—and the length of tax-paying required reduced from two and half years to six months. These reforms were exogenous to each individual town and provide a major source of variation in the franchise variable. Further, both of these changes would be expected to focus on the poor since these citizens were most likely to fail to pay taxes, move more frequently and to pay taxes through their landlords.

Regressions of franchise against observable characteristics

There are, however, important reasons that part of the variation in the franchise could be capturing the effects of observable town characteristics. Town population, for instance, is linked to our franchise variable by definition (since it forms the denominator of the measure), but might also be related to economies of scale in the provision of sanitation. Similarly both population growth and urban crowding (defined as population/number of houses) may be correlated with demand for public goods and also the extent of the franchise. This is because, first, population growth may be associated with more adults failing to meet the residence requirements for receiving the franchise. Second, more individuals per household would lead to individuals being disenfranchised since they were not heads of households.

Appendix Table 3.7 shows that in fact the level of the franchise was correlated with the level of the franchise in four different cross sections (1866, 1873, 1885 and 1897). As such it is important to control for these characteristics in the main regressions. To check whether these controls are sufficient to remove correlation between the level of the franchise and observable town characteristics, I check whether the remaining variation in the franchise can be explained by other characteristics that we might expect to be correlated with expenditure on public goods. Specifically, I first regress the male franchise on urban crowding, population growth, the size of town population (split into six bins), and a dummy variable indicating whether the town was incorporated in 1835. I then regress the residuals of that regression on four additional variables that we might expect to be correlated with expenditure on public goods: town population density (in 1871), the town tax base per capita, a dummy variable identifying whether more than 10% of the town population were engaged in farming in 1881, and a dummy variable indicating whether more than 5% of the town were engaged in the textiles industry in 1881. All individual coefficients, as well as joint F-tests, are statistically insignificant in these residual regressions. This provides reassurance that the observable characteristics we use in the regressions are sufficient to account for any correlation between the franchise and other town characteristics affecting town expenditure.

Did the wealthy get the right to vote first?

A key assumption of the model is that the extension of voting rights increased the representation of the poor, rather than other citizens. In this subsection I test the hypothesis that the franchise was extended to the wealthy first using the proportion of parliamentary electors in the electorate as a proxy for town wealth distribution. The right to vote in parliamentary elections is an indicator that a citizen was relatively wealthy since (unlike the municipal franchise) most citizens could only vote in parliamentary elections if they occupied a property of at least £10 annual rental value. In 1866 this requirement excluded, on average, around two-thirds of citizens.[15] If extensions of the municipal franchise increased the representation of relatively poor citizens, then the rich would be more over-represented the smaller the franchise. We can then measure the over-representation of the wealthy through comparing

[15] The empirical analysis in this subsection uses data from the 1866 electoral returns (Parliamentary Paper 1866, no. 3626) relating to the approximately 150 municipal boroughs which had boundaries coextensive with parliamentary constituencies in 1866.

the percentage of parliamentary voters in the municipal electorate to the percentage of parliamentary voters in the entire population. Specifically, we can measure over-representation as follows:

$$\text{Over-representation} = \frac{\%\ \text{Parliamentary electors in municipal electorate}}{\%\ \text{Parliamentary electors in population}}$$

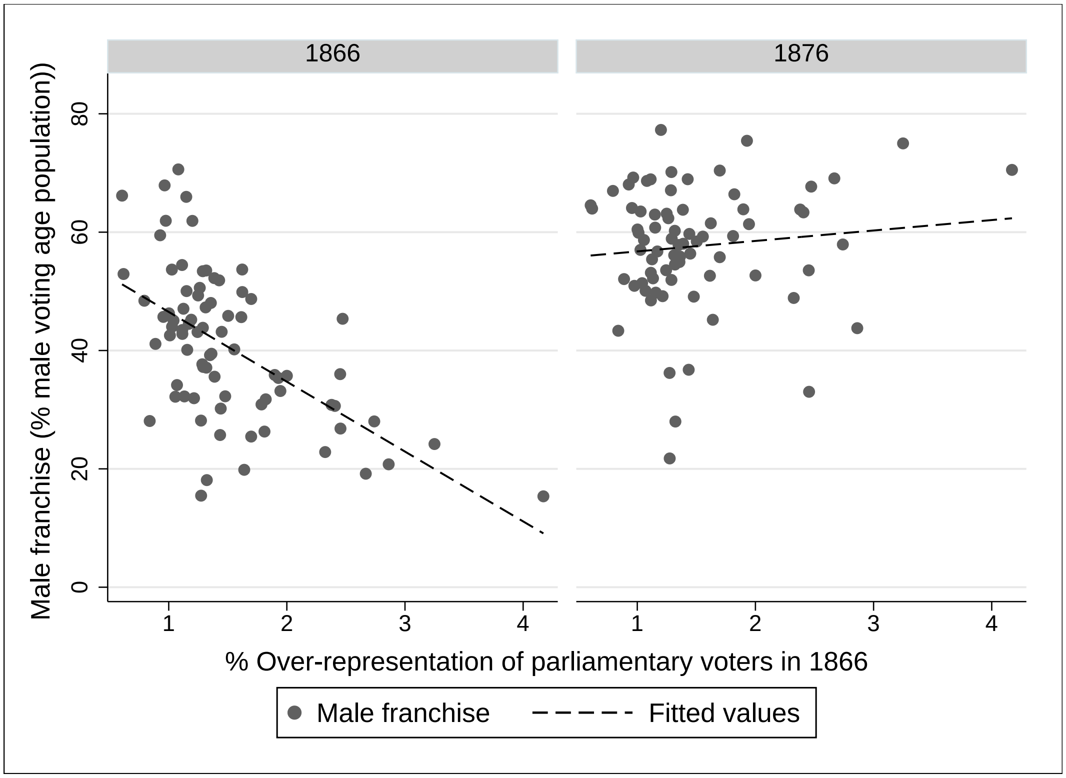
where "population" refers to the number of male occupiers in the town—that is the potential electorate under the male household franchise. If the electorate were entirely representative, we would expect the measure to equal one. If the wealthy were over-represented, on the other hand, then the number will be greater than one.

As shown in the left hand panel of Figure 3.3, in 1866 there was a clear negative relationship between the extent of over-representation and the extent of the municipal franchise. This relationship indicates that the electorate was more representative of relatively poor citizens when the franchise was higher. After the reforms of 1869, however, the downward-sloping relationship had disappeared—in 1876 there is no relationship between the extent of the franchise and the make-up of the pre-reform electorate. Further, the largest increases in the franchise occurred in those towns where the parliamentary electors were most over-represented, providing further evidence that the effects of the reforms was to extend the vote to poorer citizens.

Poverty in Britain 1860-1900

A key part of our argument is that poorer citizens opposed expenditure due to income constraints. An important question is then what the poor were "giving up" in return for greater government expenditure. Answering this question is complicated, since it relies on understanding not only average incomes—a difficult task in itself—but also elements of the income distribution. However, it is possible to glean some insights into the type of constraints the poor were facing using contemporary data from specific places, at particular points in

Figure 3.3: Over-representation of wealthier citizens predicts extent of franchise before, but not after 1869 reforms.



Source: Author's calculations based on *Parliamentary Papers*, 1866, no. 3626, "Electoral Returns, 1865–1866", and municipal franchise series (see Appendix 3.A).

time. In particular, we can use these sources to provide some crude indication both the proportion of the urban population in poverty, and also how the poor spent increases in income. A detailed discussion of these questions is presented in Appendix D: in this subsection I provide a summary of the results presented there.

First, I use Rowntree's well-known 1901 survey of York to identify the financial constraints faced by households at different levels of income—how much income was needed to escape poverty? This survey provides crude estimates of the proportion of households living beneath the poverty line in 1899. I then back-cast these estimates to provide an indication of the proportion of the population living in different levels of poverty in earlier years. The results indicate that a substantial portion of the urban population lived in poverty. Approximately 40% of urban households are estimated to have lived in "primary poverty"—indicating that individuals did not receive sufficient calories to achieve "minimum physical efficiency"—in 1860, falling to 16% in 1880 and 5% in 1914. However, a much larger proportion were estimated to live in under a more general qualitative measure of poverty—associated with living in squalor—with estimates indicating that up to three-quarters of individuals faced these constraints in 1860, falling to 27% in 1914. These figures seem high, reflecting the fact that they represent perceptions of what constituted poverty forty years later, and so we must be cautious in interpreting them. However, they are useful in indicating that a high share of the population were likely facing important financial constraints during the period.

To understand in more detail what these constraints meant in practical terms, I estimate the income elasticities of the poor citizens using contemporary (1890) budget data for a sample of approximately 1,000 households (obtained from Haines (2006)). This analysis suggests that at very low levels of income, individuals used added income to increase their spending on rent and began to switch to higher quality foods——including meat, vegetables and fruit. As income increased further, individuals continued to increase the share of their spending on quality food, but also began to purchase more leisure goods (e.g., alcohol and tobacco). This suggests that the trade-offs the poor faced in voting against greater expenditure on public goods were between better sanitation and expenditure that could lead to improved health through improvements in nutrition.

3.5 Empirical results

In this section I test the key hypothesis of the model: that the relationship between the extent of the franchise and per capita expenditure on public goods is inverted-U-shaped. I first present simple semi-parametric plots of the data, followed by panel regressions that show the relationship is robust to the inclusion of time-varying town characteristics and town- and year-fixed effects. The subsequent subsection discusses the robustness of the results, using the reforms of 1869 as a source of exogenous variation and presenting two placebo tests. The final subsection shows that the magnitude of the reforms was large, but that the effect on sanitary expenditure weakened over time.

3.5.1 Semi-parametric analysis

Figure 3.4 plots the relationship between the male franchise (on the x-axis) and both tax revenue per capita (left hand panel) and public goods expenditure per capita (right hand panel), after controlling for year- and town- fixed effects. The y-variable in each figure is calculated by regressing the relevant dependent variable on year and town dummies, and then estimating the residuals. The figure presents a Nadaraya-Watson non-parametric regression of these residuals against the male franchise.

Both panels show clear evidence of the inverted-U-relationship. In both, there is evidence that the dependent variable increases until a franchise of approximately 50%, and then declines beyond this point. This represents around the median level of the franchise prior to the reforms of 1869, and around the 25th percentile of the franchise immediately following the reforms.

3.5.2 Panel regressions

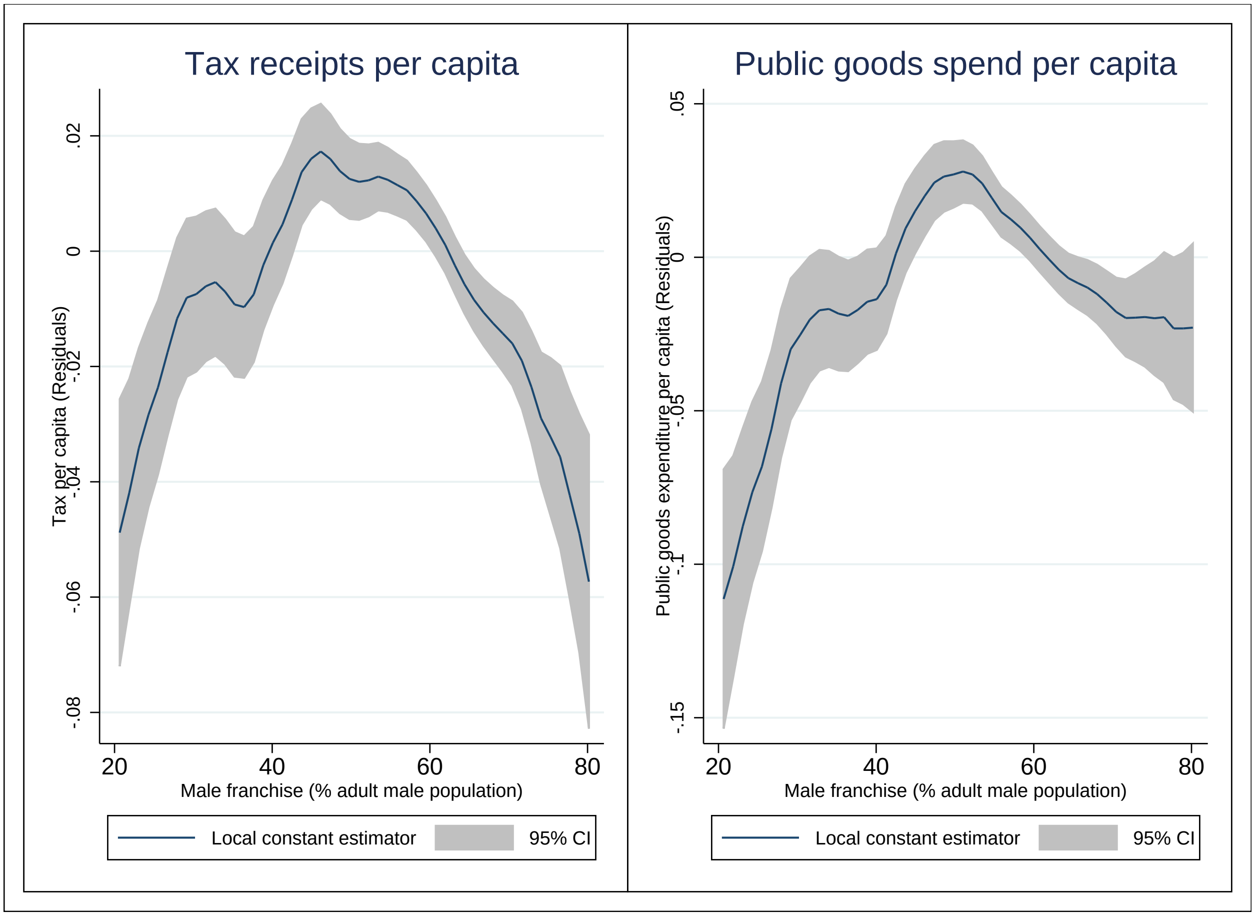
The figures above show clear evidence of the inverted-U-relationship. In this subsection I use panel regressions to test whether this relationship remains after controlling for potential confounding factors.

I use a quadratic specification:

$$g_{i,t} = \alpha + \beta_1 franchise_{i,t} + \beta_2 franchise^2_{i,t} + \gamma X_{i,t} + \gamma_0 Z_i + \delta year + \epsilon_{i,t}$$

where i indexes towns, t indexes year and ϵ is an error term. The vector X includes town-

Figure 3.4: Semi-parametric approach shows inverted-U-relationship with per capita tax receipts and expenditure, using Nadaraya-Watson nonparametric regression of residuals from regression against year and town dummies.



Source: Residuals estimated from linear regression of each dependent variable on year and town dummy variables for 1867-1900. Smoothed using Nadaraya-Watson nonparametric regression with Epanechnikov kernel, bandwidth chosen by rule-of-thumb estimator.

specific time-varying controls including urban crowding (measured as number of houses/population), population growth, the extent of the female franchise, and population. To allow for potential economies of scale in the provision of these public goods, population is binned into six categories.[16] Importantly, the panel structure also allows us to control for characteristics of

[16]The bins used are: less than 10,000 citizens, 10,000-25,000, 25,000-50000, 50,000-100,000, 100,000-250,000 and greater than 250,000 citizens. The exact definition or number of the bins is not important to the results. For instance, the main results hold with population binned by decile.

towns—e.g., location—that do not vary over time, as well as time trends. All our specifications include town level (Z) and year fixed effects ($year$) that account for any time-invariant aspects of towns that may affect the level of expenditure.

The panel structure of the dataset means that the data is likely to suffer from serial correlation. While this will not bias the estimated regression coefficients, it may bias the size of the standard errors downwards. To adjust for this I cluster standard errors at the town-level in all regressions, allowing for any form of error correlation structure within towns. As an additional test of robustness to serial correlation, I run an additional specification including one and two lags of the dependent variables. The results, which are presented in the appendix, are consistent with the main findings.

The existence of an inverted-U-shape relationship implies $\beta_1 > 0$ and $\beta_2 < 0$. As well as the individual statistical significance of these coefficients, I also check that the estimated turning point is within the interior of the franchise range, and that the two franchise terms are jointly significant with an F-test of joint significance. In addition, I use the test for U-shaped relationships developed in Lind and Mehlum (2010). This test adjusts for the fact that an inverted-U-relationship implies that the relationship between the franchise and the dependent variable must be decreasing before the turning point and increasing after—a joint restriction that may lead to problems when the estimated turning point is near the extremum of the dataset.

