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Income inequality and famine mortality: Evidence from the Finnish famine of the 1860s

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Abstract

This article examines whether economic inequality intensified the adverse effects of harvest, price, and income shocks during a famine. Using a parish-level longitudinal dataset from the Finnish famine of the 1860s, it shows that a substantial proportion of the excess mortality experienced during the famine resulted from a decline in agricultural production, a decline in incomes, and a surge in food prices. The findings indicate that the adverse effects of food output fluctuations were intensified by increasing income inequality and decreasing average income, while the market-transmitted shocks were weakened by a contraction of disposable income. The results are corroborated with multiple alternative estimation techniques, including the introduction of spatial spill-overs. The results show that even a pre-industrial famine affecting an impoverished society was meaningfully defined by the distribution of incomes.

KEYWORDS

famines, Finland, inequality, nineteenth century, poverty

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N33, C23

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Economic inequality is a common feature in narratives recounting the outbreak and evolution of famines, yet concrete empirical evidence on their connection has remained elusive. In the context of famines, inequality has been defined in terms of access to land and resources, and analysed in terms of social hierarchy. Further, inequality has been portrayed as a dimension of poverty and defined in terms of concentrated political power.¹ However, all these factors may have different implications for how food security crises arise and develop. On the basis of an analysis of income inequality during the last substantial peacetime population disaster in western Europe,² the Finnish famine of the 1860s, we seek to answer one of the most enduring questions in famine scholarship: are unequal societies more famine-prone and, if so, how?

The connection of famines to inequality stems primarily from the works of the Nobel laureate Amartya Sen.³ His entitlement framework drew attention to the way in which people acquire food via the legal means available to them, and he suggested that any changes to this may lead to large shifts in the intergroup distribution of food acquired and, ultimately, consumed. Sen's views were informed by his own experiences during the notorious Bengal famine of the 1940s: 'I knew of no one in my school or among my friends and relations whose family had experienced the slightest problem during the entire famine; it was not a famine that afflicted even the lower middle classes—only people much further down the economic ladder'.⁴ Sen's entitlement framework has found empirical resonance. Since its introduction, the vast majority of famines have been characterized by a combination of rising food prices, falling asset prices, and falling wage rates.⁵ Fuelled by Sen's theoretical apparatus and modern empirical findings, historians have also sought to link unequal food access and historical famines.⁶

Recent research in economic history has, however, been sceptical about the applicability of the entitlement framework to historical cases and has drawn attention to the fact that low living standards are too casually overlooked in the analysis of past famines. Alfani and Ó Gráda have suggested that it is 'unwise to generalise about the nature of famines based on the experience of the twentieth and twenty-first centuries',⁷ and they conclude that 'distribution and entitlement issues were not the main cause of medieval and early modern famines'.⁸ In place of a Senian focus on market access, food prices, and purchasing power, the recent 'historical turn' in the economic historiography of famines has pointed to poor transport infrastructure, extensive poverty, and an

¹ See, for example, Baro and Deubel, 'Persistent hunger'; Vogel and Smith, 'Politics of scarcity'; Ribot, 'Vulnerability and climate'; Meng, Qian, and Yared 'Institutional causes'; Johnson, 'Russian famine'. In 'Criminalization', Edkins has argued that treating inequality as a cause for famine is essentially a tautology: there simply cannot be famines without embedded inequalities in some human dimension.

² For qualifications, see, for example, Ellman, 'Soviet famine'; Johnson, 'Russian famine'.

³ Most importantly, Sen, *Poverty and famines*.

⁴ A. Sen, 'Biographical', <https://www.nobelprize.org/prizes/economic-sciences/1998/sen/biographical/> (accessed on 7 May 2021).

⁵ These constitute the so-called exchange entitlement failure; see, for example, Devereux, 'Africa'.

⁶ For studies influenced by the entitlement analysis, see, for example, Fogel, 'Second thoughts'; Geens, 'Great famine'; Slavín, 'Market failure'; Ellman, 'Soviet famine'; Camenisch, 'Two decades of crisis'; Huff, 'Vietnam famine'.

⁷ Alfani and Ó Gráda, 'Causes of famines', p. 283; for similar earlier views, see Arnold, *Famine*, p. 33.

⁸ Alfani and Ó Gráda, 'Causes of famines', p. 283. On general criticism, see, for example, Devereux, 'Critiques and counter-critiques'.



absence of proper social security as the major factors that caused prolonged crop failures to spin out of control.⁹

While a drop in food supply amidst low living standards is usually a tell-tale sign of famine,¹⁰ harvest failures do not invariably lead to food security crises.¹¹ The most probable reason for this inconsistency lies in the distribution of resources among those affected, though previous literature points towards a possibly complicated connection between the distribution of resources and the demographic effects of food security crises.¹² Uncertainty about the role of unequal resources and entitlements is mainly due to a widespread lack of systematic and good quality empirical data about inequality in famine settings.

To shed more light on the issue, we focus on the Finnish famine of the 1860s. Through unique longitudinal and multivariate spatial panel data, we analyse the determinants of the famine mortality and ask whether economic inequality intensified the adverse effects of harvest, price, and income shocks. Our analysis reveals that while low average income and high inequality intensified the negative effects of food output decline, these same conditions weakened the market-mediated shocks. Our findings show that individuals' access to food markets is an important factor determining whether price and income shocks lead to increased mortality. As output decline, price increase, impoverishment, and wage contraction become intertwined during famines, differentiating the relative importance of each factor is important and novel.

The rest of this article is structured as follows. Section I places the 1860s famine in context. Section II reviews the relevant theoretical discussions and outlines the empirical hypotheses concerning the interactions of the variables of interest. Section III discusses the source material used. The methodology and empirical strategy are covered in section IV. In section V, we conduct the empirical investigation by running regression models to study the determinants of crude death rates during the famine and review the robustness of our findings. In section VI, we analyse the interaction profiles and provide contextual insights to support their interpretations. The article concludes with section VII.

I

Finland has a long history of famines.¹³ Currently available Finnish population series document famines in 1675–9, in the 1690s (with a population decline of 20.6 per cent in 1696–7), in 1709–10, in

⁹ See, for example, Ó Gráda, 'Ripple that drowns?'; Campbell, 'Historical protagonist'; Alfani, 'Climate, population and famine'; Hoyle, 'Agricultural catastrophe'; Campbell and Ó Gráda, 'Harvest shortfalls'; Campbell, *Great transition*; Alfani and Ó Gráda, 'Causes of famines'. The countries that have experienced famines during the twenty-first century provide a clear continuation of this tendency. Based on World Bank Statistics, the GDP per capita in Niger, Malawi, Ethiopia, South Sudan, Yemen, and Somalia ranges from 5% to 15% of the global per capita average.

¹⁰ As Alfani and Ó Gráda, 'Causes of famines', describe, whether famine happens or not.

¹¹ Howe, 'Famine systems', provides a theoretical framework to explain why a sole shock probably does not suffice in causing famine. Crops fail amidst stagnant/low living standards much more often than famines happen; see, for example, Ó Gráda, 'Making famine history'. See also, for example, van Bavel, Curtis, Hannaford, Moatsos, Roosen, and Soens, 'Climate and society'; Slavin, 'Climate and famines'.

¹² See, for example, Dribe, Olsson, and Svensson, 'Manorial system'; Ravallion, 'Famines and economics', pp. 1216–17.

¹³ For an overview of the 1860s famine and Finnish demographic history, see, for example, Pitkänen, *Deprivation*; Voutilainen, *Finnish 1860s famine*; Voutilainen, Helske, and Högmänder, 'Historical population'; Ó Gráda, 'Finland'; Häkkinen, 'Great famine'.

the early 1740s, and more regionally delineated crises during the 1830s and 1850s, with continued food security crises related to harvest failure well into the twentieth century.¹⁴ What makes the Finnish famine of the 1860s stand out was not only its relatively late occurrence (some 120 years after the previous large-scale domestic famine and some 90 years after the last substantial famine in neighbouring Sweden)¹⁵ but also its magnitude, with a loss of close to 10 per cent of the pre-famine population.

The Finnish famine of the 1860s, which was a ‘European outlier’,¹⁶ took place in a poor country that, in 1820, had a per capita income level that was only about 40 per cent of what it was in the UK and three-quarters of what it was in Sweden, with this disparity growing further by 1870. Even famine-stricken Ireland—the infamous ‘poor man of Europe’—had a higher per capita income level than Finland for the first half of the nineteenth century.¹⁷ The low average income level was an outcome of an overwhelmingly agrarian low-productivity economy. Only about 6 per cent of the population lived in urban centres, and about 90 per cent worked in agriculture. The structure of the economy, combined with the dietary dependency on volatile grain output (rye being the staple in the south, cold-resistant barley in the east and north), meant that the economy and society as a whole were highly vulnerable to harvest fluctuations.

Social vulnerability to crop failures increased during the nineteenth century. The rural labourer population—that is, farm hands and seasonal workers—increased by some 150 per cent, and the number of crofters and tenant farmers doubled between 1815 and 1865. At the same time, the number of landowners scarcely changed at all (growing by only about 10 per cent over the same period).¹⁸ This meant that the proportion of the population relying on volatile harvests for employment grew substantially in the decades preceding the famine. The situation was aggravated by only a minute increase in agricultural productivity, which during the nineteenth century meant gains mostly for landowners who then rented their lands to crofters and hired casual labour for harvesting. At the same time, population growth drove an increasing number of people onto marginal land,¹⁹ which increased the population in the inner parts of the country, the poor hinterlands.²⁰

Socio-economic development in the pre-famine era had left its mark by 1865, as visible in figure 1. Measured in nominal Finnish marks (FIM), the highest income levels (both in household and per capita terms) were concentrated in south-west Finland, with reasonably high income levels also along the western coast. While many of these regions displayed fairly high Gini coefficients (over 0.5),²¹ high average household income was generally associated with low between-household inequality (correlation = -0.69 , $p < 0.001$), illustrating that much of the pre-famine income inequality stemmed from the large number of poor households at the low end of the income distribution.

The poorest parts of the country were in the highland drainage divides which ran from the west to the north-east (Suomenselkä) of the country and from the east to the north (Maanselkä).

¹⁴ Voutilainen, Helske, and Högmander, ‘Historical population’.

¹⁵ Dribe, Olsson, and Svensson, ‘Nordic Europe’.

¹⁶ Alfani and Ó Gráda, ‘Causes of famines’, p. 284.

¹⁷ Bolt, Inklaar, de Jong, and van Zanden, ‘Rebasing “Maddison”’.

¹⁸ For details, see, for example, Voutilainen, *Finnish 1860s famine*, pp. 78–83.

¹⁹ Solantie, *Ilmasto*.

²⁰ Mokyr, *Ireland*. Kelly and Ó Gráda’s ‘Three decades’ shows similarly that the pre-famine Irish population grew the fastest in the poorest parts of the country.

²¹ Gini coefficients are calculated from reconstructed income distribution using log-normal assumption, as outlined in Hong, Alfani, Gigliarano, and Bonetti, ‘giniinc’. See section III and online app. for details.

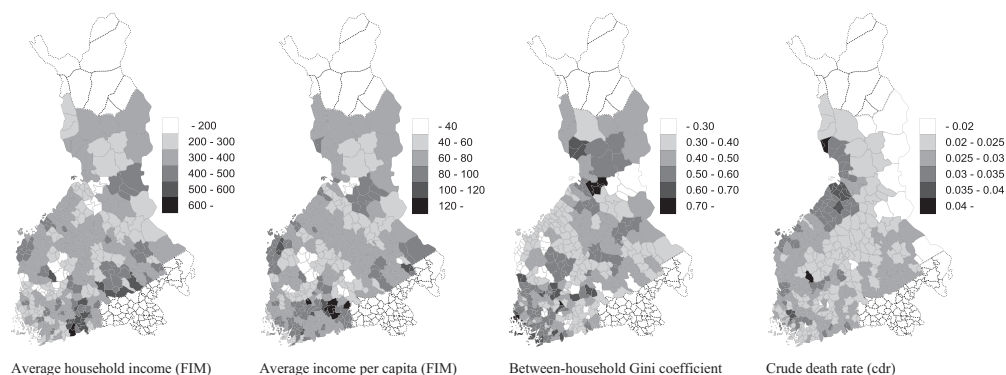


FIGURE 1 Average income, income inequality, and mortality in rural Finnish parishes, 1865. 1 Finnish mark (FIM) = 4.4987 grams of silver. Income distribution estimated with maximum likelihood using a log-normal assumption and the Stata package *giniinc*; for qualifications, see online app. S1. Regions in dashed lines are not included in the analysis; see section III for details. *Sources*: See section III

These were also the places that saw the biggest growth in population during the first half of the nineteenth century, but probably due to their relatively low population density had the lowest crude death rates in 1865 at the onset of the famine (figure 1).

The geographical patterns of poverty and vulnerability were magnified and, to an extent, caused by the uneven spread of crop failures. Harvest failures happened with varying degrees of severity about every three years, with the northern provinces facing a considerably higher risk of annual crop failure.²² The simultaneous failure of rye (sown before the winter) and barley (sown in the spring) posed a serious threat to food security in the absence of significant over-year storage.

While pre-1860s Finland experienced large crop failures in 1821, 1856, and in consecutive years in the early 1830s (leading to regional famines), it was only in the 1860s that a full-blown famine developed. Severe frosts in early September 1867, which regionally destroyed well over half of all the grain harvests, had been preceded in many places by multiple harvest failures for several consecutive years previous to this. The crop failure of 1867 resulted in a 25 per cent decline in real wages, and roughly a twofold increase in grain prices, from the lowest price in autumn 1866 to the peak in the spring of 1868.²³

In retrospect, the 1860s famine was the result not simply of abysmal weather conditions but a perfect storm of rural poverty and concentrated landownership. The situation was aggravated by ill-timed monetary reform that led to an initial unwillingness of the government to borrow grain from abroad.²⁴ The resulting surge in mortality and drop in births reduced the Finnish population by as many as 200 000 people—roughly 10 per cent of the pre-famine population.²⁵ While substantial, the famine's impact proved transitory: population, production, and income returned to their pre-famine levels in a few years, and the growth of the rural underclass continued all the way to the early twentieth century.

²² Voutilainen, *Finnish 1860s famine*, pp. 92–9.

²³ Heikkinen, Hjerppe, Kaukiainen, Markkanen, and Nummela, 'Levnadsstandarden i Finland'; Pitkänen, *Deprivation*.

²⁴ On the government's response, see, for example, Rantanen, 'Pitfall'. The situation is worthy of comparison with that in 1840s Ireland; see esp. Read, 'Laissez-faire'.

²⁵ Pitkänen, *Deprivation*; Voutilainen, *Finnish 1860s famine*.

II

Even a cursory glance at the socio-economic history of nineteenth-century Finland provides ample explanation for the magnitude of the famine. After all, since at least the work of Tawney,²⁶ the standard ‘ripple that drowns’ discourse has linked famine mortality to the distribution of living standards, arguing that mortality is more susceptible to fluctuations in living standards the poorer and/or the more unequal the society is.²⁷

In order to examine this phenomenon in more detail, we will study Sen’s entitlement function.²⁸ Here, the maximum food entitlement of an occupation group j is $f_j = p_j q_j / p_f = p_e q_j$, where q_j is the quantity of a commodity or service (j) sold or consumed (q_f is the quantity of food), p_j is the commodity’s price, p_f is the food’s price, and p_e is the exchange rate for food. An individual (i) who produces some of the food they consume and obtains the rest through selling their commodity or service (j) has the maximum food entitlement function:

$$f_i = q_f^i + p_e q_j^i \quad (1)$$

If the individual is a subsistence producer, the maximum food entitlement will only consist of self-produced food.²⁹ If they obtain food solely via income, the maximum entitlement function consists of only the $p_e q_j^i$ term. Everyone else has a maximum entitlement function which combines the two.