The results are presented in Table 3.1. Specifications (1) and (2) use tax receipts per capita as the dependent variable, while specifications (3) and (4) use public goods expenditure per capita as the dependent variable. Specifications (1) and (3) include only the measure of the male franchise and franchise squared, while specifications (2) and (4) include the control variables discussed above. To aid interpretation, the franchise variable is measured in terms of a 10% increase, while the dependent variable is standardized. As such, the coefficient on the franchise variable represents the effect of a 10% change in the proportion of men enfranchised as a proportion of a standard deviation of the dependent variable.

The inverted-U-relationship is strongly supported in all specifications, with both the individual coefficients and joint tests strongly statistically significant. The addition of the control variables does, however, reduce the size of the franchise coefficients in the regression of public goods expenditure per capita by around one-sixth. We discuss the magnitudes of these effects further below.

Table 3.1: Fixed effects regressions show inverted-U-hypothesis, with and without control variables.

	Tax receipts p.c.		Public goods spend p.c.	
	(1)	(2)	(3)	(4)
Male franchise	0.44***	0.40***	0.58***	0.47***
	(0.12)	(0.12)	(0.16)	(0.15)
Male franchise sq	-0.05***	-0.05***	-0.05***	-0.04***
	(0.01)	(0.01)	(0.02)	(0.01)
No. obs	4850	4850	4850	4850
No. towns	150	150	150	150
Year Fixed Effects	Y	Y	Y	Y
Town Fixed Effects	Y	Y	Y	Y
Popn. controls	N	Y	N	Y
Franchise turning point (%)	45	44	54	53
F-test (p-val)	0.00	0.00	0.00	0.01
U-test (p-val)	0.00	0.00	0.00	0.00

Dependent variables are standardized. Franchise coefficients represent the effect of a 10% increase in the franchise. Population controls include town population (in six bins), urban crowding, decadal population growth, and female franchise. Standard errors are adjusted by clustering by town, and are displayed in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

3.5.3 Additional tests for exogeneity of franchise and robustness

The previous subsection shows clear and consistent evidence of an inverted-U-relationship between the level of the franchise and the size of government. By controlling for key town characteristics, as well as time-invariant town features, we have been able to account for many potential confounding factors. However, some readers may still be concerned that our franchise measure is capturing the effects of other, unobserved, variables that are also correlated with the size of government, and that lead to the inverted-U-shaped relationship.

As discussed in Section 4.3, the analysis in Table 3.7 in the appendix provides evidence that our control variables are sufficient to capture these effects—particularly when combined with the inclusion of town fixed effects. Further, the most likely relationship between these variables biases against our hypothesis. In particular, we might expect that high population growth and high urban crowding would be associated with both a *low* franchise (as explained above) and a *high* level of expenditure on public goods—contradicting our findings. This is because both variables are likely to reflect rapid urbanization and so, if anything, would be associated with a higher demand for sanitation infrastructure and other public goods.

I address any lingering concerns in three ways. First, I seek to control directly for additional potential confounding effects by controlling for town tax base per capita, and by allowing for differing polynomial time trends according to 1871 town characteristics. Second, I restrict the analysis to focus on the period close to the 1869 reforms to the franchise. As explained in Section 4.3, these reforms comprised the single largest change to the franchise across the period of study. Focusing the analysis on the years immediately before and after these reforms therefore provides confidence that we are directly capturing the effects of the changing franchise, rather than other variables.

Third, I undertake two placebo tests by re-estimating the quadratic specification using two dependent variables that we would not expect to be affected by the franchise: per capita revenue from rents and property sales, and per capita expenditure on “lunatics”. I then check that there is, in fact, no evidence of the inverted-U-relationship in this case. This confirms that the finding of the inverted-U-relationship is not a spurious relationship created, in some way, by the structure of the dataset.

Fourth, I carry out a further set of robustness checks, varying the specification used and removing differing groups of towns from the sample. This ensures that the results are not dependent on a particular empirical framework or towns with specific characteristics. The results show consistently strong evidence of the inverted-U-relationship.

Controls for tax base and complex time trends

As a further test that we are capturing a causal relationship, I include additional control variables to capture potential sources of spurious correlation with the franchise. First, I include as a control variable a measure of the size of the tax base per capita in each town. This measure represents the aggregate "rateable" value of property in the district—including both houses and other forms of property. Including this variable acts as a proxy for town wealth, and in particular checks that the inverted-U-relationship is not driven by a relationship between the size of the tax base and decisions over who to tax: for instance if wealthier towns were more able to avoiding taxing the poor in order to deny them the right to vote. Data regarding the level of the tax base per capita is available (almost) annually from 1872 onwards, and also for 1866 and 1870: values for missing years are interpolated linearly. I use a three year moving average to provide a smoother measure of the tax base available to town councils.[17]

Second, I include interactions between the 1871 levels of the three major correlates with the franchise discussed above (population, urban crowding, and population growth) and a fourth-order polynomial in time. By doing so, we allow for differences in the time path of the dependent variables according to these observable characteristics. This accounts for factors that might affect public health expenditure and be correlated with the franchise indirectly through these characteristics: for instance if public health movements began in more highly crowded cities in the early 1870s. (See Gentzkow (2006) for a previous application of this approach.)

[17] Further discussion of the construction of this variable are provided in the appendix. Given these measurement difficulties, I have also experimented with binning the tax base variable into several quantiles, but this did not substantially change the results.

Table 3.2 presents the results of these regressions; specifications (1) and (5) include the controls for tax base per capita, while the remaining specifications include the interactions between the observable characteristics and the fourth-order polynomial in time. There is clear evidence of the inverted-U-relationship in all eight specifications, with both the linear and quadratic terms statistically significant in all cases. The joint tests of significance are also statistically significant in all cases. Further, the estimated turning points remain similar to those reported in the main regressions. As such these results provide further reassurance that we are capturing idiosyncratic variation in the franchise.

Table 3.2: Inverted-U-shape relationship is robust to inclusion of controls for wealth and interactions between control variables and time-polynomial.

	Tax receipts p.c.				Public goods spend p.c.			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Male franchise	0.28**	0.25**	0.24*	0.27**	0.38***	0.30**	0.46***	0.39**
	(0.12)	(0.11)	(0.13)	(0.13)	(0.14)	(0.14)	(0.15)	(0.16)
Male franchise sq	-0.04***	-0.03***	-0.03**	-0.03**	-0.04***	-0.03**	-0.04***	-0.04**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
No. obs	4695	4850	4850	4850	4695	4850	4850	4850
No. towns	150	150	150	150	150	150	150	150
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Town FE	Y	Y	Y	Y	Y	Y	Y	Y
Popn. controls	Y	Y	Y	Y	Y	Y	Y	Y
Tax base p.c.	Y	N	N	N	Y	N	N	N
Popn-time interaction	N	Y	N	N	N	Y	N	N
Crowd-time interaction	N	N	Y	N	N	N	Y	N
Growth-time interaction	N	N	N	Y	N	N	N	Y
Fran. turn point (%)	39	41	39	41	51	55	54	53
F-test (p-val)	0.00	0.01	0.01	0.02	0.03	0.10	0.01	0.04
U-test (p-val)	0.04	0.04	0.08	0.05	0.01	0.05	0.00	0.02

Dependent variables are standardized. Franchise coefficients represent the effect of a 10% increase in the franchise. Population controls include town population (in six bins), urban crowding, decadal population growth, and female franchise. Time interactions reflect the interaction between the value of the relevant observable characteristic in 1871 (population, urban crowding and population growth, respectively) and a fourth-order time polynomial. Note that the 1871 levels of these variables are captured by the town fixed effects. Tax base per capita measures a three year moving average in the level of the rateable value per capita in each town. The number of observations is reduced in these regressions due to missing data in earlier years. Standard errors are adjusted by clustering by town, and are displayed in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Reforms of 1869

As detailed in Section 4.3 the reforms of 1869 acted as a considerable shock to the franchise, leading to rapid growth in the franchise within a five-year period, and continued growth over a ten year period as towns slowly adjusted to the new regulations. The simplest way to use this exogenously-imposed variation is to test that the inverted-U-relationship holds over the years immediately preceding and following these reforms. Over this shorter period there are less likely to be major changes in other variables, providing reassurance that we are capturing the effects of changes in the franchise. In particular, I repeat the quadratic tests above, but limit the analysis to three periods. Specifically, I include the year immediately before the reforms (1868), one year following the initial shock to the franchise and using the 1873 franchise data (1876), and one year using the franchise data a decade after the reforms—i.e., once the level of the franchise had stabilized across different towns (1882). The results, displayed in Appendix 3.E, again provide clear evidence of the inverted-U-relationship with all individual coefficients statistically significant at a 5% level.

Placebo tests

I undertake two placebo tests to ensure that that the results are not a spurious artifact of the dataset. In particular, I re-estimate the quadratic specification using two dependent variables that we would not expect to be related to the franchise: per capita receipts from "rents and property sales", and the per capita expenditure on the maintenance of "lunatics" and asylums. We would not expect rent receipts to be directly connected to the franchise, since they are likely based on exogenous holdings of land. Similarly, responsibilities for lunatic payments were defined by external legislation, and depended on the number of paupers in a town—which was determined by the (separately elected) Poor Law Unions.[18]

[18] Unfortunately, these variables are only available from 1872 onwards. Other results, available from the author upon request, show that the results in Table 3.1 also hold for this smaller period.

Table 3.3 presents the results of these tests. As expected, none of the individual or joint tests are statistically significant and in specifications (1) and (2) the coefficients have the incorrect sign.

Table 3.3: Placebo tests show no relationship with the franchise.

	Receipts from rents p.c.		Expenditure p.c. on lunatics	
	(1)	(2)	(3)	(4)
Male franchise	-0.02	-0.07	0.25	0.27
	(0.17)	(0.22)	(0.19)	(0.20)
Male franchise sq	0.00	0.01	-0.02	-0.02
	(0.02)	(0.02)	(0.02)	(0.02)
No. obs	4216	4216	4215	4215
No. towns	150	150	150	150
Year Fixed Effects	Y	Y	Y	Y
Town Fixed Effects	Y	Y	Y	Y
Popn. controls	N	Y	N	Y
Franchise turning point (%)	38	46	70	67
F-test (p-val)	0.98	0.94	0.38	0.38

Dependent variables are standardized. Franchise coefficients represent the effect of a 10% increase in the franchise. Population controls include town population (in six bins), urban crowding, decadal population growth, and female franchise. Standard errors are adjusted by clustering by town, and are displayed in parentheses. Change in franchise represents the effect of a 10% increase. Standard errors are adjusted by clustering by town, and are displayed in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

3.5.4 Additional robustness checks

I have also undertaken a number of additional robustness checks on the results. First, I have tested alternative polynomial specifications, including a linear specification and polynomial specifications including franchise terms up to order six. In no case are any of the higher-order terms statistically significant at the 10% level. There is narrow statistical significance in the linear specification for the tax regression, but this is much weaker than in the quadratic specification, and the quadratic specification is preferred under both the Akaike and Bayesian Information Criteria. In addition, I have varied the groups of towns included in the specification, including i) focusing on a balanced panel of towns, ii) including towns that received sanitary authority after 1872 and iii) including towns excluded as outliers due to very high or very low values of the franchise. Second, I vary the definition of the franchise variable—including using different lag lengths, and alternative measures of population. As an additional check that our results are not capturing other characteristics of towns, I also tested the robustness of the results when removing towns with "extreme" 1871 characteristics, defined as being in the top bottom 10% or top 90% of the distribution of three variables: population, urban crowding and population growth. In addition, I tested the robustness to limiting the sample to towns incorporated in 1835. The results are supported in all regressions, with strong statistical significance in the expenditure regressions in particular.

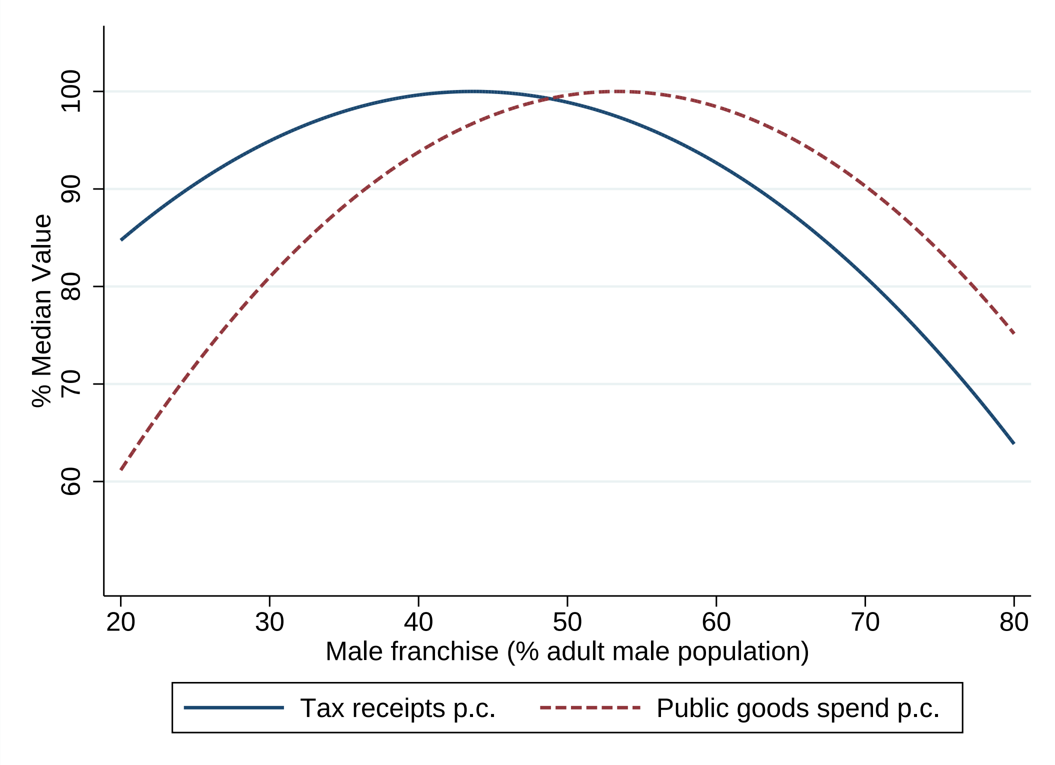
3.5.5 Magnitude of the effects

The previous results have shown consistent evidence of the inverted-U-relationship until 1900—both for public goods expenditure per capita and for tax receipts per capita. In this section I show that these effects were large.

Figure 3.5 plots the estimated effect of extending the franchise using the results from Table 3.1 above. To provide a sense of scale, the effect is measured as a percentage of the median of the dependent variable across all towns between 1867 and 1900. An extension of the franchise from 30% to 40%, for example, is estimated to have led to an increase in taxation per capita of around 5% of the median level of taxation across the period. The changes in the franchise had an even bigger impact on public goods expenditure. An increase of the franchise from the maximum (at 53%) to 75% led to an estimated decline of over 15% of the median expenditure per capita.

While these effects were sizable, they may have changed over time as new public goods became available. In particular, the model predicts that, as aggregate town income increases expenditure on public goods will increase. Over time therefore, we would expect the overall

Figure 3.5: Franchise extensions had sizable effect on the level of taxation and expenditure per capita, measured as a percentage of the median between 1867 and 1900.



Estimates based on results of specifications (2) and (4) in Table 3.1.

level of expenditure to increase and, possibly, that the relationship with the franchise will weaken. To explore this, I analyze the changing relationship between the franchise with both "all public goods" (our main dependent variable) and "sanitary public goods"—water supply, sewers, street cleaning and refuse collection. This also lets us assess the extent to which the inverted-U-shape hypothesis applies to public goods in general, or whether it was limited to specific public goods. This is particularly important, since it provides some indication of whether opposition to greater expenditure might have been driven by, for example, a lack of understanding of the health benefits associated with sanitary public goods.

Figure 3.6 explores this possibility via a rolling regression in which I extend the sample by one year at a time. That is, the first regression covers the period 1872–1886, the second 1872–

1887, etc. I then plot the estimated coefficient for the quadratic term on the franchise for "all public goods" and "sanitary public goods" separately over time (that is, the y-axis measures the β_2 term in main specification). This provides an indication of the changing size of the relationship between the franchise and expenditure across the period. For comparability, both dependent variables are standardized in terms of standard deviations of the *all public goods* variable.