Griffin expanded on this by exploring the role of unequal incomes. He analysed the demand of two groups (rich and poor), and arrived at a simple Marshallian aggregate demand curve, kinked at the point where food prices became sufficiently high to drive the poor out of the market.³⁰ The tipping point will occur at a lower food-price level, the more unequally distributed incomes are, or the lower the average income is. Devereux later put this in more general terms:

given that the poor outnumbered the rich, it is clear that many people will have been excluded from the market for food during the famine as a consequence of price rises induced by the demand pressure exerted on the restricted supplies by the wealthy minority ... the more unequal the initial distribution ... the more pronounced this effect will be.³¹

The skewness of the income distribution also restricts the extent to which income can be used to buffer fluctuations in agricultural self-produce. This same logic also applies to average income:

²⁶ Tawney, *Land and labour*, p. 77.

²⁷ For example, Galloway, ‘Basic patterns’; Mokyr, *Ireland*, p. 262; Fernihough, ‘Malthusian dynamics’, p. 329; Herdt, ‘Food shortages’, p. 505; Ravallion, ‘Famines and economics’, p. 1213; Alamgir, *Famine*, p. 48.

²⁸ For example, Sen, *Poverty and famines*; see also Ó Gráda, ‘Ripple that drowns?’.

²⁹ We distinguish income (earned through wages or selling assets) from food that is grown and consumed. This allows the ‘inequality possibility frontier’ to be breached; see Milanovic, Lindert, and Williamson, ‘Pre-industrial inequality’; feasible income inequality might breach the theoretical maximum, but people do not starve because what they self-produce is not counted as income.

³⁰ Griffin, *International inequality*. The analysis would also hold for heterogeneous populations and multiple groups, but the clarity of exposition would be sacrificed; *ibid.*, p. 172.

³¹ Devereux, ‘Entitlements’, p. 279. In ‘Irish famine’, Read suggests the existence of such a mechanism during the Irish famine of the 1840s.



the lower the average income level, the easier it is for individuals to be more seriously affected by fluctuations in food production. The ‘ripple that drowns’ hypothesis sums these up: *increased income inequality and/or lower average income strengthen the negative effects of income, price, and food output fluctuations*.

While this hypothesis is broadly intuitive, taking it at face value is tricky. Farmers selling food will gain from higher food prices and lower wage costs during a famine, while landless labourers will lose.³² Further challenging the ‘ripple that drowns’ logic, Ravallion has pointed out that price instability (or a drop in incomes) during a famine does not necessarily result in increased mortality. For that to happen, the survival function needs to be sufficiently concave (in terms of food consumption), and the potential famine victims must rely on current food markets.³³ Recent empirical growth literature notes that inequality tends to reduce the responsiveness of poverty to a growth in mean income.³⁴ While typically this has been analysed in relation to when and why economic growth does or does not favour the poorest income groups, Ravallion contends that the opposite holds true as well: in more unequal societies, the poor tend to be more protected from aggregate income contractions.³⁵

The price and income shocks (exchange entitlement failure) work through food markets,³⁶ and for this to translate into increased mortality, *ceteris paribus*, the affected populace need to have first been in the markets *before* a famine to drop out of them during one. This is less likely to be the case the more unequal the distribution of income, or the lower the average income, and will result in predictions that contradict the ‘ripple that drowns’ hypothesis. In other words, *high inequality and/or low average income depress the adverse effect of income contraction and/or price increase*.

Ultimately, the tug of war—over whether inequality alleviates or accentuates the transmission of shocks—depends on the composition of aggregate food entitlements. In an environment of low average incomes, high initial inequality would mean a greater proportion of subsistence farmers, which will lessen the importance of changes in $p_j q_j$. In economies in which a substantial share of agricultural goods are produced for one’s own consumption and access to land is equal, both the agricultural labour market and the food markets tend to be thin, but when there is a certain degree of land inequality, the functioning of labour and food markets will dictate how aggregate shocks affect the poor.³⁷ Trade-offs such as these mean that high income inequality does not necessarily imply that there will be an equally high inequality in food consumption—at least not in terms of calorific intake.³⁸

³² Ravallion, ‘Famines and economics’, p. 1213; Galloway, ‘Basic patterns’, p. 277; Ó Gráda, ‘Ripple that drowns?’, p. 28.

³³ Ravallion, *Markets and famines*.

³⁴ For more on empirical evidence, see, for example, Ravallion, ‘High-inequality developing countries’; *idem*, ‘Income inequality’; Fosu, ‘Growth on poverty’; *idem*, ‘Poverty reduction’.

³⁵ Ravallion, ‘High-inequality developing countries’.

³⁶ In the pre-industrial era especially, many wages were paid in kind; see, for example, Humphries and Weisdorf, ‘Unreal wages’. In empirical terms, this means that the effect of food output fluctuation is partially confounded by the fluctuation of incomes.

³⁷ Ravallion, ‘Famines and economics’, p. 1221. See also, for example, Seaman and Holt, ‘Markets and famines’; Ravallion, *Markets and famines*; Devereux, ‘Entitlements’.

³⁸ See, for example, Floud, Fogel, Harris, and Hong, *Changing body*, p. 50. Generally speaking: inequality of wealth > inequality of incomes > inequality of calorific consumption.

III

High-quality data collected under famine conditions are rare; even many modern famine-stricken regions lack the most rudimentary social and economic statistics. The fact that most regions in the western world escaped their hungry past before the advent of high-quality population registers justifies Ravallion's lament that there is 'little hope of rigorously testing the relationships econometrically on suitable micro-data collected under famine conditions'.³⁹

The Finnish famine of the 1860s is an exception to this rule: its relatively late occurrence means there are abundant data. We have gathered substantial archival material to answer the questions posed and compiled longitudinal parish-level panel data that cover the famine years 1865–9, with an annual number of cross-sections at 198 (N = 990).⁴⁰ As the famine was almost completely a rural phenomenon, our data cover rural parishes.⁴¹ The south-eastern province of Viipuri and the northernmost administrative district of Lapland cannot be included due to unavailability of data. The spatial coverage of the data is showcased in figure 1. In the rest of this section, we present the sources used before moving on to discuss the methodological issues.

Finland's poll tax registers (*henkikirja*), which were originally compiled for tracking the taxation of individuals, are one of the oldest and most often used sources to identify Finnish individuals and households and to track population movements. In this study, the registers were used to collect data on the parish population and the number of households. While there is a long tradition of criticizing the tax register as an unsuitable source for measuring population, the 1860s Finnish poll tax registers recorded approximately just 5 per cent fewer people than the official population censuses.⁴² The high coverage during the 1860s was partly because the poll tax registers were used as a local bureaucratic benchmark for other administrative purposes, such as registering income tax (discussed later in this section).⁴³

In addition to demographic information, we used these registers to collect information about poll tax exemption (the share of households that had at least one member exempted). We used poll tax exemptions as a poverty control variable, though the vulnerability measurement it provides is noisy.⁴⁴ While exemptions pinpoint vulnerable individuals, such as the sick and disabled, they do not concentrate on the low end of the income distribution in any clear-cut manner. This is because exemption was also granted based on the number of children and, for example, taking care of the elderly, both of which usually applied to more well-off households.⁴⁵ The crude death rate figures come from high-quality local parish church registers, as reported by Turpeinen.⁴⁶

Income tax was first introduced to Finland in 1865. It was mildly progressive, so that for incomes of between 501 and 5 000 Finnish marks, the tax rate was 0.8 per cent (of the amount above 500

³⁹ Ravallion, 'Famines and economics', p. 1212.

⁴⁰ As data sources come in different spatial resolutions, many parishes were merged to form the statistical units used in this study.

⁴¹ During the peak of the mortality crisis in 1868, a mere 3% of excess mortality came from urban areas, representing half of the population share.

⁴² Kilpi, *Ammatissa toimiva väestö*, pp. 9, 110; Happonen, *Kaksi todellisuutta*, pp. 37–9. For an international treatment of the same phenomenon, see, for example, Arkell, 'Incidence of poverty'; Jütte, *Poverty*.

⁴³ Imperial Statute, *Keisarillisen majesteetin armollinen julistus. Siitä suostuntaverosta, jonka Suomenmaan säädty ovat ottaneet maksaakseen vuosina 1865, 1866 ja 1867* (2 March 1865), 2:15, 18.

⁴⁴ Voutilainen, 'Tax exemptions'. Collected from National Archives in Helsinki, provincial poll tax registers 1865–70.

⁴⁵ Jütte, *Poverty*; Voutilainen, 'Tax exemptions'.

⁴⁶ Turpeinen, *Nälkä vai tauti tappoi*; for a discussion on their quality, see esp. Pitkänen, *Deprivation*.



marks), for 5 001 to 10 000 marks, it was 1 per cent, and for incomes exceeding 10 000 marks, it was 1.2 per cent.

The lowest taxable income, at 500 marks, was fairly high. It was equal to roughly 2 250 grams of silver (1 FIM = 4.4987 grams of silver) and approximately corresponded to the combined annual expenditures (including food and housing) of a household consisting of an adult woman and man.⁴⁷ This *de facto* household-specific tax was paid by some 24.6 per cent of households in 1865, but the coverage varied greatly depending on the location and livelihoods of the occupants.

Taxable income was assessed by local taxation boards, and based on each taxpayer's declaration. If no declaration was made (as was often the case), the board levied a tax that was deemed fit, which could be contested by the taxpayer. In principle, a taxpayer was assigned the previous year's income (that is, taxable income for 1865 was based on the income earned in 1864). It is not clear if a taxpayer's economic status at the moment of taxation was taken into account, but no income tax was levied for the year if they died before the first of July.

The definition of yearly income was fairly rudimentary, but, at the same time, quite modern. Income from wages, capital returns, and inheritances were all taxable, after the deduction of 'natural costs'; that is, interest and payments to the state and local community. Dividends were excluded, however, to avoid taxing corporate income twice, which probably meant a downward bias for taxed incomes in the upper bracket of income distribution.⁴⁸

The income assessments are reliable. The taxation boards consisted of local people who were aware of the general economic situation of people living in their tax district. This has been corroborated in studies using comparative sources and from closely examining taxation hearings in which detailed discussions would often determine the economic standing of a household.⁴⁹ While relatively stable economic qualities, such as wealth, were an important starting point for assessing yearly income, aggregate tax revenue closely followed fluctuations in the nominal GDP.⁵⁰

For the data used in this study, household income information was gathered from provincial income tax registers for the famine years. Unfortunately, the income tax registers from Kuopio Province for 1870 are missing, so the information from 1871 was used instead. In total, taxation records were available for approximately 350 000 households.⁵¹

The data on grain output come from the governors' reports for each province,⁵² containing information about the volume of the most important grain varieties sown and consumed—in our case, rye and barley. The monthly price series for rye and barley come from information reported by local bailiffs to the Department of Finance in the Senate.⁵³ These market prices are considered the most accurate ones available from the 1860s. Most of the data were kindly shared by Prof. Kari Pitkänen, with additional archival work conducted for the purpose of this study.

The grain and price figures were only available at the administrative district level ($n = 39$ per year). While not ideal, this was not deemed problematic for our analysis. Finnish grain markets

⁴⁷ SVT IV: 1 1869, 5–8; Jutikkala, 'Suomen suurituloiset', p. 74; Voutilainen, *Finnish 1860s famine*.

⁴⁸ Wikström, *Valtion tuloveron*, pp. 22–3; Jutikkala, 'Suomen suurituloiset', pp. 75–6.

⁴⁹ Kaarniranta, *Sekatavarakauppiat*; Voutilainen, *Finnish 1860s famine*.

⁵⁰ Hjerpe, *Suomen talous*.

⁵¹ National Archives in Hämeenlinna, Vaasa, Joensuu, Mikkeli, Oulu, and Turku, income tax registers 1866–71. The data for 1870/1 were kindly shared by Prof. Ilkka Nummela.

⁵² National Archives in Helsinki, provincial governors' reports 1865–70.

⁵³ National Archives in Helsinki, Department of Finance (Valtiovarainoimituskunta), regional price reports 1865–70.



were sufficiently integrated,⁵⁴ so price levels in two adjacent parishes were closely correlated; and as environmental factors dictated much of the fluctuation in the agricultural economy, there was a similar geographical autocorrelation in local grain production figures that remained largely undistorted by analysing them on the administrative district level.

IV

There is no established methodology for analysing famine mortality. Cross-sectional analyses, whereby crude death rates or population changes during a famine are regressed against pre-famine variables, form the bulk of the existing methods used.⁵⁵ However, these studies exclude intertemporal variation in mortality and generally assume that spatial units are independent from one another. The studies that have explicitly addressed spatiality tend to suggest that the relationships between mortality and the independent variables are not homogeneous across spatial units.⁵⁶ As for other methodological developments, Huff has looked at the spatial autocorrelation of mortality during the Vietnamese famine of the 1940s, and there have been contributions based on longitudinal panel data.⁵⁷

Our principal analysis was conducted using standard fixed-effect ordinary least squares (OLS) models with parish crude death rate (cdr_{it}) as a dependent variable. Our basic formulation was:

$$\ln \text{cdr}_{it} = \beta_0 + \sum_{j=1}^n \beta_j X_{ij,t-1} + \sum_{(k=n+1)}^m \gamma_k Z_{ikt} + \tau_t + u_{it}, \quad (2)$$

where the logarithm of cdr in parish i in the year t was regressed against respective lagged (X) and contemporaneous (Z) correlates. We applied a location fixed-effect specification ($\beta_0 = \theta_i + u_{it}$), and to account for common shocks, we used time fixed effects (τ_t).

We used log-log specification for two reasons: first of all, it allowed us to interpret the coefficients as elasticities; that is, to track a percentage change in the dependent variable to a percentage change in the independent variables. This is convenient, as theoretically, there would be differences in mortality's *sensitivity* to changes in the independent variables. The second reason was that logarithmic transformation tones down the annual variability in the data, which is usually substantial during a famine.

In order to test our hypotheses, we used the interactions of continuous variables, a specification not often used in empirical models. In the model $Y = a + bX + cZ + dX \times Z$, an interaction $X \times Z$ graphs a line along which the effect of X on Y varies continuously with Z . The qualitative interpretation of the d coefficient depends on the sign of the main effect—a negative effect of X diminishes with an increase in Z when the estimate for d is positive, while a positive effect of X will increase (vice versa for a negative interaction term). We estimated models so that the main effect of X was the effect when $Z = 0$, but, in general, one cannot interpret the main effect

⁵⁴ Ó Gráda, 'Finland'; Voutilainen, Turunen, and Ojala, 'Multi-currency regime'.

⁵⁵ For example, Geens, 'Great famine'; Mokyry, Ireland; McGregor, 'Demographic pressure'; Kelly and Ó Gráda, 'Poor law'; eisdem, 'Three decades'; Ó Gráda, 'Irishmen'; idem, *Black '47*; idem, 'Ripple that drowns?'; idem, *Eating people*; Pitkänen, 'Patterns'; Voutilainen, 'Feeding the famine'.

⁵⁶ Fotheringham, Kelly, and Charlton, 'Demographic impacts'; Voutilainen, 'Feeding the famine'.

⁵⁷ Huff, 'Vietnam famine'; Lin and Yang, 'Food availability'; Clément, 'Radicalism'.

**TABLE 1** Hypothesized signs for interaction coefficients

	'Ripple that drowns' hypothesis	'Market access' hypothesis
Income inequality × average income	<0	>0
Grain output × average income	>0	-
Grain output × income inequality	<0	-
Grain price × average income	<0	>0
Grain price × income inequality	>0	<0

Notes: Expected signs for d coefficient in $Y = a + bX + cZ + dX \times Z$. See section IV for details.

in isolation from the interaction term. Because estimated coefficients are a cumbersome way to interpret the continuous × continuous interaction, we interpreted them using the graphical method detailed in section VI.