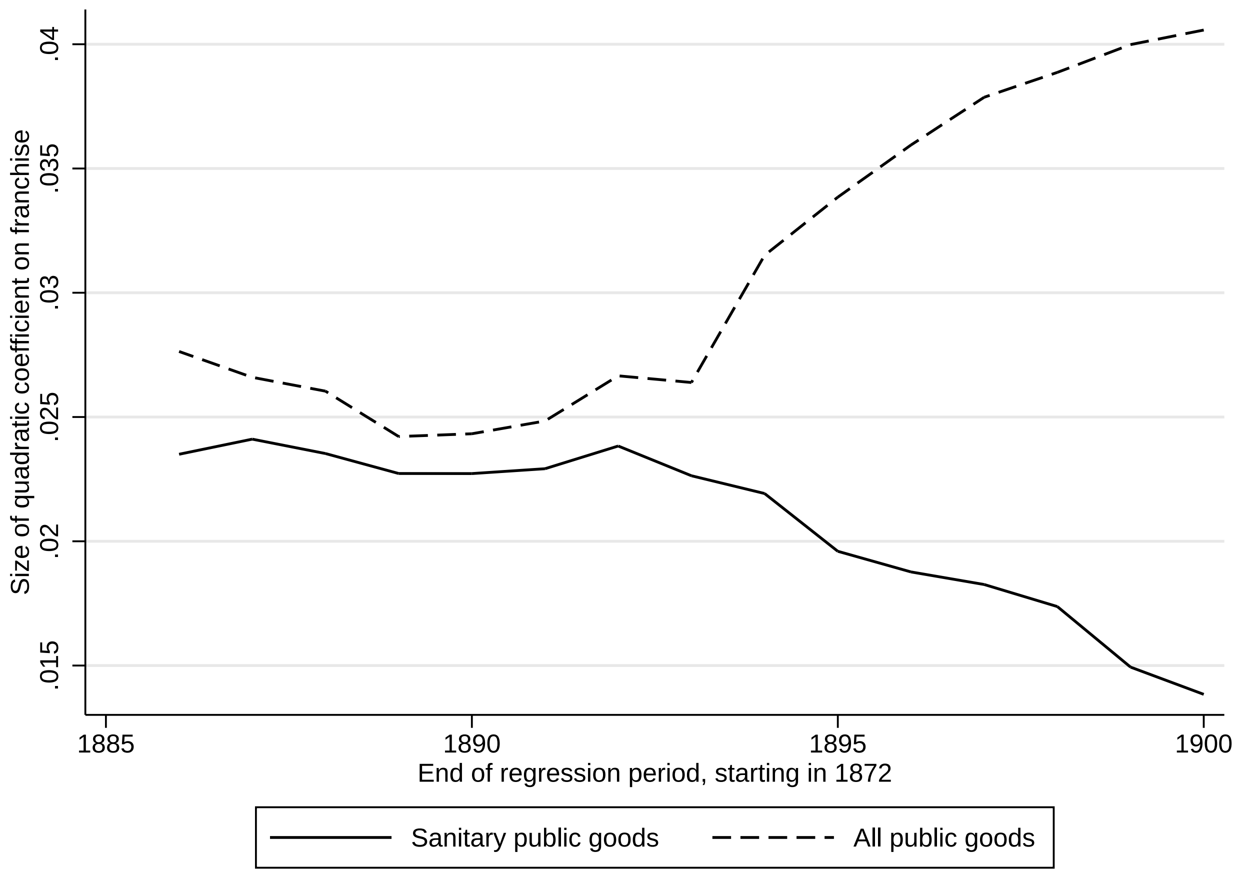
The figure shows that at the beginning of the period, the effect size is similar across the two categories: the effect of the franchise was focused on the important sanitary public goods. Over time, however, the size of the effect of the franchise on expenditure sanitary public goods decreased, supporting the hypothesis that growing wealth gradually overcame taxpayer opposition to greater expenditure on these public goods. However, the relationship between the franchise and all public goods expenditure actually grew, reflecting the greater levels of expenditure that occurred towards the end of the period as new public goods, such as tramways and electric lighting, became available. Again, expenditure on these public goods was highest in towns with intermediate levels of the franchise.

3.6 Discussion

These results show that the relationship between the franchise and public goods expenditure was inverted-U-shaped: expenditure was highest at intermediate levels of the franchise. This finding is robust to the inclusion of a number of control variables, town-level fixed effects, and exclusions of specific groups of towns. The relationship is supported when focusing on the 1869 national reforms as an exogenous shock to the franchise. Further, placebo tests show that the relationship does not apply to variables not under the control of the town council, indicating the relationship is not an artifact of the dataset.

I have proposed a simple model that explains this relationship through differences in

Figure 3.6: The effect of the franchise on sanitary public goods changed over time; however the effect on new infrastructure, such as tramways, remained large.



Y-axis represents absolute value of the coefficient on quadratic franchise term from rolling regression of dependent variable on franchise, franchise squared and control variables. See Table 3.1 for further details of specification. Dependent variables are standardized in terms of standard deviations of "All public goods". First regression covers the period 1872-1886, the second 1872-1887 etc. To ensure comparability across sample periods, I exclude top 1% of values for each dependent variable in each year from each regression.

demand for public goods at different levels of wealth. Essentially the poor cannot "afford" public goods (they have a higher marginal utility from consumption), whereas the rich must pay a higher price (since their absolute tax burden is higher). This fits with historical evidence that shows that middle class reformers often struggled to win the support of the poor in pushing for sanitary investment.

Despite the opposition to public expenditure, it is clear that investment in sanitation grew over time. This could be a result of growing demand for sanitation as population grew, placing greater and greater pressure on existing systems. Alternatively, it could be a reflection of diffusion of knowledge, as the benefits of sanitation became more widely known over time. Third, greater investment could be a result of growing wealth, leading to higher marginal rates of taxation and hence investment across the board. This explanation is supported by the fact that the inverted-U-relationship applied not only to sanitation infrastructure, but also public goods such as tramways and electric lighting. This suggests that opposition to sanitation investment was not driven purely by a lack of understanding of the health benefits, but reflected more general factors.

These results have important implications for ongoing debates regarding the benefits of decentralization of expenditure powers to local government bodies. We frequently assume that poorer citizens will be willing to vote for public goods expenditure. However, this may only be true if they are able to pass the cost onto the rich. In the setting examined here, this was not possible due to a reliance on property taxation; today many local governments face similar constraints on their ability to raise taxation. In other settings, many of the tax costs associated with environmental change such as gas taxes or airplane charges are also regressive. Identifying these constraints is critical to understanding why change does—or often does not—occur.

Finally, the evidence presented here suggests a return to Lizzeri and Persico's (2004) question: if it would lead to a decrease in public goods expenditure, why would the elites extend the franchise? One possibility is that extensions occurred in a period when the wealthy could still control how the poor voted either by manipulating the registration list or through directing them how to vote. After the reforms of 1869 and the secret ballot of 1872, however, that became much more difficult. Alternatively, it may be that the changes in the municipal franchise were a reflection of national changes following the Second Reform Act of 1867. The growth of party politics during this period created new requirements for party agents to find and register supporters, and this may have spilled down to the level of municipal elections. Both of these are questions for future research.

3.A Data

The majority of the data used in the paper are drawn from reports to Parliament downloaded from the House of Commons Parliamentary Papers Database[19]. A full list of the reports used is available upon request. Other sources are discussed below.

3.A.1 Financial data

Information is collected from the annual financial accounts reported to Parliament and collated in the *Local Taxation Returns* contained in the Parliamentary Papers collection.[20] These accounts contain detail on the sources of revenue and types of expenditure in each town annually. Each town reported separately as both a municipal borough and as a sanitary authority (as a local board, improvement commission or urban sanitary authority): these accounts are aggregated together. This information is used to construct an annual panel dataset between 1867 and 1910.[21] Financial values are then translated into current prices using the Rousseaux Price Index (Mitchell, 1971, pp. 723–4) following Millward and Sheard (1995).

Defining ongoing public goods expenditure

Prior to 1884 the financial data does not distinguish between one-off and ongoing expenditure items: as such the accounts include a number of very high expenditures, reflecting investment activities. To separate ongoing expenditure from investment expenditure for different types of public good, I first identify "investment periods" by analyzing deviations in trend expenditure in each of the following categories "sewerage and sewer systems", "water supply", "highways, watering and scavenging", and "other public works". The first three of these categories are defined separately in the financial reports. The "other public

[19] See http://parlipapers.chadwyck.co.uk/

[20] A full list of the parliamentary papers used is available from the author upon request.

[21] Comprehensive data is not available prior to 1867.

works" series is the aggregate of (loan and nonloan) expenditure on "other public works", "markets", "lighting", "lighting and sewers", "electric lighting", "tramways" "municipal buildings", "bridges", "housing", "asylums", "libraries", "burial", "baths", "hospitals", and "other". In non-investment periods, the level of ongoing expenditure is simply the per capita expenditure in that period. In investment periods, the level of ongoing expenditure is the level of expenditure in the next non-investment period. For instance, if 1873 and 1874 were investment periods, but 1875 was not, then the level of expenditure in 1873 and 1874 is set equal to that in 1875.

For the period following 1871, a year is identified as the beginning of an investment period for each good if:

1. Expenditure per capita exceeds the median percentile of expenditure per capita (across all towns and years) in the relevant category; and:

    - the town started expenditure on the relevant good in that period (the spending in the previous period was 0); or
    - there is a 100% year-on-year growth in expenditure on the good, and the expenditure p.c. exceeds the median future per capita spending for the town; or
    - the two previous years of data are missing, and the expenditure p.c. exceeds the median future per capita spending for the town; or
    - the level of expenditure p.c. is higher than the previous year and twice the median future per capita spending for the town.

The years following the start of an investment period are identified as investment periods if either:

1. expenditure p.c. is greater than the previous period; or

2. the expenditure p.c. exceeds the median future per capita spending for the town; and either:

   - the expenditure is twice the town's average expenditure over the period; or
   - the level of expenditure exceeds the median percentile of expenditure per capita (across all towns and years) in the relevant category.

Between 1867 and 1871, public goods expenditure is not disaggregated in the financial reports, and so we cannot use the process above. Instead, investment periods are identified as being twice the level of ongoing expenditure in 1872, and the above process is then applied to total public goods expenditure in those towns.[22]

Definition of dependent variables used in regressions

Tax receipts: Aggregation of all different "rates" collected by towns as municipality and sanitary authority.

Sanitary public goods expenditure: Sum of ongoing expenditure per capita on "sewerage and sewer systems", "water supply", "highways, watering and scavenging". See previous subsection for details of construction of series.

All public goods expenditure: After 1872, sum of "sanitary public goods expenditure" and ongoing expenditure on "other public works" series (see previous subsection for details). Prior to 1872, total of expenditure on "public works" and on sewerage and lighting.

Tax base per capita

Information on the value of the tax base (the "rateable value" of the district) is reported annually in the *Local Taxation Returns* from 1872 onward, with the exception of 1883. For many years, the tax base is reported separately for the town as a sanitary district, and as a municipal borough. Before 1872 information regarding the annual value of the tax base was not reported alongside the financial accounts. However, there is some data available

[22]For a small number of towns the first period that disaggregated data was available is later than than 1872: in this case investment periods are defined relative to the first period data is available.

regarding the size of the tax base in 1867 and 1870—however, this relates only to the sanitary districts and not the municipal boroughs. We use this information to construct an annual time series by i) using the *maximum* reported tax base by a town in each year and ii) linearly interpolating values for missing years.

The need to interpolate missing values leads to one potential source of measurement error in these estimates. A further concern is that before 1872 we may underestimate the tax base, because we do not have information on the tax base reported as a municipal borough. While towns generally reported similar values under both categories, there were sometimes significant differences, reflecting factors such as local exemptions and discounting for tax purposes. Further, this is particularly concerning since this effect could differ across towns, and is focused on the period before the 1869 reforms—an important period for the analysis. Given these concerns, we measure the tax base per capita as a rolling three year average (for non-interpolated years) to smooth the effect of potential year to year changes. I have also checked that the results are robust to binning the tax base per capita variable.

3.A.2 Electoral data

Information as to the number of electors was collected from returns to Parliament supplemented by information for 1879 reported in Vine (1879). Information for the total number of electors in each town was collected for years 1850, 1852, 1854, 1852–1866, 1869, 1871, 1873, 1879, 1883, 1885 and 1897. Information broken down by gender was collected for 1871, 1885, and 1897. Values relating to the number of electors in Shaftesbury (for all years), Carlisle (1854) and Buckingham (1866, 1869, and 1873) were excluded, since there were clear discrepancies in the returns (for instance, where the number of parliamentary electors was reported rather than the number of municipal electors).

The time series for total number of electors was estimated as follows. First, the franchise is calculated as a percentage of the total population, using the series relating to the number of electors above. The missing years are then interpolated using a constant compound growth rate—with the exception of the years 1867 and 1868 which are replaced with the 1866 value, since reforms in 1869 led to a large jump in the level of the franchise. Missing values for 1864 and 1865 are replaced with the value from 1866.

To estimate the male / female franchise used in the main specifications, I first estimate the proportion of male electors in 1871, 1885, and 1897. This series is then interpolated at a constant growth rate for the intervening years. (In general this proportion did not tend to change substantially between periods). Multiplying these two series provides an estimate of the number of male and female electors in each year. The franchise measure is then estimated using the estimated adult male population discussed in the following two subsections.

As discussed in Section 4.3, the key franchise variable used in the paper is calculated using an adjustment factor relating to proportion of males and females that were of voting age (21 and 30 respectively). The main measure uses individual-level census data obtained from the North Atlantic Population Project (Minnesota Population Center, 2008; Schürer and Woollard, 2003). The individual-level data is aggregated to identify the age distribution of voters at the level of administrative sub-districts.[23] Each town was then matched to the relevant sub-districts using the 1881 census: often each municipal borough was spread across several of these sub-districts (the boundaries did not, unfortunately, overlap directly). To estimate the town-level age distribution I then average across the different sub-districts, weighted by the proportion of 1881 population in each of the sub-districts (which is also identified in the 1881 census).

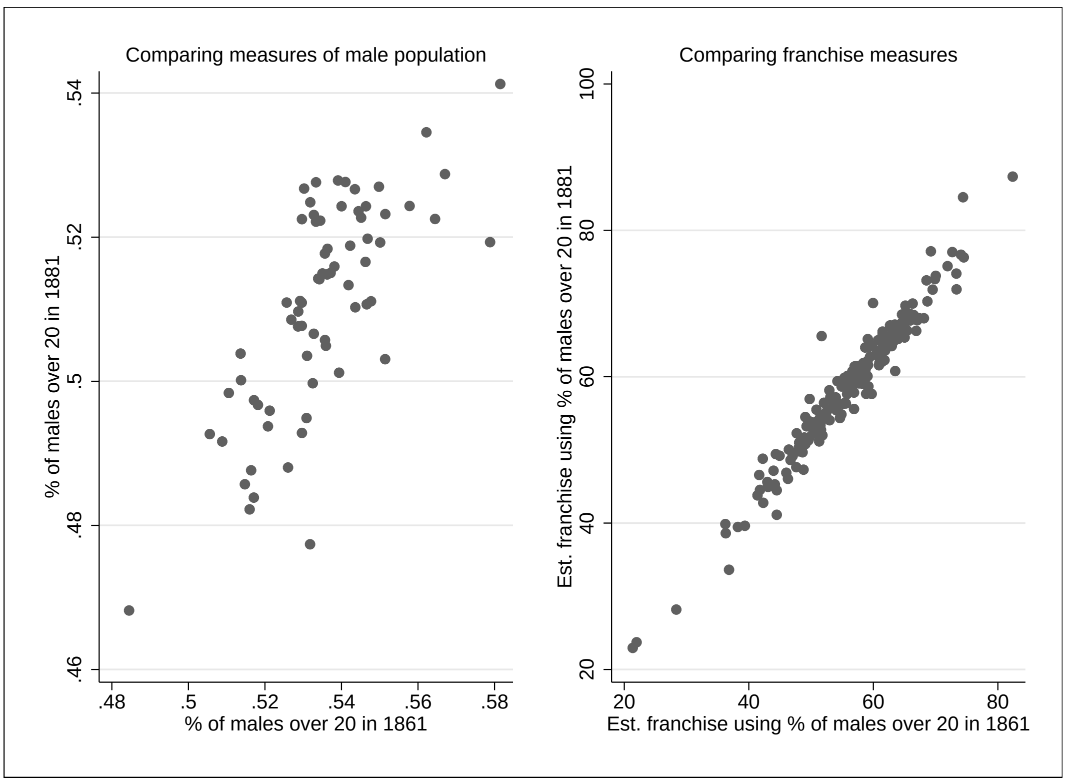
While this measure should accurately account for variation in the age distribution across towns, one potential concern is the use of a constant adjustment factor for every year. To check whether this is an issue, I compare the estimated proportion to data from the period 1861–1870 collected from the decennial reports of the Registrar General. Unfortunately, this

[23]More precisely, these are the registration sub-districts used by the Registrar General.

data is only available at the level of the registration district rather than sub-district, and so can be matched to towns less precisely.[24]

The left hand panel of Figure 3.7 compares the estimated percentage of the male population over 20 using the two measures in large (over 20,000 population) towns—which correspond most closely to registration districts and hence are more comparable over time. The right hand panel compares the estimated franchise in 1881 using the two measures. The resulting comparison shows a very high degree of correlation over time in the town age distribution, providing confidence that our use of a constant adjustment factor is appropriate. Further, the results are robust to these different measures of the franchise.