Table 1 provides the expected signs for these interactions. If the 'ripple that drowns' hypothesis holds, mortality should react more strongly to changes in income when income inequality is higher (a negative coefficient for the interaction means lower values—that is, more negative—for elasticity between income and mortality at higher levels of inequality). If the effect is mediated through market access, however, we would expect the opposite: concentrated income would mean that fewer people were affected by its fluctuations (a positive coefficient for interaction means higher values—that is, closer to zero—for elasticity between income and mortality at higher levels of inequality). We would expect the interaction between grain output and average income to be positive; that is, the higher the income level, the smaller the effect of output fluctuations on mortality. Similarly, we would expect that the higher the income inequality, the larger the effect of output fluctuations on mortality (<0 for the expected coefficient would mean that with a higher level of inequality, the hypothesized negative relationship between food output and mortality becomes more negative). Meanwhile, as per the 'ripple that drowns' hypothesis, we would expect higher inequality and lower average income to increase the effect of price level on mortality, and to reduce this effect if higher inequality and lower average income constrained access to food markets.

Because this empirical setup is prone to multiple phenomenon-related pitfalls, we also ran a substantial set of alternate specifications to verify the results. These include alternative grain variable measurements, procedures to disentangle the effects of average income and income inequality, alternative ways to reconstruct the income distributions, accounting for the dynamics properties of famine mortality, and, importantly, accounting for spatial dependency between the statistical units. Robustness checks and their theoretical motivations are detailed in online appendix S1.

V

We began our analysis by mapping the development of the most important variables. Table 2 provides the descriptive statistics and figure 2 shows the crude death rate, average household income, and between-household income inequality for each of the famine years with respect to their levels in 1865.

**TABLE 2** Descriptive statistics

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
Crude death rate	990	-3.29	0.57	-4.53	-1.10
Average income (reconstructed)	990	5.78	0.34	3.91	6.85
Gini coefficient (reconstructed)	990	-0.67	0.30	-1.65	-0.04
Sen income (reconstructed)	990	5.15	0.53	1.75	6.24
Average income (taxed households)	990	4.99	0.49	2.83	6.61
Gini coefficient (taxed households)	990	-1.52	0.40	-3.10	-0.38
Rye output	990	10.43	0.57	8.02	11.55
Rye price	990	3.35	0.14	3.08	3.67
Barley output	990	9.79	0.72	8.12	11.37
Barley price	990	3.14	0.13	2.89	3.54
Grain output (rye + barley)	990	10.92	0.49	9.58	11.90
Grain price (rye + barley)	990	3.28	0.14	3.01	3.62
Poll tax exemption rate	990	-2.32	0.60	-5.22	-1.05

Notes: All variables are in natural logarithms. Statistical unit: parish ($n = 198$ per year). Prices in Finnish marks, volumes in barrels (1 barrel = c. 165 litres). Reconstructed income distribution estimated with maximum likelihood, using a log-normal assumption and the Stata package `giniinc`; for qualifications, see online app. SI.

Sources: See section III.

The top panel in figure 2 shows how the crude death rate developed regionally. The famine-escalating crop failures struck most places in the autumn of 1867, but even before then, mortality had grown to crisis proportions in certain areas, striking Kainuu in the north-east in 1865/6 and south-west Finland in 1866/7. Famine mortality peaked in 1868 across a ‘horseshoe’ shaped region, depicted in figure 2. The highest mortality (with a crude death rate above 20 per cent in some places) stretched upwards from eastern Finland to Northern Ostrobothnia, then down to the west and around into southern Finland.

The contraction of average income can be seen in the middle panel of figure 2. The drop was largest in the poorer middle parts of the country, which were hit hardest by the crop failures. Income levels fell by over 30 per cent in some places, and in others by more than half, accompanied by an increase in inequality; the correlation between the change in the level of income and inequality between 1865 and 1867 was a high -0.73 ($p < 0.001$). The jump in inequality was mainly due to the impoverishment of those with the lowest incomes: while the overall number of taxed households decreased by 24.3 per cent, the average taxed income (over 500 marks) remained almost constant (a drop of only 4.44 per cent).

By 1869, the famine had receded from most regions. In the majority of parishes, income levels rose above their 1865 levels, and mortality and income inequality fell to below pre-famine levels.⁵⁸ The rest of this section details the statistics for these connections. We first study the hypotheses, and only after confirming the robustness of the results proceed to a graphical analysis of the interaction profiles.

Due to the natural sequence of events, we introduced average income, Gini coefficient, grain harvests, and poll tax exemptions in lags (defined largely by harvests in the autumn, with records compiled by the end of the year), and price level contemporaneously (peak price in the next

⁵⁸ See also Roikonen and Heikkinen, ‘Income inequality’.

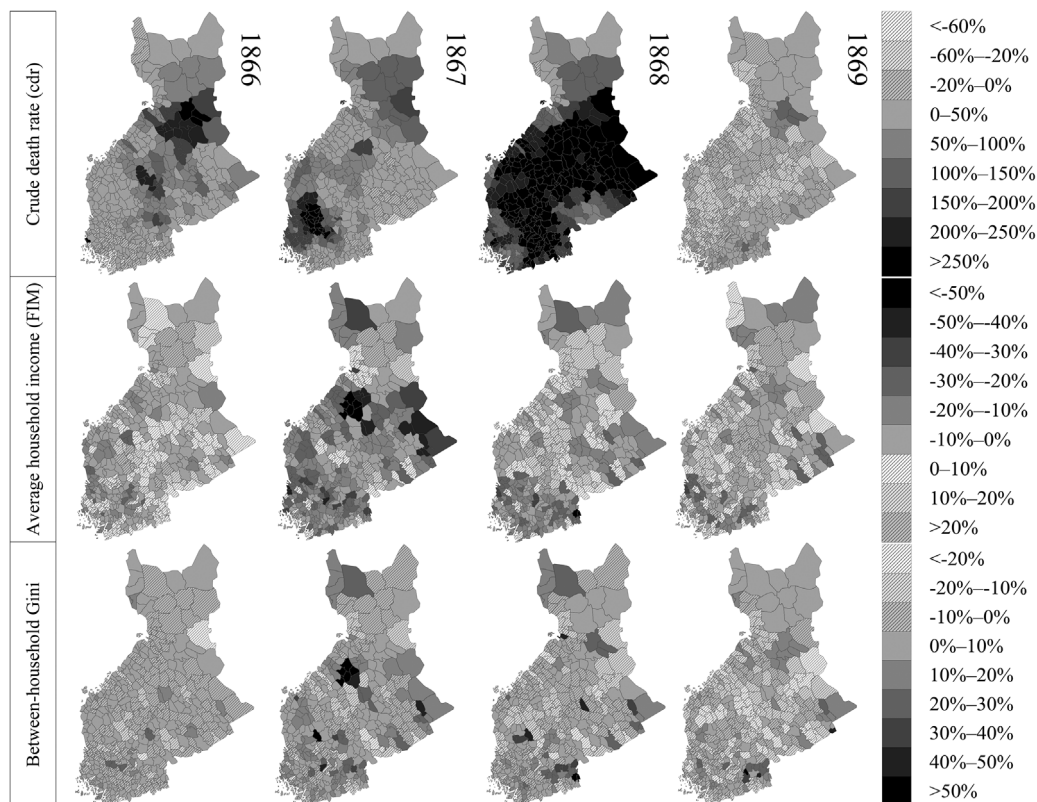


FIGURE 2 Development of crude death rate, average income, and income inequality, 1866–9, in relation to 1865. Income distribution estimated with maximum likelihood, using a log-normal assumption and the Stata package `giniinc`; for qualifications, see online app. S1. *Sources:* See section III

spring/summer). We followed the econometric specifications of Clément and estimated models using the volume of grain output.⁵⁹ For the same reason, we measured income at the household level and used fixed denominator (number of households) throughout the famine, with no spurious increase in household income resulting from changes in the denominator.⁶⁰ In the first stage, income distribution was reconstructed with maximum likelihood, using log-normal assumption, but this was later relaxed.