Figure 3.7: High correlation in franchise variable using different age distribution measures



Source: See text.

[24]Smaller boroughs were often only a small part of a registration district. As such this measure combines urban and rural areas.

3.A.3 Census data

Characteristics of urban areas, including population and number of houses, were gathered from a series of census reports between 1861 and 1901, and the parish-level population statistics for the 1911 census gathered by Southall (2004). Between censuses the population is interpolated at a constant annual growth rate. In several cases, however, towns underwent boundary changes between census years. To adjust for this, I have identified the towns that underwent boundary changes using the census and the year of the boundary changes using both the census reports themselves and the annual reports of the Local Government Board. The population series is adjusted to the revised population (provided in the census reports) at this date.

3.B Key legislation affecting the municipal franchise

1835 Municipal Corporation Act: Established the structure of municipal councils in 178 towns with historic charters, with unincorporated towns allowed to petition for incorporation at a later date. Under the terms of this Act, councils were chosen under a system of annual elections (with one third of councilors replaced each year) by an electorate consisting of all male householders subject to residence and tax-paying requirements. Prior to 1835 female householders were able to vote in some towns, but were disenfranchised by the Act. In order to vote citizens had to have resided in the relevant municipal borough for three years and paid local property taxes (the “rates”) for 2.5 years prior to the election. This included a stipulation that individuals were ineligible to vote if they had received poor relief in the twelve months prior to an election. Precisely, they had to have occupied a property (e.g., a house or shop) in the town and lived within seven miles of the borough.

1850 Small Tenements Rating Act: This Act gave local authorities the ability to collect taxes directly from landlords for poorer tenants, on the condition that the tenants were granted the municipal franchise. This practice was known as "compounding", with the tenants whose taxes were collected in this way known as "compounders". In particular, the Act applied to those in tenements of annual rateable value of 6 pounds or under. This decision was not taken by the municipal council, but by the local vestry, who held responsibility for tax collection.[25]

1869 Assessed Rates Act: This Act enshrined the right of compounders to vote.

1869 Municipal Franchise Act: This Act reduced the period of residency from three years to one—and the length of tax-paying required from two and half years to six months. The Act also enfranchised female householders aged 30 or older.

3.C Proofs

Proof of Proposition 1

Proof. Individuals consume whatever remains after taxation $c_i = y_i(1-\tau)$. Denote average income as $\bar{y} = \frac{Y}{N}$. Then the individual's problem is

$$\max_{\tau_i} U = u(y_i(1-\tau_i)) + v(\tau_i \bar{y})$$

First note that this problem has a unique maximum since $U(c_i, g)$ is strictly concave. In addition, the assumption that both $u(\cdot)$ and $v(\cdot)$ functions satisfy the Inada conditions ensures an interior solution as long as $u(y_i) > 0$ (i.e., utility is positive when all income is spent on consumption).

[25] Vestries were the governing body of parishes which, after 1834, did not hold responsibility for deciding the level of taxation or spending. There were generally several parishes within each town (although boundaries did not coincide).

Taking the first-order conditions, the optimal τ^* is implicitly defined by the equation:

$$y_i u'(c_i^*) = \bar{y} v'(\tau_i^* \bar{y}) \tag{3.1}$$

where $c_i^* = y_i(1 - \tau_i^*)$.

As y_i increases, it must be the case that c_i^* increases. To see this, consider otherwise. Since consumption is lower, the value of the left hand side would increase relative to the right hand side. Further for consumption to fall, the tax rate must be higher. But then the right hand side of the equation will decrease, meaning there is no equilibrium.

Now, note that the left hand side of (3.1) is the marginal cost of raising taxation. Then the derivative of the marginal cost with respect to y_i at τ_i is given by:

$$u'(c_i^*) + y_i(1 - \tau_i^*) u''(c_i^*) \tag{3.2}$$

When this expression is negative, the marginal cost of taxation is decreasing as y_i increases: thus the optimal tax rate is increasing in y_i. In contrast, if the expression is positive, then the optimal tax rate will be decreasing in y_i. For simplicity I denote $r_R(c_i^*, u)$ as r_R.

The optimal tax rate is increasing in income if:

$$u'(c_i^*) + y_i(1-\tau_i^*)u''(c_i^*) \leq 0$$

$$-\frac{u'(c_i^*)}{y_i u''(c_i^*)} \leq (1-\tau_i^*)$$

$$1 + \frac{u'(c_i^*)}{y_i u''(c_i^*)} \geq \tau_i^*$$

$$1 - \frac{1}{\frac{y_i}{c_i} r_R} \geq \tau_i^*$$

$$1 - \frac{(1-\tau_i^*)y_i}{y_i}\frac{1}{r_R} \geq \tau_i^*$$

$$1 - \frac{(1-\tau_i^*)}{r_R} \geq \tau_i^*$$

$$r_R - 1 \geq (r_R - 1)\tau_i^*$$

If $r_R - 1 > 0$, this gives $1 \geq \tau_i^*$. If, on the other hand, $r_R - 1 < 0$ this gives $1 \leq \tau_i^*$. Implicitly define $\tilde{y}$ by $r_R(y_i(1-\tau_i^*)) = 1$. Then by assumption 2 $\exists y_i < \tilde{y}$. We know that $\tau_i^* < 1$ since $u(\cdot), v(\cdot)$ satisfy the Inada conditions, thus the inequality holds strictly. Further, since r_R is monotonically decreasing, this holds for all $y_i < \tilde{y}$. Similarly, assumption 2 ensures $\exists y_i > \tilde{y}$. In this case the inequality can never hold: thus optimal tax rates are declining after this point. This completes the proof.

□

Proof of Proposition 2

Proof. First, note that preferences over τ are single peaked, since $U(\cdot)$ is strictly concave. Then for a given electorate we can apply the standard Median Voter Theorem. (Note that the median voter here is not necessarily equivalent to the voter with the median income). From Proposition 1, we know that τ_i^* reaches a unique maximum at $y_i = \tilde{y}$, and the optimal tax rate is decreasing in y_i for $y_i > \tilde{y}$.

Define τ^0 as the median tax rate under E_0, and τ_i^m as the median optimal tax rate when i is the poorest enfranchised citizen. Order the voters in order of income. That is voter $i+1$ is the next richest voter after voter i. For all citizens $\{i|y_i \geq \tilde{y},\ i \neq E_0\}$, $\tau_i^* > \tau_{i+1}^* \geq \tau^0$. Thus as each of these citizens are enfranchised τ^m (weakly) increases. Further, this increase is strict at some point since $|\{i|y_i < \tilde{y}, i \neq E_0\}| \geq 2$. By proposition 1, the optimal tax rate is increasing in y_i for $y_i < \tilde{y}$. Then all citizens $\{i|y_i < \tilde{y}\}$, $\tau_i^* > \tau_{i-1}^*$. As a result, if the median tax rate decreases as the franchise is increased, it will always decrease for further extensions.

Now suppose τ^m never decreases as the electorate increased. Then $\tau_i^m \geq \tilde{\tau}$ $\forall i$ with $y_i < \tilde{y}$. But this is not the case, since by assumption there are at least two citizens for which $\tau_i^* < \tilde{\tau}$. □

Proof of Proposition 3

Proof. Consider the situation where each voter's income is a constant share, α_i, of average income $\bar{y}$. Then the first-order conditions become:

$$-\alpha_i \bar{y} u'((1-\tau_i^*)\alpha_i \bar{y}) + \bar{y} v'(\tau_i^* \bar{y}) = 0 \tag{3.3}$$

First I show that spending per capita increases with $\bar{y}$. Note that we can divide through both sides by $\bar{y}$. Then suppose otherwise, which implies a reduction in τ_i^*. Since $u'', v'' < 0$, then this implies that both terms increase, which is a contradiction. Since this is true $\forall i$, then the median level of spending will also increase.

To identify the relationship with τ_i^*, we can use implicit differentiation of the first-order conditions. This identifies that:

$$\frac{\partial \tau_i^*}{\partial \bar{y}} \leq 0 \iff \tau_i \geq \frac{\alpha_i^2 u''((1-\tau_i^*)\alpha_i \bar{y})}{\alpha_i^2 u''((1-\tau_i^*)\alpha_i \bar{y}) + v''(\tau_i^* \bar{y})}$$

Note that this expression is less than 1 and positive (since both the numerator and denominator are negative). Thus in general, this relationship will depend on the level of income of the individual α_i, and the relative levels of (u'', v''). Thus the outcome on the optimal tax rate will vary dependent for each individual, and the implemented tax rate will depend on the identity of the median voter (which may also change with a change in $\bar{y}$). However, as $v''(\cdot)$ approaches $-\infty$, the expression will tend towards 0, and hence always hold.

□

3.D Poverty and expenditure amongst the urban populace 1860-1900

How poor were the poor during this period? Answering this question is complicated, since it relies on understanding not only average incomes—a challenging enough task—but also the income distribution. Further, the extent of living standards will depend also on the composition of households since many living costs, such as rent or fuel, are a fixed cost for the household. These are significant challenges, and I do not aim to address them fully in this article. However, we can use existing data to make some crude generalizations that provide some insight into the composition of the urban electorates that are the focus of this study. I undertake this task in two steps. First, I use Rowntree's well-known 1901 survey of York to identify the financial constraints faced by households at different levels of income—i.e., how much income was needed to escape poverty? This survey provides very basic estimates of the poverty line, which we then back-cast to estimate the proportion of the population living in different levels of poverty in earlier years.

This analysis provides very crude estimates of the proportion of the population in poverty, but it does not provides any detail as to what the poor spent their income or, how this changed as they became richer. This is important for our analysis since it is these trade-offs that the poor faced when voting for or against taxes. To address this issue I analyze budget data collected by the United States Commissioner of Labor to estimate income elasticities of demand for different categories of expenditure.

3.D.1 The extent of poverty

To identify the level of income associated with poverty, I use Rowntree (1901)'s detailed 1901 survey of York households. This survey estimates the income of all households in the city of

York in 1899.[26] Based on qualitative reports of investigators, Rowntree estimates that 28% of the entire population of the city were in living in poverty—defined as displaying existence of "obvious want or squalor"—at this time (p117). Approximately 10-13% of the population were estimated as living at a level of poverty below "the minimum expenditure necessary for the maintenance of physical efficiency", with the remainder explained as being poor due to "improvident expenditure" (particularly alcohol).[27]

Rowntree's analysis suggests that individuals earning below 18 shillings per week were living in "chronic want", and those living at an income between 18 and 21 shillings per week were living hand to mouth, with any extraordinary expenditure requiring cutting back on food. These calculations are based on detailed calculations based on household size, adjusting for the fact that poverty depends on both total income and the composition of the household—including both household size and the number of children in the household.[28]

Ideally we would use this detailed analysis of the composition of households when assessing the overall distribution of poverty over time. Unfortunately, Rowntree does not explain exactly how his level of "primary poverty" is distributed across household income groups. As such, I make the simple assumption that the 10% (28%) of population he classifies as being in primary (secondary) poverty relate to the lowest income households unadjusted for household size or composition.

Using this assumption, we can estimate the proportion of households in poverty by using Rowntree's income categories. In particular we use the following three categories:

- 20 shillings per week: corresponding approximately to the proportion in "primary

[26] This is one of the best known sources of information regarding the extent of poverty in the period. For further discussion of other sources see Gazeley and Newell (2007). There are some differences between the methods used to estimate poverty in these different sources, particularly over adjustments for household size. Given the crude estimates used here these differences are not likely to be very important.

[27] Gazeley and Newell (2000) re-analyze Rowntree's figures using a different adjustment for household size and argue that the correct figure is approximately 6%. However, this does not qualify the general conclusions relating to the number of households whose fluctuations in income led to changes in food consumption; or the total perception of the population living in poverty.

[28] See Gazeley and Newell (2000) for a detailed critique of Rowntree's methodology.

poverty";

- 25 shillings per week: Rowntree's identifies that moderate-sized families in this income category often lived in poverty; and

- 28 shillings per week: corresponding to the estimated income threshold beneath which households were in "secondary" poverty.

Specifically, the proportion of households within each category is calculated by adjusting the percentage of working class households into a percentage of population using a fixed ratio, and assuming that households were uniformly distributed within income categories. The former assumption implies that household size was fixed across groups. This is clearly inaccurate, but is difficult to adjust for accurately due to data constraints. However, using simple adjustments to take this into account led to similar results.

Having identified these thresholds, I "back-cast" the proportion of households beneath these thresholds in 1860 and 1880, using figures from MacKenzie (1921). MacKenzie provides estimates of the proportion average family income at the 10th, 25th, 50th, and 75th percentiles of the income distribution for the years 1860, 1880 and 1914; based on adjustments from figures of A.L. Bowley—a source often used by modern economic historians.[29] I adjust these figures into 1899 constant values using the wage series of Crafts and Mills (1994), and adjust for the proportion of agricultural laborers in the labor force (based on the original article). The resulting proportions are shown in the table below.

The first point of interest is that the figures from Rowntree correspond relatively closely to the figures from 1914.[30] This likely reflects the fact that first, there was relatively little real wage growth between 1899 and 1914 (the Crafts and Mills series estimates growth of

[29]Reflecting this fact, the average growth rates in the median income were close to the average growth rates in the Crafts and Mills (1994) wage series. This provides further reassurance that we are accurately capturing the growth in income.

[30]I have also estimated figures for 1899 directly by interpolating between 1880 and 1914, but the results were very similar to the 1914 figures, so for simplicity I use the MacKenzie figures.

Table 3.4: Estimated proportion of urban households in different income groups 1860-1900

% of households	1860	1880	1914	Rowntree (1901)
Income < 20s	39%	16%	5%	10%
Income < 25s	62%	40%	18%	19%
Income < 28s	76%	56%	27%	28%

Source: Income figures refer to weekly income, and are in real terms. Estimates based on author's calculations based on information from Rowntree (1901); MacKenzie (1921); Crafts and Mills (1994). See text for details of methodology.

around 3% over this period) and second that York was a relatively prosperous town (Gazeley and Newell, 2007). This comparability provides some confidence that MacKenzie's estimates are accurately capturing the income distribution of urban households.

The results suggest that a large proportion of households faced significant financial constraints during the period of study. In 1860—near the beginning of our period—almost 40% of urban households are estimated to have been living "hand to mouth". By 1880 the proportion of the population facing these constraints had fallen considerably; but between 40% and 56% of households nevertheless earned incomes that were associated with Rowntree's secondary poverty.

3.D.2 Spending of the poor

What did the poor spend their money on? Rowntree provides evidence that for the very poorest category rent was a major expense; accounting for almost 30% of income on average. This proportion fell dramatically as income increased however, accounting for 19% for those with income between 18 and 20 shillings per week, 17% for those between 20 and 25 shillings per week, and 16% for those earning between 25 and 30 shillings per week.[31] Further, he indicates that even the poorest paid rates (largely through their landlord), with the combined

[31] The corresponding figures for higher income households were: 31s-40s: 14%; 41-50s: 12%; 51-60s:12% and over 60s: 9%.

total of rents and rates accounting for approximately 20% of income.