Table 3 shows the results from the within estimated OLS models. Model 1 produced effects with the hypothesized signs for lagged income (-0.349 , $p = 0.017$), lagged rye output (-0.508 , $p < 0.001$),

⁵⁹ Because an increase in death rates leads to a decrease in population, this might *ceteris paribus* lead to an increase in per capita grain production, and to a spurious positive correlation between mortality rates and per capita production; see Clément, ‘Radicalism’.

⁶⁰ We used the maximum household number reported between 1865 and 1870 in poll tax registers for a parish i as the local denominator. The short-term changes in household numbers most likely reflect taxation practices. The famine did not produce a unified response in household numbers—in many places, the number of registered households actually increased during the famine. This was probably because many farm owners dissolved labour contracts which had them paying labourers’ taxes, and these labourer households would have been unreported in pre-famine poll tax records.



TABLE 3 Baseline OLS models of parish crude death rates, 1865–9

Estimator	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	OLS within	OLS within	OLS within	OLS within	OLS within	OLS within	OLS within	OLS within	OLS within
Income _{t-1}	-0.349 (0.017)**	-0.155 (0.263)	-0.495 (0.561)	-0.331 (0.038)**	-2.432 (0.019)**	-0.398 (0.015)**	-5.156 (0.010)**	-0.100 (0.577)	
Gini _{t-1}	0.369 (0.111)	-2.634 (0.059)*	0.372 (0.110)	0.965 (0.529)	0.351 (0.130)	1.775 (0.230)	-2.728 (0.082)*	2.386 (0.372)	
Rye price _t	1.008 (<0.001)**	1.008 (<0.001)**	1.012 (<0.001)**	1.016 (<0.001)**	-2.371 (0.146)	0.624 (0.164)	-3.129 (0.112)	0.496 (0.308)	-2.071 (0.064)*
Rye output _{t-1}	-0.508 (<0.001)**	-0.489 (<0.001)**	-0.596 (0.257)	-0.559 (<0.001)**	-0.495 (<0.001)**	-0.500 (<0.001)**	-1.933 (0.006)**	-0.762 (<0.001)**	-0.969 (0.005)**
Poll tax exemption _{t-1}	0.087 (0.034)**	0.083 (0.043)**	0.088 (0.034)**	0.088 (0.033)**	0.080 (0.053)*	0.083 (0.045)**	0.080 (0.054)*	0.080 (0.055)*	0.077 (0.059)*
Sen income _{t-1}									-3.308 (0.006)**
Interactions									
Income _{t-1} × Gini _{t-1}		0.502 (0.025)**					0.522 (0.041)**	0.562 (0.013)**	
Rye output _{t-1} × Income _{t-1}			0.015 (0.861)				0.252 (0.033)**		
Rye output _{t-1} × Gini _{t-1}				-0.057 (0.687)				-0.318 (0.029)**	
Rye price _t × Income _{t-1}					0.580 (0.039)**		0.723 (0.032)**		
Rye price _t × Gini _{t-1}									
Rye output _{t-1} × Sen income _{t-1}						-0.422 (0.356)			0.090 (0.152)
Rye price _t × Sen income _{t-1}									0.595 (0.005)**
Time fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Location fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
R ² within	0.736	0.737	0.736	0.736	0.738	0.737	0.740	0.740	0.739
R ² between	0.005	0.006	0.005	0.005	0.005	0.005	0.004	0.003	0.004
R ² overall	0.434	0.425	0.435	0.435	0.425	0.433	0.423	0.423	0.435
Intraclass correlation (rho)	0.591	0.607	0.590	0.590	0.606	0.594	0.612	0.609	0.595
Pesaran CD average absolute correlation	0.508	0.506	0.508	0.508	0.507	0.508	0.506	0.506	0.508
N	792	792	792	792	792	792	792	792	792

Notes: Dependent variable: parish crude death rate; variables in logarithm; cluster robust standard errors; all models include constant; statistical significance: ***1%, **5%, *10% risk.

Sources: See section III.



and rye price level (1.008, $p < 0.001$). As the variables were measured in logarithms, the coefficients are elasticities. This means that a 1 per cent decline in average income resulted in a 0.35 per cent increase in crude death rate, a 1 per cent decrease in rye output in a 0.51 per cent increase in crude death rate, and a 1 per cent increase in rye prices in an equal increase in crude death rate. Poll tax exemptions displayed a small positive association with crude death rate in most of the models. The more elaborate the model, the less statistically significant the poll tax exemption rate proved to be.

The variable interactions are also presented in table 3. The relationship between income inequality and average income found unequivocal support (models 2, 7, and 8). Not only was the interaction statistically significant, but there was also a roughly identical coefficient estimate in all specifications. The positive coefficient indicates that with high levels of inequality, crude death rates reacted more stickily to changes in income level, which aligns with the hypothesis emphasizing market access.

The 'ripple that drowns' hypothesis is supported in models 7 and 8; variability in grain output loses importance as average household income grows and strengthens as inequality increases. However, model 7 also shows that the effect of rye price on crude death rate becomes greater the higher the income level, which contradicts the 'ripple that drowns' hypothesis and lends support instead to the hypothesis that accentuates the importance of market access in market-mediated shocks.

When controlled with other variables, the (inequality \times output) interaction correlated highly with (income \times output), as did (inequality \times price) with (income \times price). This made estimating their respective effects difficult if introduced into the same model. As a consequence, we combined inequality and average income by using Sen's distributionally corrected average income. With this specification, seen in model 9, we corroborated the previous findings, although the connection between rye output and average income was no longer statistically significant. This may have been because of the roughly equal but opposite effects of income inequality and average income interactions on rye output in models 7 and 8, which we will return to later.

While all models displayed high within R^2 figures (about 74 per cent), the results were deficient in several important ways. First, an average absolute correlation with the Pesaran cross-sectional dependence test indicated that there was cross-sectional dependency in the residuals. Second, we needed to assess the arbitrariness of the log-normal assumption of income distributions. Third, rye was not an ideal measure for food entitlements if drops in output and surges in price triggered a transition to substitutes, that is, barley, the availability of which would then affect the mortality outcome. Given these deficiencies, we ran robustness checks to analyse the stability of our results.

Table 4 shows representative models using not only barley output and price, but also barley and rye summed together ('grain price and output'). Models 1 and 2 in table 4 confirm that measuring the staple matters; the interaction effects between barley output/price and income/inequality are significantly stronger and more consistent than for rye. This is probably because, first, an increase in the price of food that is already highly priced (rye) results in substitution for a cheaper one (barley), while there is less room for substitution if the food was already cheap. In other words, price changes in goods where the income effect is small do not lead to a mortality response if cheaper substitutes are available; and second, the higher the initial price of the food means a higher chance that the poorest would never consume it anyway, so would not be influenced by fluctuations in its price, *ceteris paribus*.

TABLE 4 Alternative grain output OLS models of parish crude death rates, 1865–9

Estimator	(1) OLS within	(2) OLS within	(3) OLS within	(4) OLS within
Income _{t-1}	-9.628 (<0.001)***	-0.412 (0.026)**		
Gini _{t-1}	0.124 (0.943)	10.745(<0.001)***		
Barley price _t	-4.937 (0.023)**	-0.189 (0.702)	-2.518 (0.021)**	
Barley output _{t-1}	-3.946 (<0.001)***	-1.218 (<0.001)***	-2.464 (<0.001)***	
Grain price _t				-3.622 (0.005)***
Grain output _{t-1}				-2.816 (<0.001)***
Poll tax exemption _{t-1}	0.060 (0.224)	0.039 (0.405)	0.049 (0.293)	0.065 (0.137)
Sen income _{t-1}			-6.261 (<0.001)***	-7.704 (<0.001)***
Interactions				
Income _{t-1} × Gini _{t-1}	0.039 (0.889)	0.224 (0.323)		
Barley output _{t-1} × Income _{t-1}	0.597 (<0.001)***			
Barley output _{t-1} × Gini _{t-1}		-0.789 (<0.001)***		
Barley price _t × Income _{t-1}	1.026 (0.006)***			
Barley price _t × Gini _{t-1}		-1.296 (0.011)**		
Barley output _{t-1} × Sen income _{t-1}			0.374 (<0.001)***	
Barley price _t × Sen income _{t-1}			0.673 (0.001)***	
Grain output _{t-1} × Sen income _{t-1}				0.407 (<0.001)***
Grain price _t × Sen income _{t-1}				0.891 (<0.001)***
Time fixed effects	YES	YES	YES	YES
Location fixed effects	YES	YES	YES	YES
R ² within	0.743	0.742	0.743	0.751
R ² between	0.003	0.006	0.006	<0.001
R ² overall	0.306	0.295	0.280	0.391
Intraclass correlation (rho)	0.730	0.737	0.753	0.659
Pesaran CD average absolute correlation	0.503	0.504	0.503	0.503
N	792	792	792	792

Notes: Dependent variable: parish crude death rate; grain = rye + barley; variables in logarithm; cluster robust standard errors; all models include constant; statistical significance: ***1%, **5%, *10% risk.