Rowntree's evidence is less thorough, however, in estimating other types of expenditure—such as food—since he collected detailed budget data for just 18 households. Instead, we investigate the effect of changes in income on the composition of household expenditure using data from 1889 and 1890 surveys of the United States Commissioner of Labor (USCL).[32] These surveys provide detailed information on the income and expenditure of 1,024 British families headed by industrial workers. These families are not a representative sample since they were chosen on the basis of industry (including woolen and cotton textiles, pig iron, bar iron and steel making, coke and glass manufacture, and coal mining).[33] As a result, while the average incomes appear representative of their industries, the average earnings appear much higher than the population as a whole and are "not generally representative of the laboring poor" (Horrell and Oxley, 1999, p. 499). Nevertheless, we can use the budgets to estimate the changes in composition of income at least amongst this class of citizens. A further advantage of using the USCL data is that we can adjust for household size allowing us to assess the poorest citizens more accurately. In particular, we can identify the poverty line—the minimum level of income required to maintain physical efficiency—adjusted for the composition of the household, and then assess how close households are to that poverty line.

To identify the poverty line we use the estimated equivalence ratios calculated by Gazeley and Newell (2000). These estimates identify the minimum income needed for a childless couple, and then identify the multiple of that income needed to maintain a family with different numbers of children—up to families with 6 children. We exclude families with more than two adults or more than 6 children from the analysis, reducing the sample from 1,024 to 921 (all families had at least two adults).

The results for this analysis indicate that only 8 families in the sample fall beneath this

[32]The data were obtained from the IPCSR (Haines, 2006).

[33]For more discussion of the representativeness of the sample, see Horrell and Oxley (1999).

poverty line, reflecting the bias in sample discussed above. As such we cannot identify the budgets of the very poorest individuals. However, we can identify groups of workers relatively close to this poverty line. In particular, we use three definitions of poverty: those with an income of 1.25 times the poverty line, 1.5 times the poverty line, and 2 times the poverty line. The 1.5 times group relates most closely to Rowntree's definition, if we consider a household income of around 18-20 shillings as defining primary poverty and an income of around 25-30 shillings as defining secondary poverty.

We will shortly use the data to estimate income elasticities of demand for different expenditure categories. However, as a preliminary step Table 1 displays the raw share of income spent on different expenditure categories for these three groups. Note that the first group is relatively small (including only 50 households), meaning that we should be careful about the conclusions we draw. In addition, the table also displays the proportion of households spending more than their income. A significant proportion of households were spending more than their income—almost 20% in the most generous poverty definition.

Food expenditure is split into "basic" and "non-basic" categories. Basic foods include butter, bread, condiments, flour, lard, potatoes, rice, tea and other foods. Non-basic foods include meat, poultry, pork, fish, fruit, vegetables, cheese, eggs, coffee, sugar, molasses and milk. We can see that the share of food in expenditure falls across the three categories, but the share of these non-basic foods increases slightly. A further point of interest is that even households in the poorest group spent money on both amusements (including reading), liquor and tobacco. At first glance one might think that this discretionary expenditure means that the household is not that poor. However, both contemporary and current evidence suggests that this kind of expenditure is common even amongst the very poorest. Rowntree (1901) argues that much of the secondary poverty he identifies is due to expenditure on alcohol—and that this is was itself an "outcome of the adverse conditions under which many of the working classes live" (p144). A recent modern study shows that those earning less than $1 per day—the modern poverty line—frequently spend a significant proportion of their budget on alcohol, tobacco and festivals even at the expense of more calories (Banerjee and Duflo, 2007).

Table 3.5: Household budgets for different income groups

	Income ≤ 1.25x poverty line	Income ≤ 1.5x poverty line	Income ≤ 2x poverty line
Share of income			
Food-basics	30%	27%	25%
Food-non-basics	23%	24%	25%
Food-total	53%	51%	50%
Rent	15%	14%	13%
Clothing	14%	15%	15%
Lighting / fuel	9%	8%	7%
Amusements / vacations	1%	2%	3%
Liquor and tobacco	4%	4%	4%
Other	6%	6%	7%
Savings	-1%	0%	2%
Proportion borrowing	34%	26%	19%
N	50	163	447

Basic foods include butter, bread, condiments, flour, lard, potatoes, rice, tea and other foods. Non-basic foods include meat, poultry, pork, fish, fruit, vegetables, cheese, eggs, coffee, sugar, molasses and milk. Clothing is the aggregate of clothing for husband, wife and children. Amusements / vacations includes reading expenditure. Other includes contributions to labor, religious, charitable and other organizations, taxes (except property taxes), property insurance, life insurance, sickness insurance, furniture and other expenditure.
Source: Author's calculations using data from 1889 and 1890 surveys of the USCL.

To understand the effect of increasing income more formally, we undertake a simple regression analysis. Using regressions allows us to use the variation in income within the broad categories discussed above, and also adjust for differences in household composition. Adjusting for the make-up of the household is important since the food needs of a household will depend on the number (and age of children) in the household, as well as the occupation of household members. Those working in heavy industry, for instance, will have greater food requirements. Further, these variables will also be correlated with income per household member since how many individuals are working and the industry of employment will both affect the total income of the household.

We estimate the income elasticity of demand for this group on a number of expenditure items, using the following specification:

$$ln(e_i/N_i) = \beta_0 + \beta_1 ln(\text{income}_i/N_i) + \gamma X_i + \epsilon_i$$

where i indexes households and j indexes an expenditure category (e.g., food). The variable e_i thus identifies the spending of household i on category j. The variable *income* represents the total household income, and N_i is the total size of household i. Since both the independent and dependent variables are in logs, the coefficient β_1 in this specification represents the income elasticity of demand for the good j.

The vector X contains a number of characteristics of the composition of the household—the number of children split by age categories (0-4, 5-9, 10-15, and over 15), the number of working children, whether the wife works and eight dummy variables for industry of employment: pig iron, bar iron, steel, coal, coke, cottons, woolens, and glass.

In addition to calculating the income elasticities, we carry out a similar analysis to identify the effect of increased income on the probability of borrowing during the period. The probit specification we use is:

$$\text{borrow}_i = \beta_0 + \beta_1 ln(\text{income}_i/N_i) + \gamma X_i + \epsilon_i$$

Where $borrow_i$ is a binary variable taking the value 1 if a household spent more than their income, and zero otherwise.

The results of this analysis are displayed in Table 2. Each cell represents the estimate of β_1 from the regression specification above, along with the estimated standard error. The first eight rows refer to the income elasticity specifications, where the dependent variable is log expenditure on each of the expenditure categories.[34]

Table 3.6: Estimated income elasticities of demand by expenditure category for different income groups

	Income ≤ 1.25x poverty line	Income ≤ 1.5x poverty line	Income ≤ 2x poverty line
Income elasticity			
Food-basics	-0.27	0.39*	0.46***
	(0.54)	(0.20)	(0.08)
Food-non-basics	1.77***	1.31***	1.03***
	(0.42)	(0.17)	(0.07)
Food-total	0.87***	0.87***	0.76***
	(0.27)	(0.11)	(0.05)
Rent	1.99***	1.04***	0.58***
	(0.45)	(0.21)	(0.08)
Clothing	0.50	1.14***	0.87***
	(0.62)	(0.26)	(0.11)
Lighting / fuel	0.53	0.40*	0.08
	(0.97)	(0.22)	(0.09)
Leisure	0.91	1.70**	1.21***
	(2.32)	(0.64)	(0.29)
Other	2.18	1.88***	1.75***
	(1.33)	(0.52)	(0.22)
Change in probability of borrowing	1.73**	-0.19	-0.25***
	(0.92)	(0.30)	(0.11)
N	50	163	431

Robust standard errors in parentheses. Income elasticities based on regressions of log expenditure on log income per household member, with control variables of: number of children in age categories 0 to 4; 5 to 9; 10 to 15; and over 15, number of children working, whether wife working, and dummy variables for industries pig iron, bar iron, steel, coal, coke, cottons, woolens, and glass. "Change in probability of debt" represents the marginal effect of log income per household member on a binary variable identifying whether the household spent more than income, measured at the means of all control variables. Some regressions have fewer observations than the total in the group, due to zero expenditures on that category by some households.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The results indicate that in the poorest group additional expenditure led to large increases in the share of expenditure spent on higher quality food and on rent. Noticeably, the income elasticity of food as a whole is close to one—suggesting that these individuals may have been sufficiently poor that Engels' Law did not apply.

[34] There are fewer categories here than in the previous table. This is because we group some categories to overcome expenditures of zero on certain items.

Expanding the sample to include wealthier households (column 2) shows a similar pattern, with high income associated with a shift towards non-basic food items. However, rent now appears to increase proportionally with income, as does clothing. Both leisure and the other category are now classed as luxury goods—the latter category is driven in large part by furniture spending. Once households with income per family member of up to two times the poverty line, the income elasticity of both rent and non-basic food falls significantly. However, there is now evidence that an increase in income is associated with a decrease in the probability that individuals are relying on debt to fuel their expenditure.

In summary, this analysis suggests that at very low levels of income, individuals used added income to increase their spending on rent and to switch to higher quality foods, including meat, vegetables and fruit. As income increased further, individuals continued to increase the share of their spending on quality food, but were also able to purchase more leisure goods, such as liquor and tobacco. As income increased even further, the share of expenditure on both rent and good declined, with income instead being directed further towards these more discretionary goods, and also a reduction in borrowing.

3.E Additional regression results

Table 3.7 presents the results of regressions of the franchise against key dependent variables, in four cross sections: pre-reform (1866), immediately post-reform (1873), 12 years after the reforms (1885) and the end of the study period (1897). The top panel shows the relationship between the franchise and the three major time-varying observable characteristics: population, urban crowding, population growth, as well as a dummy variable indicating that the town was incorporated in 1835. In the bottom panel, the residuals from these regressions are regressed on other observable characteristics that could plausibly be correlated with the level of government expenditure on public goods. These include the level of population density in 1871, the value of the tax base per capita, and dummy variables identifying whether the town had a significant proportion of farmers (more than 10% of the population) or textile workers (more than 5% of the population) in 1881.[35] For the 1885 and 1897 cross sections, the measure of the tax base per capita reflects the three year moving average of the tax base per capita. For the 1866 and 1873 cross sections the measure relates to the three year average in 1875 (that is, including the 1874, 1875 and 1876 levels) since this is the first year that a relatively stable value of the tax base, and hence a better proxy for wealth, is available. None of the independent variables in the second panel are statistically significant, suggesting that the remaining variation in the franchise is idiosyncratic.

Table 3.8 presents the results of the panel regressions including one and two lags in the dependent variable. The signs of the franchise coefficients have the correct signs and are statistically significant in all four specifications. Table 3.9 shows that the inverted-U-relationship holds when the sample is restricted to the three periods 1868, 1876, and 1882—the period near the 1869 reforms to the franchise. Again the inverted-U-relationship

[35] Measures of the proportion of farmers or textile workers were constructed from the 100% sample of the 1881 census, discussed above.

is strongly supported in these regressions.

Table 3.7: Variation in the franchise is idiosyncratic after controlling for urban crowding, population growth and incorporation year.

	1866 (1)	**1873** (2)	**1885** (3)	**1897** (4)
DV=Franchise (% Adult male population)				
Population growth	-84.51	-4.62	23.34	-240.37***
	(68.13)	(65.42)	(86.46)	(85.99)
Urban crowding	-6.17***	-6.26***	-5.14***	-4.37***
	(0.93)	(0.79)	(0.93)	(1.21)
Popn 10k-25k	-3.68*	-2.53	-3.00*	-2.15
	(2.07)	(1.72)	(1.80)	(1.52)
Popn 25k-50k	1.01	1.75	-2.94	-2.91
	(2.69)	(1.93)	(1.81)	(1.82)
Popn 50k-100k	-9.40***	3.67	0.85	-3.07
	(3.16)	(2.38)	(2.13)	(2.23)
Popn 100k-250k	2.29	4.26	0.19	-2.31
	(4.79)	(2.88)	(2.53)	(2.02)
Popn >250k	-19.14***	3.99	-3.98	-5.88**
	(2.80)	(2.89)	(3.15)	(2.93)
Incorporated 1835	-3.28	-3.90**	-1.43	-1.53
	(2.13)	(1.58)	(1.72)	(1.38)
No. obs	144	145	145	148
Adj. R-sq	0.37	0.38	0.25	0.36
F-stat	18.34	12.64	7.38	7.37
F-test (p-val)	0.00	0.00	0.00	0.00
DV=Residuals from franchise regression				
farmingTownDummy	0.42	0.42	0.77	-0.10
	(1.94)	(1.68)	(1.73)	(1.44)
> 5% textiles	-0.57	0.71	-1.27	0.79
	(2.30)	(1.43)	(1.40)	(1.35)
1871 popn density	-0.01	0.01	0.00	-0.03
	(0.05)	(0.04)	(0.04)	(0.03)
Tax base per capita	0.78	-1.10	-1.02	-0.52
	(1.01)	(0.90)	(0.62)	(0.54)
No. obs	139	139	139	141
Adj. R-sq	-0.02	-0.02	-0.00	-0.01
F-stat	0.26	0.42	1.26	0.72
F-test (p-val)	0.90	0.80	0.29	0.58

Dependent variable in bottom panel is the residuals from the regression in respective column in panel 1. Once population, population growth, urban crowding and whether incorporated in 1835 are controlled for, none of the remaining observable characteristics of towns predicts the level of the franchise.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3.8: Inverted-U-relationship supported in tests for serial correlation.

	Tax receipts p.c.		Public goods spend p.c.	
	(1)	(2)	(3)	(4)
Male franchise	0.14***	0.11***	0.17***	0.15**
	(0.04)	(0.04)	(0.07)	(0.06)
Male franchise sq	-0.02***	-0.01***	-0.02**	-0.01**
	(0.00)	(0.00)	(0.01)	(0.01)
Lag 1 tax p.c.	0.72***	0.58***		
	(0.02)	(0.02)		
Lag 2 tax p.c.		0.20***		
		(0.02)		
Lag 1 spend p.c.			0.67***	0.61***
			(0.02)	(0.02)
Lag 2 spend p.c.				0.10***
				(0.02)
No. obs	4550	4533	4550	4533
No. towns	150	150	150	150
Year Fixed Effects	Y	Y	Y	Y
Town Fixed Effects	Y	Y	Y	Y
Popn. controls	Y	Y	Y	Y
Franchise turning point (%)	45	44	54	54
F-test (p-val)	0.00	0.00	0.03	0.05
U-test (p-val)	0.00	0.01	0.02	0.02

See notes to Table 3.1. Note that the number of observations is reduced in comparison to Table 3.1 due to the inclusion of the lagged terms.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3.9: Inverted-U-relationship is also supported during period near reforms.

	Tax receipts p.c.		Public goods spend p.c.	
	(1)	(2)	(3)	(4)
Male franchise	0.33**	0.34**	0.46**	0.54***
	(0.15)	(0.15)	(0.18)	(0.19)
Male franchise sq	-0.03**	-0.03**	-0.05***	-0.05***
	(0.02)	(0.02)	(0.02)	(0.02)
No. obs	418	418	418	418
No. towns	145	145	145	145
Year Fixed Effects	Y	Y	Y	Y
Town Fixed Effects	Y	Y	Y	Y
Popn. controls	N	Y	N	Y
Franchise turning point (%)	50	52	51	50
F-test (p-val)	0.08	0.09	0.03	0.02
U-test (p-val)	0.03	0.04	0.02	0.02

See notes to Table 3.1. Regression restricted to years 1868, 1876 and 1882.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Chapter 4

Local government sanitation expenditure and the decline in mortality from waterborne disease

4.1 Introduction

Between 1851 and 1900 mortality rates in Britain declined by almost 20%. Over the same period, local government expenditure on sanitation infrastructure increased rapidly, so that by 1890 spending by local authorities accounted for over 41% of total public expenditure (Lizzeri and Persico, 2004), with much of the money used for clean water and sewers. This simple pattern leads to the natural conclusion that government sanitation expenditure was the driving force to the improvement in life expectancy. However, the importance of sanitation investment remains a matter of debate, and there is disagreement about the extent and effectiveness of sanitary investment during this period (see, in particular, Williamson, 2002; Szreter, 2005).

The rapid urbanization accompanying the Industrial Revolution overwhelmed existing sanitary infrastructure and caused urban living environments to deteriorate (Szreter, 2005), creating challenges similar to those faced in developing countries today (Günther and Fink, 2011). To deal with these problems, municipal governments had to increase local government expenditure to unprecedented levels, but that created financial difficulties and sparked taxpayer opposition (Hennock, 1963; Wohl, 1983). To understand the opposition, we must identify whether the spending that did occur was beneficial. Evidence from other countries (e.g., Cain and Rotella, 2001; Troesken, 2002) has shown that investment in sanitary infrastructure, such as clean water supply, can have positive effects on mortality. But no comprehensive empirical evidence has been brought to the question for England.