Sources: See section III.

This result held when we summed the two grain variables together and when we added average income and inequality to the Sen income (models 3 and 4). Each model told the same story: high income and low inequality shield against fluctuations in food output, whereas high inequality and/or low average income mitigate price shocks.

Table 5 reconstructs the results with varying estimators for the censored income distribution. For the sake of expositional clarity, we took the results from the models that used aggregate grain output and price, and Sen income (combining average income and inequality measures). Model 4 dropped any parametric assumption underlying the income distribution.

**TABLE 5** Alternative income distribution OLS models of parish crude death rates, 1865–9

Estimator	(1) OLS within	(2) OLS within	(3) OLS within	(4) OLS within
Distribution:	Log-logistic	Weibull	Log-normal (Mills ratio)	Unadjusted
Sen income _{t-1}	-9.306 (<0.001)***	-6.315 (<0.001)***	-6.156 (<0.001)***	-5.340 (0.001)***
Grain price _t	-4.166 (0.007)***	-2.328 (0.027)**	-2.563 (0.011)**	-1.529 (0.171)
Grain output _{t-1}	-3.600 (<0.001)***	-2.305 (<0.001)***	-2.318 (<0.001)***	-2.063 (<0.001)***
Poll tax exemption _{t-1}	0.072 (0.098)*	0.063 (0.153)	0.059 (0.175)	0.080 (0.077)*
Interactions				
Grain output _{t-1} × Sen income _{t-1}	0.532 (<0.001)***	0.341 (<0.001)***	0.323 (<0.001)***	0.296 (<0.001)***
Grain price _t × Sen income _{t-1}	0.970 (<0.001)***	0.705 (0.001)***	0.715 (<0.001)***	0.550 (0.017)**
Time fixed effects	YES	YES	YES	YES
Location fixed effects	YES	YES	YES	YES
R ² within	0.749	0.752	0.752	0.747
R ² between	<0.001	<0.001	<0.001	0.002
R ² overall	0.399	0.403	0.390	0.447
Intraclass correlation (rho)	0.647	0.647	0.663	0.593
Pesaran CD average absolute correlation	0.503	0.503	0.503	0.505
N	792	792	792	792

Notes: Dependent variable: parish crude death rate; grain = rye + barley; variables in logarithm; cluster robust standard errors; all models include constant; statistical significance: ***1%, **5%, *10% risk.

Sources: See section III.

The most evident outcome from this was that none of the models proved different to those presented in tables 3 and 4. Log-logistic assumption provided coefficients that were a little larger, but generally, the models proved to be quantitatively similar and qualitatively identical. Importantly, none of them differed in any meaningful way from the previous models in R² terms: alternate income distribution estimators neither changed the overall model fit nor affected the conclusions drawn previously.

Table 6 provides quasi-maximum likelihood estimates for the spatial versions of the previous models. The results from spatial autoregression models (models 1–5, 8, and 9) were consistent with the OLS models in tables 3–5. Furthermore, the interaction between grain output (rye and barley) and income level was consistently statistically significant in every specification, as was the interaction between income/inequality and grain price in every model except for model 3. The results from the spatial error models (6 and 7) were also consistent with these and showed that the results for the barley variables were stronger than for the rye variables.

Introducing spatial dependency was appropriate, as the estimated spatial lag of crude death rate was statistically significant, with an estimated coefficient ranging from roughly 0.8 to 0.95 ($p < 0.001$) in all models. Similarly, spatial error was statistically significant, with an estimated coefficient of between 0.9 and 0.95. There were no qualitative differences between spatial error



TABLE 6 Spatial quasi-maximum likelihood models of parish crude death rates 1865–69

Estimator	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	ML (SAR)	ML (SAR)	ML (SAR)	ML (SAR)	ML (SAR)	ML (SEM)	ML (SEM)	ML (SAR)	ML (SAR)
Income _{t-1}	-0.356 (0.008)***	-4.615 (0.014)**	-0.131 (0.450)	-7.875 (<0.001)***	-0.402 (0.018)**				
Rye price _t	0.559 (0.012)**	-2.711 (0.142)	0.093 (0.838)			-2.297 (0.050)**		-3.286 (0.011)**	
Rye output _{t-1}	-0.316 (<0.001)***	-1.727 (0.008)**	-0.579 (<0.001)***			-1.029 (0.003)***		-0.753 (0.124)	
Barley price _t				-3.538 (0.072)*	-0.313 (0.495)		-1.803 (0.084)*		-3.180 (0.002)***
Barley output _{t-1}				-3.330 (<0.001)***	-0.951 (<0.001)***		-2.044 (<0.001)***		-2.000 (<0.001)***
Gini _{t-1}	0.347 (0.098)*	-2.465 (0.087)*	2.760 (0.278)	-0.046 (0.976)	9.593 (<0.001)***			0.079 (0.189)	0.064 (0.281)
Poll tax exemption _{t-1}	0.080 (0.031)**	0.075 (0.045)**	0.074 (0.049)**	0.070 (0.102)	0.050 (0.216)	0.064 (0.102)	0.058 (0.166)		
Sen income _{t-1}						-3.397 (0.007)***	-4.900 (<0.001)***	-3.731 (0.024)**	-5.908 (<0.001)***
Interaction									
Income _{t-1} × Gini _{t-1}		0.475 (0.044)**	0.477 (0.020)**	0.064 (0.797)	0.166 (0.408)				
Rye output _{t-1} × income _{t-1}		0.248 (0.025)**							
Rye output _{t-1} × Gini _{t-1}			-0.324 (0.017)**						
Rye price _t × income _{t-1}		0.573 (0.071)*							
Rye price _t × Gini _{t-1}									
Barley output _{t-1} × income _{t-1}				0.522 (<0.001)***					
Barley output _{t-1} × Gini _{t-1}									
Barley price _t × income _{t-1}									
Barley price _t × Gini _{t-1}									
Rye output _{t-1} × Sen income _{t-1}						0.117 (0.065)*		0.104 (0.252)	
Rye price _t × Sen income _{t-1}						0.544 (0.015)**		0.673 (0.006)***	
Barley output _{t-1} × Sen income _{t-1}							0.300 (<0.001)***		0.339 (<0.001)***
Barley price _t × Sen income _{t-1}							0.488 (0.014)**		0.668 (0.001)***

(Continues)



TABLE 6 (Continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Estimator	ML (SAR)	ML (SAR)	ML (SAR)	ML (SAR)	ML (SAR)	ML (SEM)	ML (SEM)	ML (SAR)	ML (SAR)
$W \times$ crude death rate	0.940 (<0.001)***	0.939 (<0.001)***	0.940 (<0.001)***	0.944 (<0.001)***	0.944 (<0.001)***			0.783 (<0.001)***	
$W \times$ error						0.939 (<0.001)***	0.942 (<0.001)***		
Crude death rate _{t-1}								-0.069 (0.223)	0.073 (0.223)
$W \times$ crude death rate _{t-1}								-0.064 (0.464)	-0.137 (0.161)
Time fixed effects	YES	YES	YES	YES	YES	YES	YES	NO	NO
Location fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
R ² within	0.651	0.656	0.660	0.553	0.528	0.637	0.569	0.767	0.791
R ² between	0.003	0.003	0.002	0.004	0.008	0.004	0.005	0.001	0.002
R ² overall	0.303	0.282	0.286	0.123	0.092	0.315	0.156	0.546	0.412
σ^2_e	0.068	0.070	0.067	0.065	0.065	0.069	0.066	0.086	0.081
N	792	792	792	792	792	792	792	792	792

Notes: Dependent variable: parish crude death rate; variables in logarithm; cluster robust standard errors; all models include constant; SAR refers to spatial autoregression, SEM refers to spatial error model, statistical significance: ***1%, **5%, *10% risk. Sources: See section III.

and spatial autoregression models, and both modelling choices confirmed that spill-over from one parish to another is an important feature in the spatial arrangement of crude death rate.