This paper assesses the effectiveness of local investment in sanitary public goods in reducing waterborne diseases using a new panel dataset for England and Wales between 1871 and 1890. This dataset combines information on town-level expenditure on public goods with information on local mortality rates from waterborne diseases. In particular, the analysis uses information on local public goods controlled by the "urban sanitary authorities" tasked with improving sanitary environments after 1872. During this period decisions over investment in public goods were made by local town councils, leading to great variation in the extent of investment across the country which can be exploited for empirical analysis.

The core specifications estimate the effect of urban sanitation expenditure on mortality rates from cholera and diarrhea in the registration districts for which mortality rates were reported. The main specifications are estimated using two-period fixed effects regressions, where the two cross sections are the decades 1871–1880 and 1881–1890. By including district and year fixed effects I am able to control for time-invariant district-specific factors and time trends, and hence identify the effect of sanitary expenditure.

The results show that government spending on sanitary public goods—including water supply, sewer systems, and cleaning and paving of streets—had economically and statistically significant effects on mortality rates from cholera and diarrhea. A one standard deviation increase in sanitary expenditure is estimated to have led to a decline of between 0.1 and 0.20 standard deviations in the mortality rate from these diseases during the period. The size of this estimate implies that sanitary expenditure accounted for between 18% and 41% of the reduction in mortality from these waterborne diseases at all ages across the whole period.

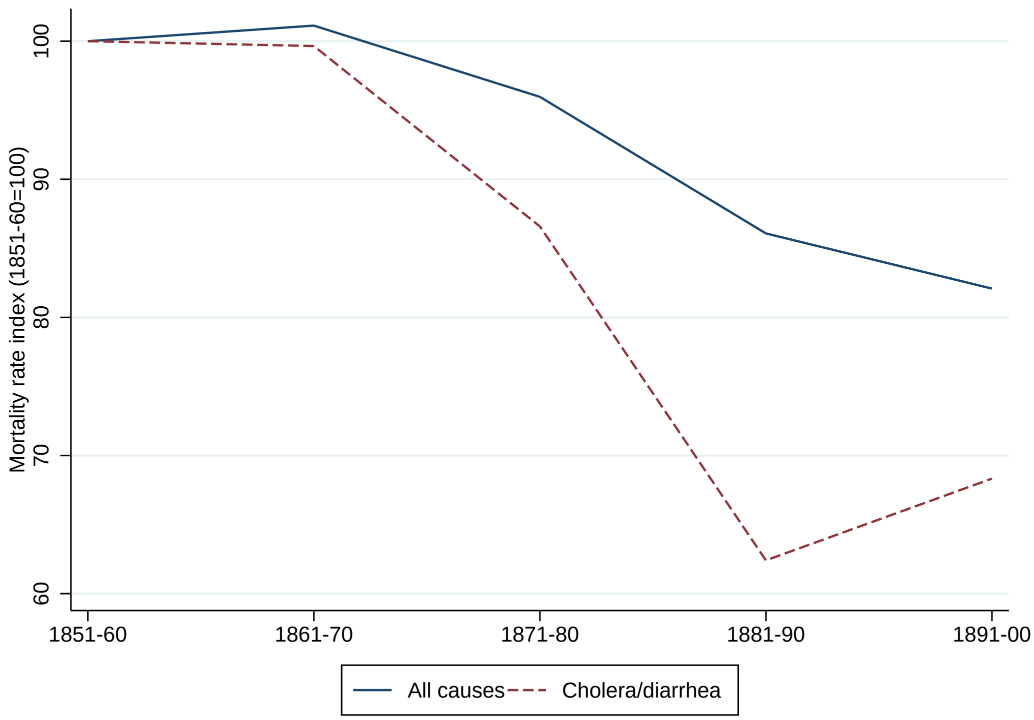
I undertake a number of checks to ensure that the relationship is causal. First, I include control variables measuring the tax base per capita and the level of expenditure on gas per capita. These variables act as proxies for the wealth of the district to account for the fact that, for instance, wealthier areas may have had higher expenditure on public goods and also engaged in behavioral change that reduced mortality. Second, I carry out a number of placebo tests on other diseases that we would not expect to be directly affected by sanitation expenditure, including tuberculosis—a central part of the overall reduction in mortality over this time period. As expected, there is little evidence of a negative relationship between sanitation expenditure and these other diseases. Finally, I control for mortality trends in the rural areas surrounding each urban district to account for other local factors affecting mortality that may erroneously be attributed to greater sanitation expenditure in our regressions. The estimated effect of the sanitation expenditure is robust to this test and remains large and statistically significant.

Beyond their direct historical significance, these findings also have important implications for wider debates about democratic reform in the nineteenth-century. In Chapter 3 I have argued that both the poor and the rich opposed expenditure on public goods in this period due to the high financial cost of infrastructure investment. Lizzeri and Persico (2004) have argued that the local franchise was extended in England in order to prevent pork barrel spending and achieve greater government expenditure on key public goods. Both stories rely on the assumption that public goods expenditure was (or at least was expected to be) effective—rather than being wasted through incompetence or corruption. My results in this paper provide evidence that this assumption is justified, and thus that the extension of the franchise had a big impact not just on the level of government expenditure but also on important economic outcomes.

4.2 Background

Britain became a much healthier place in the second half of the nineteenth century, with crude total mortality rates falling from 22 to 18 per 1,000 living between 1851 and 1900. Deaths from waterborne diseases fell at an even faster rate, as shown in Figure 4.1.

Figure 4.1: Mortality from waterborne diseases fell by over 30% between 1870 and 1900, faster than the 20% decline in total mortality rates.



Source: *Decennial Reports of the Registrar General* 1851–1900.

This overall mortality decline, however, masks significant variation in the experience across different localities. As shown in Figure 4.2, while life expectancy increased across all major cities during the second half of the century, the extent of the increase differed considerably across different towns. This is illustrated by the two towns highlighted in the Figure: Nottingham (NOT) and Sunderland (SUN). Whereas Nottingham was one of the least healthy towns in the decade 1851–1860, by the end of the century it was ranked in the top third of these large towns for life expectancy. Sunderland, in contrast, was relatively healthy at the beginning of the period but was in the bottom third by the end of the century.

Figure 4.2: General increase in life expectancy across English cities, but with significant variation in experiences between towns.

Source: Szreter (2005). NOT=Nottingham; SUN=Sunderland.

The question for this paper is the extent to which these differences in mortality between towns were caused by different levels of sanitation investment. As suggestive evidence, between 1871 and 1890 Nottingham—where life expectancy rose sharply—spent an average of £0.45 per capita each year on sanitation public goods, while Sunderland—where life expectancy stagnated—spent only £0.14 per capita.[1] Recent studies from other countries have shown that government public health interventions did have a large impact on mortality in the early twentieth-century. Cain and Rotella (2001), for example, estimate that a 1% increase in sanitation expenditures would have led to close to a 3% decline in the annual death rate in 48 American cities between 1899 and 1929. Cutler and Miller (2005) find that clean water technologies had a social rate of return that was 23 to 1 in major US cities in the

[1] These figures are based on the dataset discussed in detail in Section 4.3.

early twentieth-century (see also Troesken, 2002; Ferrie and Troesken, 2008; Kesztenbaum and Rosenthal, 2013). Several studies within the modern development literature also show significant effects of water improvements and sanitation access on health outcomes, particularly amongst infants (e.g., Zwane and Kremer, 2007; Ahuja et al., 2010; Fink et al., 2011; Zhang, 2012).

Despite this evidence, the role of public health in explaining British mortality decline in the nineteenth-century remains disputed. Although mortality rates fell dramatically after 1850, the classic explanation—due to McKeown (1976)—has emphasized the importance of better nutrition rather than improved sanitary environments. This conclusion followed from estimates showing that the greatest contribution to the decrease in mortality rates during this period came from reductions in airborne, rather than waterborne, diseases. However later work has questioned this conclusion, arguing that it overlooks the potential contribution of sanitary reform in reducing overcrowding (and hence deaths from airborne diseases) and does not account for differences in the death rates from different airborne diseases (e.g., Woods, 1984; Szreter, 2005). After accounting for the latter factor Szreter (2005) argues that "the classic sanitation diseases come to the fore" in explaining the mortality decline after 1850 (p115).

This literature lacks detailed quantitative data regarding the extent of public sanitation investment during the period. Those studies that do exist either focus on particular case studies (e.g. Woods, 1984) or use small samples of towns (Millward and Sheard, 1995; Millward and Bell, 1998). As such, they are unable to identify how many people benefited from sanitary investments, or whether these investments were associated with mortality improvements on a large scale. This study addresses these issues through constructing and putting to use a dataset identifying town-level expenditure across England and Wales.

4.3 Data and empirical specification

The dataset I use for my empirical analysis combines town-level expenditure on public goods with information on mortality. In this section I first outline the sources from which the data was collected and then explain the geographical units that are the basis of the empirical analysis. I then explain the empirical specification and, finally, detail the construction of the key independent and dependent variables.

4.3.1 Data sources

Mortality data

Information about mortality and causes of death comes from official statistics reported by the Registrar General for the period 1871–1890. These reports detail nationwide mortality information disaggregated according to varying levels of administrative geography. The most basic reporting unit was the registration sub-district, of which there were approximately 2,000 in England and Wales. Each sub-district then formed part of a larger registration district—which in turn formed part of a registration county and, finally, a registration division.[2]

This paper uses data at the level of registration sub-district and registration district. Registration sub-district information was collected from the *Quarterly Returns of the Registrar General* for the third quarter of each year between 1871 and 1891, with the exception of the years 1880 and 1882.[3] These reports were digitized for the purposes of this project, with the exception of the years 1871, 1881, and 1891 which were previously digitized by Southall (1998) and stored at the UK Data Archive. The third quarter was chosen since waterborne diseases—such as diarrhea—were particularly likely to strike during the summer months.

[2] There were approximately 600 registration districts, 50 registration counties and 9 registration divisions.

[3] Reports for these years were unavailable at the time of writing, but they will be collected as part of ongoing research. In addition, data was missing for some districts in other years as the reports were illegible.

The Quarterly Reports during this period contain information on the total number of deaths, and deaths from nine causes: smallpox, measles, scarlet fever, cholera, diarrhea, violence, whooping cough, diphtheria and fever.[4] This list, however, excludes a number of important causes of death during this period—particularly airborne diseases such as tuberculosis. Nor do the quarterly reports disaggregate the cause of death by age group, precluding us from identifying the effect of sanitary intervention on specific age groups.

However, information on causes of death for different age groups is available at the level of registration district in a series of decennial reports by the Registrar General[5]—in particular, the reports for the decades 1861–1870, 1871–1880 and 1881–1890. Each report details the average population and number of deaths in each registration district in the decade, disaggregated by age group (in five or ten year intervals) and cause of death.

One concern with both of these sources is the frequent changes to district boundaries that occurred over the course of the nineteenth century. This difficulty is mitigated, to an extent, when using registration district data, since most changes involved reallocations of parishes between sub-districts within a single registration district—and so there were fewer changes in registration district boundaries. However, to address the issue fully I adjust the mortality data for each year to consistent 1881 district boundaries. To do this, I first identified all sub-district boundary changes between 1871 and 1891 and re-weighted the data to the 1881 district boundaries based on population weight. A fuller explanation of this procedure is provided in the appendix.

Financial data

Financial data are drawn from the *Local Taxation Returns* reported to Parliament and collected in the Parliamentary Papers collection. Data was collected for all "urban sanitary

[4] The category "fever" covered a range of maladies including typhoid (or enteric fever), simple continued fever and puerperal fever.

[5] This data was digitized by Woods (1997).

authorities" for each year from 1872 to 1900.[6] This includes approximately 900 towns, which were all granted standardized expenditure powers under the terms of the 1872 Public Health Act. The accounts report sanitary expenditure in three categories: "water supply", "sewers and sewer systems" and "highways, scavenging and watering". Financial values are then translated into constant values using the Rousseaux Price Index (Mitchell, 1971, pp. 723-4) following Millward and Sheard (1995). Information on sub-district population, number of houses, and area was collected from census information. Town-level data was collected directly from census reports for the purposes of this project. Additional census information was collected from existing datasets collected by Southall (2004)—further details are provided in the appendix.

4.3.2 Units of analysis

Unfortunately, town boundaries during this period did not match the boundaries of the registration districts or sub-districts for which mortality data was reported. Registration districts varied in the number of urban authorities they include: large towns comprised whole (and sometimes multiple) registration districts, while some registration districts included multiple smaller sanitary authorities. Given this issue, I link the financial and mortality data by first linking each town to the registration sub-district(s) in which it was situated using information reported in the 1881 census, Vol II. Where town boundaries crossed multiple registration districts, town spending was allocated to each registration district according to the population residing in each district at the time of the census.

The major unit of the analysis following this linking exercise is the *registration district*. This approach has the advantage of matching directly to the mortality information reported in the Registrar General's decennial reports—and it is those reports that provide the most

[6] For 1872 the accounts are reported under the titles of Local Boards of Health and Improvement Commissions— the bodies which were renamed Urban Sanitary Authorities in the 1872 Public Health Act.

detailed disaggregation of mortality. The main disadvantage is that registration districts often included large swathes of rural areas as well as urban districts. This could lead to a concern that our measure of mortality at the level of the registration district is not capturing the true effects of urban expenditure. To address this issue, we undertake a second analysis in which we measure only mortality in urban registration sub-districts—that is the registration sub-districts that contain part of a town. That has two advantages. First, it allows us to exclude deaths in purely rural areas from our analysis. Second—and even more importantly—by splitting registration districts into their urban and rural components, it allows us to control for shocks or trends that affect the whole district, but that have nothing to do with sanitary investment, such as a general behavioral change, or a reduction in the virulence of a disease in the district due to weather fluctuations. By controlling for such shocks or trends, we will capture the true effect of sanitary expenditure and not something extraneous.

4.3.3 Empirical specification

The data is used to construct a two-period panel dataset, where each cross section relates to a decade reported in the annual reports of the Registrar General: 1871–1880 and 1881–1890. I then estimate the effect of sanitary expenditure on deaths using the following specification:

$$death\_rate_{i,t} = \alpha + \beta spendpc_{i,t} + \gamma X_{i,t} + \delta_0 Z_i + \delta_1 year + \epsilon_{i,t}$$

where i indexes registration districts and $t = 1, 2$ indexes each decade. The variable *death_rate* measures the number of deaths per capita from waterborne diseases, and *spendpc* is the level of urban sanitary expenditure per capita. (Details of the construction of these two variables are provided in the following subsection.) X is a vector of control variables, Z_i includes district fixed effects, *year* is a decade fixed effect, and ϵ is an error term. The basic set of control variables includes district population, urban population, percentage population urban, 10-year district population growth, population density, and urban crowding (measured as number of people / number of houses). In addition, I include death rate from violence as a measure of urbanization, and the percentage of population aged under 5 as a measure of the population most vulnerable to the diseases under study.

In interpreting the results, one concern could be that the coefficient on sanitary spending is capturing the effect of other correlated urban variables. In particular, we might think that higher sanitary spending is associated with greater town wealth, with other government spending that may improve the urban environment in different ways, and possibly with greater public awareness leading to behavior change such as more hand-washing.[7]

I control for this in two ways. First, I include additional control variables for urban tax base per capita and urban per capita expenditure on gas supply. As a second test that I am identifying a causal relationship, I undertake a series of placebo tests using deaths from other diseases that should be unaffected by sanitary investment. When analyzing the sub-district level data, the dependent variable for this placebo test is the combined death rate from the other diseases specified in the Quarterly Reports: smallpox, measles, scarlet fever, whooping cough, and diphtheria, with the exception of the category "fever" (which includes deaths from typhoid which was potentially affected by sanitation). In the registration district analysis, the dependent variable is the mortality rate from pulmonary tuberculosis. Tuberculosis is particularly interesting, since it was a major health risk during this period, with a crude death rate almost three times that from cholera and diarrhea. However, since it is not waterborne, we would not expect the sanitary investments studied here to have any effect on the number of tuberculosis deaths.

[7] For example, see Troesken (1999) for a discussion of the "hand-washing" effect on typhoid deaths.

4.3.4 Definition of key variables

Mortality data

The key dependent variables in the analysis are crude mortality rates according to various causes of death and at different ages. The main focus of the analysis is on deaths from waterborne diseases—in particular, deaths from cholera, diarrhea and dysentery. Ideally, deaths from typhoid would also be included in this measure. Unfortunately, that is not possible because deaths from typhoid were not clearly distinguished in the dicennial reports of the Registrar General from those from typhus until 1871, and even after 1871 there were considerable reporting inaccuracies, with typhoid often incorrectly diagnosed as either typhus or continued fever.[8]

Because each cross section in our panel covers a decade, the appropriate measure is the average death rate over the decade:

$$death\_rate\_ageI = \frac{\text{Number of deaths at ageI}}{\text{(Average population at ageI/ 100,000)}}$$

When analyzing the entire registration district we can use the information directly from the Registrar's Decennial reports, which provide average mortality information across each decade. Mortality data for deaths in registration sub-districts, on the other hand, is reported by year (precisely, the third quarter in each year). For the numerator of the measure we use the average the number of deaths in the sub-district across the years for which data is available.[9]

The Decennial registration district reports also report average district population across the decade. Average populations are not available for the registration sub-districts, so I

[8] For discussion of these problems, see *The Lancet*, September 21, 1878 and *Supplement to the Fifty-Fifth Report of the Annual Report of the Registrar-General*, p. xxvii.

[9] As discussed above, data was missing for all districts for 1880 and 1882, and some data was missing for some districts for other years due to illegible reports.

estimate an average population by assuming that sub-district population grew at an compound average growth rate between decennial censuses and interpolating. The average of this interpolated population then serves as the denominator of the measure.

4.3.5 Measuring sanitary expenditure

Financial data

The key independent variable used in the analysis is the level of "sanitary expenditure" per capita. This measure aggregates spending on "water supply", "sewers and sewerage", and "highways, scavenging and watering". The last category of spending is included because it paid for street cleaning and emptying of privy middens, as well as paving.[10]

To estimate the effect of sanitary expenditure it is important to differentiate between investment and ongoing expenditure for maintenance—all the more so since investment expenditure often involves large up-front costs. Failing to account for this fact could lead to the erroneous conclusion that expenditure is falling over time, as would happen, for instance, if a town built a sewer system in year 1 and then only carried out maintenance expenditure thereafter.[11]

Unfortunately, the annual reports do not separate ongoing and investment expenditure for most of the study period. To separate ongoing expenditure from investment expenditure, I first identify "investment periods" by analyzing deviations in trend expenditure for each type of expenditure. Investment periods are identified using both the level and year-on-year increase in expenditure.[12] An investment period is identified as starting when either a town begins spending for the first time, when year-on-year expenditure increases by more than 100%, or if the town's per capita expenditure is higher than twice the median of per capita

[10]These categories are those identified as having a sanitary aspect in Millward and Sheard (1995).
[11]The fact that we are estimating the effects across a decade mitigates this concern to a large degree; however it is important consideration when thinking about the benefits of public good investment.
[12]See the Appendix for more detail on the identification of these investment periods.

expenditure in the town in the following ten years. An investment period is then identified as continuing until expenditure falls significantly again, relatively both to other towns and future expenditure in the same town.

I then took the increased expenditure from the investment period and spread it over the following twenty-five-year period, to reflect the estimated life-time of the debt generally used to finance investments. Total sanitary expenditure in year t is then measured as:

$$sanitary\_expend_t = ongoing\_expend_t + \sum_{s=t-25}^{t} \frac{investment\_spend_s}{25}$$

Here the level of ongoing expenditure in non-investment periods is simply the expenditure in that period. In investment periods, the level of ongoing expenditure is the level of expenditure in the next non-investment period. For instance, if 1873 and 1874 were investment periods, but 1875 was not, then the level of ongoing expenditure in 1873 and 1874 is set equal to that in 1875. Investment expenditure in period t is equal to the actual level of expenditure minus the level of ongoing expenditure in that period.

Our key measure of sanitary expenditure is *per capita* sanitary expenditure in each registration district. We use the per capita measure since many of these local public goods—e.g., water supply—suffer from important congestion effects (in other words they are very impure public goods in the theoretical sense). Our independent variable of interest is then:

$$spendpc_t = \frac{Average\_sanitary\_expend}{Average\_decadal\_population}$$

where $Average\_sanitary\_expend$ averages annual expenditures for each town within the district across the decade.[13] The measure of the $Average\_decadal\_population$ is then the same as in the calculation of the mortality rates.

[13] Generally this involves 9 periods in the first decade and 10 periods in the second decade since disaggregated expenditure data is not available before 1872. Some towns have missing data for other periods, mainly because they only started reporting to Parliament after 1872 (smaller towns in particular).

4.4 Results

4.4.1 Aggregate effect of expenditure by age group and cause

We begin our analysis by using data at the level of entire registration districts. The registration district data allows us to estimate the full magnitude of the effect of sanitary expenditure between 1871 and 1890, and also to determine which age groups benefited most from sanitary investment. We will then confirm these results by using nearby rural areas as a control group for urban areas.

Table 4.1 displays the estimated effects of sanitary expenditure on mortality rates for those aged under 5 (the group likely to be most at risk) in columns (1) to (4) and for all age groups in columns (5) to (8). The coefficients are standardized: they should be interpreted as the effect of a one standard deviation increase in the independent variable in terms of standard deviations of the dependent variable. Specifications (1) and (5) include sanitary expenditure as the only independent variable (other than the fixed effects), while (2) and (6) include both the basic control variables and the measures of town gas expenditure and tax base per capita. Specifications (3) and (7) include the lagged value of the dependent variable. Finally, specifications (4) and (8) include county-level time trends.

The results show consistent and strong evidence that sanitary expenditure reduced waterborne mortality rates across all specifications. The strength of the results for children under 5 is particularly reassuring, since it would be surprising if sanitary expenditure reduced waterborne mortality without affecting this group. There is, as expected, little evidence of a significant effect on deaths from tuberculosis in the placebo tests (see the bottom panel), providing assurance that we are capturing a causal effect of sanitary expenditure on mortality. Although there are negative coefficients that are statistically significant at the 10% level in the tuberculosis regression specifications (1) and (5), they disappear once we include the control variables, suggesting that the significance could reflect a wealth or a district size effect. Interestingly, however, there is some evidence that our proxies for wealth (tax base per capita and gas per capita) were associated with large declines in deaths from both tuberculosis and waterborne diseases.

Table 4.1: Effect of sanitary spending on death rates 1871–1890

	DV=Mortality rate under 5				DV=Mortality rate all ages			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cholera and diarrhea								
Sanitary spend p.c.	-0.20***	-0.14***	-0.14***	-0.11**	-0.20***	-0.15***	-0.15***	-0.11**
	(0.04)	(0.05)	(0.05)	(0.05)	(0.04)	(0.06)	(0.06)	(0.05)
Tax base p.c.		-0.11	-0.11	-0.21**		-0.09	-0.09	-0.20**
		(0.09)	(0.09)	(0.09)		(0.09)	(0.09)	(0.09)
Gas spend p.c.		-0.09*	-0.08*	-0.05		-0.08	-0.07	-0.03
		(0.05)	(0.05)	(0.05)		(0.05)	(0.05)	(0.05)
Lag U5 waterborne mortality			-0.09	-0.14**				
			(0.06)	(0.05)				
Lag waterborne mortality							-0.08*	-0.07
							(0.05)	(0.05)
Pulmonary tuberculosis								
Sanitary spend p.c.	-0.12*	-0.08	-0.13	-0.07	-0.06*	0.01	0.01	-0.00
	(0.07)	(0.08)	(0.08)	(0.08)	(0.03)	(0.04)	(0.04)	(0.04)
Tax base p.c.		-0.09	-0.07	-0.03		-0.14**	-0.14**	-0.11
		(0.14)	(0.13)	(0.13)		(0.06)	(0.06)	(0.07)
Gas spend p.c.		-0.02	-0.03	-0.07		-0.02	-0.02	-0.01
		(0.09)	(0.08)	(0.08)		(0.04)	(0.03)	(0.04)
Lag Under5 TB mortality			-0.34***	-0.35***				
			(0.07)	(0.06)				
Lag TB mortality							0.05	-0.08
							(0.05)	(0.06)
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
District FE	Y	Y	Y	Y	Y	Y	Y	Y
Controls	N	Y	Y	Y	N	Y	Y	Y
1891 dummy	Y	Y	Y	N	Y	Y	Y	N
County time trends	N	N	N	Y	N	N	N	Y
Obs.	830	830	830	830	830	830	830	830
No. Districts	415	415	415	415	415	415	415	415

Full results are presented in the appendix in Table 4.5 and Table 4.6. Standard errors are adjusted by clustering by district, and are displayed in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4.2 presents the results from estimating specifications (2) and (3) above on four different age groups including, for comparison, the group aged under 5 reported in Table 4.1. The results show negative coefficients on sanitary expenditure in each of the eight specifications. However, the effect is much weaker amongst the groups aged over five, with only one result—for over 65s—significantly different from zero (at a 10% level of significance). This may reflect the fact the death rates from these two diseases were much lower amongst other age groups—making it more difficult to identify the causal effect.

4.4.2 Effects of expenditure on waterborne deaths in urban registration sub-districts

Let us now limit our focus on the portion of the registration districts containing urban areas, which will allow us to confirm that we are capturing a causal effect by using nearby rural areas as a control group for the urban areas. Table 4.3 presents the results of the analysis focusing on waterborne (cholera and diarrhea) deaths in urban sub-districts. As above, all variables are standardized and so the coefficients should be interpreted as the effect of a one standard increase in the independent variable in terms of standard deviations of the dependent variable.

Table 4.2: Estimated effect of sanitary expenditure on mortality of different age groups 1871–1890 (All coefficients standardized)

	DV=waterborne mortality rate in registration districts							
	Aged Under 5		Aged 5–20		Aged 20–65		Aged over 65	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sanitary spend p.c.	-0.14***	-0.14***	-0.09	-0.07	-0.12	-0.11	-0.09	-0.14*
	(0.05)	(0.05)	(0.13)	(0.13)	(0.09)	(0.09)	(0.08)	(0.08)
Tax base p.c.	-0.11	-0.11	-0.13	-0.14	-0.16	-0.16	0.05	0.06
	(0.09)	(0.09)	(0.16)	(0.16)	(0.14)	(0.14)	(0.11)	(0.11)
Gas spend p.c.	-0.09*	-0.08*	0.06	0.10	0.12*	0.13**	0.05	0.04
	(0.05)	(0.05)	(0.10)	(0.09)	(0.06)	(0.06)	(0.07)	(0.07)
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
District FE	Y	Y	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y	Y	Y
1891 dummy	Y	Y	Y	Y	Y	Y	Y	Y
Lagged DV	N	Y	N	Y	N	Y	N	Y
Obs.	830	830	830	830	830	830	830	830
No. Districts	415	415	415	415	415	415	415	415

Standard errors are adjusted by clustering by district, and are displayed in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Specifications (1)–(3) include all registration districts containing any urban areas. Specification (1) includes only sanitary expenditure per capita as a dependent variable (in addition to the fixed effects). Specification (2) includes the set of basic control variables (population, population density, etc.), while specification (3) adds the additional controls to account for town-level wealth and urbanization. Specifications (4)–(6) include only those registration districts that also include rural areas, allowing us to correct for district-level mortality trends, as discussed above. The three specifications are the same as (1) to (3), with the addition of the control for rural mortality within the district in each specification.

The results show consistent evidence that sanitary expenditure led to statistically significant and sizable effects on mortality from waterborne diseases. Further the estimated size of this effect is consistent across the six specifications, with a one standard deviation increase in expenditure estimated to lead to between a 0.11 and 0.14 standard deviation decrease in mortality rates.

Table 4.3: Effect of sanitary spending on death rates in urban registration sub-districts 1871–1890 (All coefficients standardized)

	DV=mortality rate in urban sub-districts					
	(1)	(2)	(3)	(4)	(5)	(6)
DV=Mortality from cholera and diarrhea						
Sanitary spend p.c.	-0.14***	-0.13***	-0.10**	-0.14***	-0.14**	-0.13**
	(0.04)	(0.05)	(0.05)	(0.05)	(0.06)	(0.06)
Tax base p.c.			-0.08			-0.04
			(0.08)			(0.08)
Gas spend p.c.			-0.02			0.00
			(0.04)			(0.05)
Rural cholera/diarrhea mortality rate				0.19***	0.16***	0.16***
				(0.05)	(0.05)	(0.05)
DV=Mortality from other causes						
Sanitary spend p.c.	0.04	0.02	0.12	0.03	-0.01	0.07
	(0.08)	(0.09)	(0.10)	(0.10)	(0.13)	(0.14)
Year FE	Y	Y	Y	Y	Y	Y
District FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	Y	N	Y	Y
1891 dummy	Y	Y	Y	Y	Y	Y
Obs.	830	830	830	610	610	610
No. Districts	415	415	415	305	305	305

Full results are presented in the appendix in Table 4.7 and Table 4.8. Standard errors are adjusted by clustering by district, and are displayed in parentheses. Specifications (1)–(3) include all registration districts containing any urban sub-districts. Specifications (4)–(6) include registration districts containing both rural and urban sub-districts. Control variables include urban sub-district population, population growth, and population density; town population and urban crowding; and district-level mortality rate from violence and percentage population under five. Mortality from other causes includes deaths from smallpox, measles, scarlet fever, whooping cough, and diphtheria.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The bottom panel of the Table 4.3 shows the results of running the same specifications, but with the dependent variable as the mortality rate from other diseases (specifically smallpox, measles, scarlet fever, whooping cough, and diphtheria). As expected the results do not show significant evidence that sanitary expenditure reduced mortality on these diseases. This provides further reassurance that we are capturing a causal effect of sanitary expenditure.

4.4.3 Magnitude of the effects

These results show clear evidence that expenditure on sanitary goods reduced mortality from waterborne disease in England. In this section, we estimate how large these effects were compared to the the overall decline in waterborne mortality across the period of study. To do this, we compare the predicted values from the regression specifications to the predicted values if sanitary expenditure were zero in every district. We then estimate the proportion of the change in mortality that would have occurred even in the absence of expenditure.

We estimate magnitudes for the total population (for registration districts and urban sub-districts) and for different age groups. To estimate the potential range of the magnitude of the effects we estimate three regression specifications. The first includes as control variables district fixed effects and the set of controls relating to district characteristics. The second specification adds the two wealth proxies (tax base per capita and gas expenditure per capita), and the third adds a 1891 year dummy variable. The wealth proxies and the 1891 dummy variable help ensure that we are not capturing a spurious correlation with wealth or other time-varying factors—the reason why they are included in the specifications above (the 1891 year dummy in particular is included in all the specifications). However, it may also lead to the estimated magnitude of the effect being underestimated, since some of the variation in expenditure across time will be attributed to these factors. For instance, if greater town wealth leads to greater expenditure on sanitary goods, the effect may be captured by the measure of tax base per capita, even though the spending that resulted from the growth in wealth caused a decline in mortality rates.

Magnitudes are estimated in the following way. First, I estimate the predicted values from each regression. I then calculate a national mortality rate by multiplying district-level mortality by district-level population, summing across districts, and dividing by aggregate population. I then repeat this procedure under the counterfactual that expenditure was equal to zero in each district. The magnitude is then estimated as:

$$\text{Magnitude} = 1 - \frac{\text{1891 zero-spend mortality-1881 zero-spend mortality}}{\text{1891 actual-spend mortality-1881 actual-spend mortality}}$$

Table 4.4: Percentage of mortality decline between 1871 and 1890 explained by sanitary expenditure per capita

	(1)	(2)	(3)
Registration districts			
All ages	39%	34%	18%
Age under 5	49%	40%	23%
Age 5–20	50%	42%	20%
Age 20–65	38%	34%	14%
Age over 65	32%	37%	11%
Urban sub-districts			
All ages	41%	34%	21%
District FE	Y	Y	Y
Year FE	N	Y	Y
Wealth proxies	N	N	Y
Controls	Y	Y	Y

Estimates calculated using predicted values from regressions of mortality from waterborne diseases against sanitary expenditure per capita and set of control variables as detailed in the table. The category “controls” includes variables measuring district (urban sub-district) population, population growth, and population density; town population and urban crowding; and district- (urban sub-district-) level mortality rate from violence and percentage district population under five. Magnitudes are calculated as the proportion of the decline in mortality that would not have occurred in the absence of expenditure.

The results, presented in Table 4.4 show consistent evidence that the magnitude of the effects was large, with sanitary expenditure estimated to have accounted for approximately 18%–41% of the decline in waterborne mortality between 1871–1880 and 1881–1890. The size of the effect is similar larger for those aged under 5—the group likely most at risk–for whom sanitary expenditure is estimated to have accounted for between 23% and 49% of the decline across this period. Interestingly, the inclusion of the wealth proxies does not substantially reduce the size of the estimated magnitude, suggesting that our measures are not capturing the effects of growing town income. However, the inclusion of a time trend leads to a significant decrease in the estimated effect. This reflects the fact that expenditure grew generally across districts during this period—and so by including a time trend we do not capture the effect of the average change in sanitary expenditure across the country.

In considering these estimates, it is important to note that we are not accounting for any lagged effects of expenditure on mortality rates. If, as is likely, expenditure continued to have strong effects on mortality outside of the current decade then we will be underestimating the overall impact of sanitary investment on mortality decline.

4.5 Discussion

This paper has tested the effects of government spending on sanitation infrastructure on mortality rates from waterborne disease in England between 1871 and 1890. During this period local government took responsibility for improving urban environments, leading to rapid growth in expenditure on public goods such as clean water supply, sewer systems and street paving and cleaning. The results show that governments' spending on these local public goods contributed significantly to the reduction in mortality from waterborne disease, specifically deaths from cholera and diarrhea.

The fact that this spending was effective suggests that the demand for these public goods was driven by a belief that they would be effective—rather than as a form of government capture—as emphasized in theories of public goods such as Lizzeri and Persico (2004). However, it also raises a further question: why they were not provided more broadly or more rapidly? There was considerable variation in the extent of spending across towns, with some areas having appalling sanitary conditions even at the end of the century. In the previous chapter I have argued that one explanation for this was the opposition of the poor to higher taxes—since local governments had to largely fund expenditure themselves rather than through national grants. A further part of the story, however, is which groups benefited—i.e., experienced reduced mortality—from spending on these public goods. Future research will address this through comparing mortality trends in rich and poor neighborhoods across

Britain.

4.A Data

4.A.1 Mortality data

Registration district level

Mortality data reported at registration district level are drawn from the dicennial reports of the Registrar General for 1851–1891, which report the annual average number of deaths by cause and by age group split by registration district. This information is obtained from Woods (1997).

Registration sub-district level

Mortality data were collected from the *Quarterly Returns of the Registrar General* for the third quarter of each year between 1871 and 1890, with the exception of 1880 and 1882. This information was supplemented with the equivalent data for the years 1871, 1881 and 1891 which had been digitized previously by Southall (1998).

4.A.2 Financial data

Financial data are drawn from the *Local Taxation Returns* reported to Parliament and collected in the Parliamentary Papers collection. Data is collected for all "urban sanitary authorities" for each year from 1872 to 1900.[14] This includes approximately 900 towns, granted standardized expenditure powers under the terms of the 1872 Public Health Act.

[14] For 1872 the accounts are reported under the titles of Local Boards of Health and Improvement Commissions—the bodies which were renamed Urban Sanitary Authorities in the 1872 Public Health Act.

Defining ongoing and investment public goods expenditure

Prior to 1885 the financial data does not distinguish between one-off and ongoing expenditure items: as such the accounts include a number of very high expenditures, reflecting investment activities. To separate ongoing expenditure from investment expenditure for different types of public good, I first identify "investment periods" by analyzing deviations in trend expenditure in each of the following categories "sewerage and sewer systems", "water supply", "highways, watering and scavenging", and "gas supply". A year is identified as the beginning of an investment period for each good if:

1. Expenditure per capita exceeds the median percentile of expenditure per capita (across all towns and years) in the relevant category; and either:
    - the town started expenditure on the relevant good in that period; or
    - there is a 100% year-on-year growth in expenditure on the good, and the expenditure p.c. exceeds the median per capita spending for the town in the next ten years; or
    - the two previous years of data are missing, and the expenditure p.c. exceeds the median per capita spending for the town in the next ten years; or
    - the level of expenditure p.c. is higher than the previous year and twice the median per capita spending for the town in the next ten years.

The years following the start of an investment period are identified as investment periods if either:

1. expenditure p.c. is greater than the previous period; or
2. the expenditure p.c. exceeds the median per capita spending for the town in the next ten years; and either:

- the expenditure is twice the town's average expenditure over the period; or
- the level of expenditure exceeds the median percentile of expenditure per capita (across all towns and years) in the relevant category.

4.A.3 Linking towns to registration districts

Each town is linked to a registration sub-district using information reported in the 1881 census, Vol II. This report splits the population of each town according to registration sub-district. For example, of a total town population of 10,000 it identifies that 4,000 lived in sub-district A, 3,500 in sub-district B, and 2,500 in sub-district C. To aggregate expenditure data at the level of registration district, expenditure is allocated to each registration district proportionally to the portion of the town population that falls in each district. That is, if 85% of the town live in district X, and 15% in district Y, then 85% of town expenditure is assigned to district X and 15% to district Y. Registration district-level expenditure is then calculated through summing the spending amounts for all towns (whole or part) within the district.

A further complication is that the boundaries of registration districts changed over time, with some added and others removed. To account for this, I adjust all mortality data to the 1881 boundaries by first identifying all sub-district boundary changes (using the reports of the Registrar General) and then created a synthetic district based on population weight. That is, deaths in each year were reassigned to the 1881 district based on the population of the actual district reporting that lived in the 1881 district boundary in 1881. For instance, if two equally-sized districts merged in 1885, mortality data from the new district after this point would be split evenly between the two synthetic districts.

4.A.4 Census data

Information on town and district population, number of houses and area was collected from decennial census reports. The collected data was supplemented by additional information for registration districts using the parish-level census information for 1871 and 1891 digitized by Southall (2004).

4.B Additional empirical results

4.B.1 Full tables

Table 4.5: Effect of sanitary spending on district cholera and diarrhea death rates 1871–1890

	DV=Mortality rate under 5				DV=Mortality rate all ages			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sanitary spend p.c.	-0.20***	-0.14***	-0.14***	-0.11**	-0.20***	-0.15***	-0.15***	-0.11**
	(0.04)	(0.05)	(0.05)	(0.05)	(0.04)	(0.06)	(0.06)	(0.05)
1891 dummy	-0.37***	-0.43***	-0.42***		-0.52***	-0.54***	-0.54***	
	(0.03)	(0.06)	(0.06)		(0.03)	(0.06)	(0.06)	
Tax base p.c.		-0.11	-0.11	-0.21**		-0.09	-0.09	-0.20**
		(0.09)	(0.09)	(0.09)		(0.09)	(0.09)	(0.09)
Gas spend p.c.		-0.09*	-0.08*	-0.05		-0.08	-0.07	-0.03
		(0.05)	(0.05)	(0.05)		(0.05)	(0.05)	(0.05)
Urban popn growth		0.09	0.09	0.10		0.10*	0.10*	0.10
		(0.06)	(0.06)	(0.06)		(0.06)	(0.06)	(0.06)
District violent death rate		0.06**	0.06**	0.05*		0.08**	0.08**	0.06**
		(0.03)	(0.03)	(0.03)		(0.03)	(0.03)	(0.03)
% popn under 5		-0.13	-0.12	-0.08		-0.07	-0.07	-0.03
		(0.08)	(0.08)	(0.08)		(0.08)	(0.08)	(0.08)
District population		-0.25	-0.31	-0.26		-0.28	-0.35*	-0.22
		(0.18)	(0.19)	(0.18)		(0.19)	(0.20)	(0.17)
Town population		0.13	0.15	0.13		0.10	0.13	0.06
		(0.16)	(0.17)	(0.16)		(0.17)	(0.18)	(0.15)
Town crowding		-0.20*	-0.19*	-0.17		-0.24**	-0.23**	-0.19*
		(0.11)	(0.12)	(0.11)		(0.10)	(0.11)	(0.10)
% popn in towns		0.31**	0.33***	0.39***		0.25**	0.28**	0.35***
		(0.12)	(0.12)	(0.11)		(0.13)	(0.13)	(0.12)
Lag U5 waterborne mortality			-0.09	-0.14**				
			(0.06)	(0.05)				
Lag waterborne mortality							-0.08*	-0.07
							(0.05)	(0.05)
Constant	0.24***	0.25***	0.25***	0.22***	0.31***	0.31***	0.31***	0.29***
	(0.01)	(0.03)	(0.03)	(0.03)	(0.01)	(0.03)	(0.03)	(0.03)
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
District FE	Y	Y	Y	Y	Y	Y	Y	Y
Controls	N	Y	Y	Y	N	Y	Y	Y
1891 dummy	Y	Y	Y	N	Y	Y	Y	N
County time trends	N	N	N	Y	N	N	N	Y
Obs.	830	830	830	830	830	830	830	830
No. Districts	415	415	415	415	415	415	415	415

Standard errors are adjusted by clustering by district, and are displayed in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4.6: Effect of sanitary spending on district-level pulmonary tuberculosis death rates 1871–1890

	DV=Mortality rate under 5				DV=Mortality rate all ages			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sanitary spend p.c.	-0.12*	-0.08	-0.13	-0.07	-0.06*	0.01	0.01	-0.00
	(0.07)	(0.08)	(0.08)	(0.08)	(0.03)	(0.04)	(0.04)	(0.04)
1891 dummy	-0.42***	-0.49***	-0.51***		-0.78***	-0.92***	-0.89***	
	(0.06)	(0.11)	(0.10)		(0.03)	(0.07)	(0.08)	
Tax base p.c.		-0.09	-0.07	-0.03		-0.14**	-0.14**	-0.11
		(0.14)	(0.13)	(0.13)		(0.06)	(0.06)	(0.07)
Gas spend p.c.		-0.02	-0.03	-0.07		-0.02	-0.02	-0.01
		(0.09)	(0.08)	(0.08)		(0.04)	(0.03)	(0.04)
Urban popn growth		0.05	-0.01	0.10		-0.07*	-0.07*	-0.01
		(0.07)	(0.06)	(0.07)		(0.04)	(0.04)	(0.04)
District violent death rate		0.02	0.01	0.06		0.01	0.01	0.02
		(0.06)	(0.05)	(0.06)		(0.04)	(0.04)	(0.04)
% popn under 5		-0.09	-0.06	-0.08		-0.19**	-0.19**	-0.26***
		(0.14)	(0.13)	(0.15)		(0.09)	(0.09)	(0.10)
District population		0.45	0.29	0.06		0.58**	0.59**	0.60**
		(0.29)	(0.30)	(0.28)		(0.24)	(0.25)	(0.26)
Town population		-0.49*	-0.39	-0.31		-0.68***	-0.70***	-0.67***
		(0.28)	(0.28)	(0.25)		(0.22)	(0.22)	(0.24)
Town crowding		-0.17	-0.09	-0.10		-0.14	-0.13	-0.16*
		(0.14)	(0.13)	(0.12)		(0.10)	(0.10)	(0.09)
% popn in towns		0.05	-0.04	-0.08		0.01	0.01	0.06
		(0.22)	(0.22)	(0.20)		(0.14)	(0.14)	(0.11)
Lag Under5 TB mortality			-0.34***	-0.35***				
			(0.07)	(0.06)				
o.time_40				0.00				0.00
				(.)				(.)
Lag TB mortality							0.05	-0.08
							(0.05)	(0.06)
Constant	0.24***	0.27***	0.29***	0.27***	0.41***	0.46***	0.44***	0.52***
	(0.02)	(0.05)	(0.05)	(0.06)	(0.01)	(0.03)	(0.04)	(0.04)
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
District FE	Y	Y	Y	Y	Y	Y	Y	Y
Controls	N	Y	Y	Y	N	Y	Y	Y
1891 dummy	Y	Y	Y	N	Y	Y	Y	N
County time trends	N	N	N	Y	N	N	N	Y
Obs.	830	830	830	830	830	830	830	830
No. Districts	415	415	415	415	415	415	415	415

Standard errors are adjusted by clustering by district, and are displayed in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4.7: Effect of sanitary spending on urban sub-district cholera and diarhoea death rates 1871–1890

	DV=Urban mortality rate					
	(1)	(2)	(3)	(4)	(5)	(6)
Sanitary spend p.c.	-0.14***	-0.13***	-0.10**	-0.14***	-0.14**	-0.13**
	(0.04)	(0.05)	(0.05)	(0.05)	(0.06)	(0.06)
1891 dummy	-0.28***	-0.26***	-0.26***	-0.18***	-0.19***	-0.18***
	(0.04)	(0.07)	(0.07)	(0.04)	(0.07)	(0.07)
Urban RSD population		-0.21	-0.23		-0.14	-0.18
		(0.32)	(0.32)		(0.59)	(0.60)
Urban RSD popn growth		0.11**	0.10**		0.11**	0.11**
		(0.05)	(0.05)		(0.05)	(0.05)
Urban popn density		-0.71*	-0.70*		-2.03	-1.97
		(0.37)	(0.36)		(1.45)	(1.46)
Town population		0.38	0.41		0.87*	0.89*
		(0.37)	(0.36)		(0.50)	(0.49)
Town crowding		-0.31***	-0.33***		-0.13	-0.14
		(0.11)	(0.12)		(0.12)	(0.12)
District violent death rate		0.07*	0.07*		0.09**	0.09**
		(0.04)	(0.04)		(0.04)	(0.05)
% popn under 5		-0.00	-0.02		-0.07	-0.07
		(0.09)	(0.09)		(0.10)	(0.09)
Tax base p.c.			-0.08			-0.04
			(0.08)			(0.08)
Gas spend p.c.			-0.02			0.00
			(0.04)			(0.05)
Rural cholera/diarrhea mortality rate				0.19***	0.16***	0.16***
				(0.05)	(0.05)	(0.05)
Constant	0.14***	0.13***	0.13***	-0.09***	-0.39	-0.39
	(0.02)	(0.03)	(0.04)	(0.03)	(0.27)	(0.27)
Year FE	Y	Y	Y	Y	Y	Y
District FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	Y	N	Y	Y
1891 dummy	Y	Y	Y	Y	Y	Y
Obs.	830	830	830	610	610	610
No. Districts	415	415	415	305	305	305

Standard errors are adjusted by clustering by district, and are displayed in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4.8: Effect of sanitary spending on urban sub-district other death rates 1871-1890

	DV=Urban mortality rate					
	(1)	(2)	(3)	(4)	(5)	(6)
Sanitary spend p.c.	0.04	0.02	0.12	0.03	-0.01	0.07
	(0.08)	(0.09)	(0.10)	(0.10)	(0.13)	(0.14)
1891 dummy	-0.70***	-0.52***	-0.53***	-0.58***	-0.43***	-0.42***
	(0.08)	(0.13)	(0.13)	(0.09)	(0.15)	(0.14)
Urban RSD population		0.10	0.05		1.88**	2.19***
		(0.37)	(0.35)		(0.75)	(0.77)
Urban RSD popn growth		0.19***	0.16**		0.28***	0.27***
		(0.07)	(0.07)		(0.08)	(0.08)
Urban popn density		0.33	0.41		-0.93	-1.91
		(0.68)	(0.66)		(1.75)	(1.83)
Town population		-0.40	-0.27		-1.09	-1.03
		(0.38)	(0.35)		(0.67)	(0.64)
Town crowding		-0.47***	-0.45***		-0.43**	-0.38*
		(0.16)	(0.17)		(0.20)	(0.21)
District violent death rate		0.13*	0.12*		0.19**	0.16*
		(0.07)	(0.07)		(0.08)	(0.09)
% popn under 5		0.21	0.14		0.18	0.17
		(0.18)	(0.18)		(0.24)	(0.23)
Tax base p.c.			-0.17			-0.07
			(0.15)			(0.18)
Gas spend p.c.			-0.23**			-0.27**
			(0.09)			(0.12)
Rural other mortality rate				0.12**	0.11**	0.12**
				(0.05)	(0.05)	(0.05)
Constant	0.35***	0.26***	0.26***	0.20***	0.08	-0.09
	(0.04)	(0.06)	(0.06)	(0.05)	(0.36)	(0.37)
Year FE	Y	Y	Y	Y	Y	Y
District FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	Y	N	Y	Y
1891 dummy	Y	Y	Y	Y	Y	Y
Obs.	830	830	830	610	610	610
No. Districts	415	415	415	305	305	305

Standard errors are adjusted by clustering by district, and are displayed in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

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