The autoregressive term (cdr_{t-1}) was not found to be statistically significant in any specification, thus aligning with Clément's observation from the Great Leap Famine in China. Even if the drop in mortality after a famine is a stylized fact (see also figure 2), these results suggest that there is relatively little information available in mortality's past behaviour to predict its future *during* a famine.⁶¹ This is not an unexpected result in an environment of high mortality fluctuation. Correspondingly, the spatiotemporal lag (Wcdr_{t-1}) was not found to be statistically significant in either model 8 or 9.

VI

Figures 3 and 4 show the extent to which the effect of X on the crude death rate depended on the level of Z .⁶² Elasticities of interest were represented on the vertical axis, while the interacted variable Z took up values on the horizontal. The interaction profile was then graphed using these dimensions and interpolated to the low- and high-end values of the Z variable (displayed in relation to the density distribution of Z).

The upper panel in figure 3 shows how the crude death rate depended on grain output when the average household income varied. Changes in barley output (figure 3b) had an effect on death rates until average incomes reached roughly 500 FIM, while fluctuations in rye output (figure 3a) affected death rates at higher average income levels as well. This probably reflected the dietary differences between the income groups. The plot shows that the decline in food availability had the largest impact in poorer parishes, and the effect intensified with income contraction during the famine. In 1867/8, there were 30 parishes (15 per cent of parishes in the data) with an average household income of less than 200 FIM. This put these parishes on the downward-bending section of the income–food output interaction profile, indicating that their populations were highly vulnerable to food output fluctuations.

The lower panel in figure 3 plots the crude death rate increase due to a decline in barley and rye output in relation to the level of income inequality. Variation in barley output (figure 3d) became statistically significant once the Gini coefficient reached approximately 0.3 and dropped off to about -1.3 at the highest level of income inequality; a 1 per cent decline in barley output led to a 1.3 per cent increase in crude death rates in a high-inequality environment. The coefficient was estimated positive (based on interpolation) at Gini values below 0.2, though no Gini values that low were actually observed.⁶³ The interaction profile of rye output and income inequality was similar (figure 3c), but with a slightly less strong effect. Fluctuations in rye output had a statistically significant effect with all Gini values in the data (approximately -0.75 at the high end); a 1 per cent decrease in rye output led to a 0.75 per cent increase in crude death rates.

The relationship between grain output and inequality made the effect between output and income level worse. Most of the parishes that had the lowest average incomes in 1867 were in the

⁶¹ Clément, 'Radicalism', uses a GMM estimator. High variance during a famine may render lagged levels and/or differences as weak instruments.

⁶² These are obtained using *margins* in Stata 14.

⁶³ This results from the fact that the interaction $X \times Z$ is defined for all real values of Z . Analytical focus needs to be placed at that section of the $X \times Z$ profile that overlaps with the values of Z that are actually observed in the data.

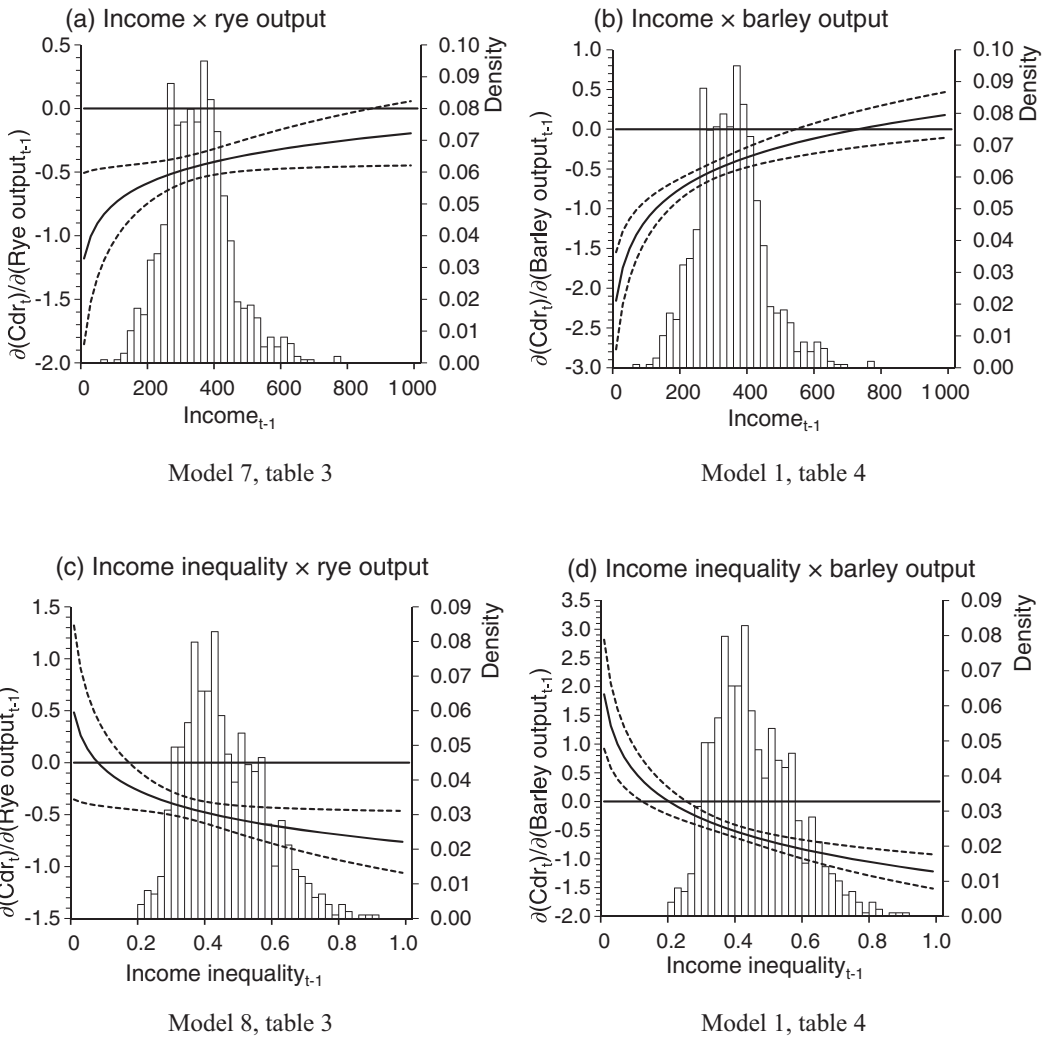


FIGURE 3 The ‘ripple that drowns’ interaction plots: income, inequality, and grain output. Coefficient estimates are elasticities; models refer to OLS models presented in tables 3 and 4; nominal income in FIM; standard errors are cluster robust. *Sources:* See section III

north, where barley consumption was the highest and crop failures had been the most severe. In many of the most impoverished parishes, Gini-measured income inequality also reached record values; in 18 of the 30 poorest parishes, it rose to above 0.6, and in seven it went above 0.7. In this respect, the simultaneous contraction of incomes and increase in inequality intensified the effects of the already substantial decline in food availability. These provide a clear vindication for the ‘ripple that drowns’ hypothesis: the poorer and more unequal the parish, the more vulnerable its populace was to fluctuations in the harvest.

The working of the market access hypothesis can be seen from the price interactions: in the upper panel of figure 4, we can see that the positive association between grain price and mortality increases as income level increases (figure 4a and b). For both grain varieties, the effect becomes statistically significant above roughly 200 FIM and increases slowly thereafter. Similarly, barley

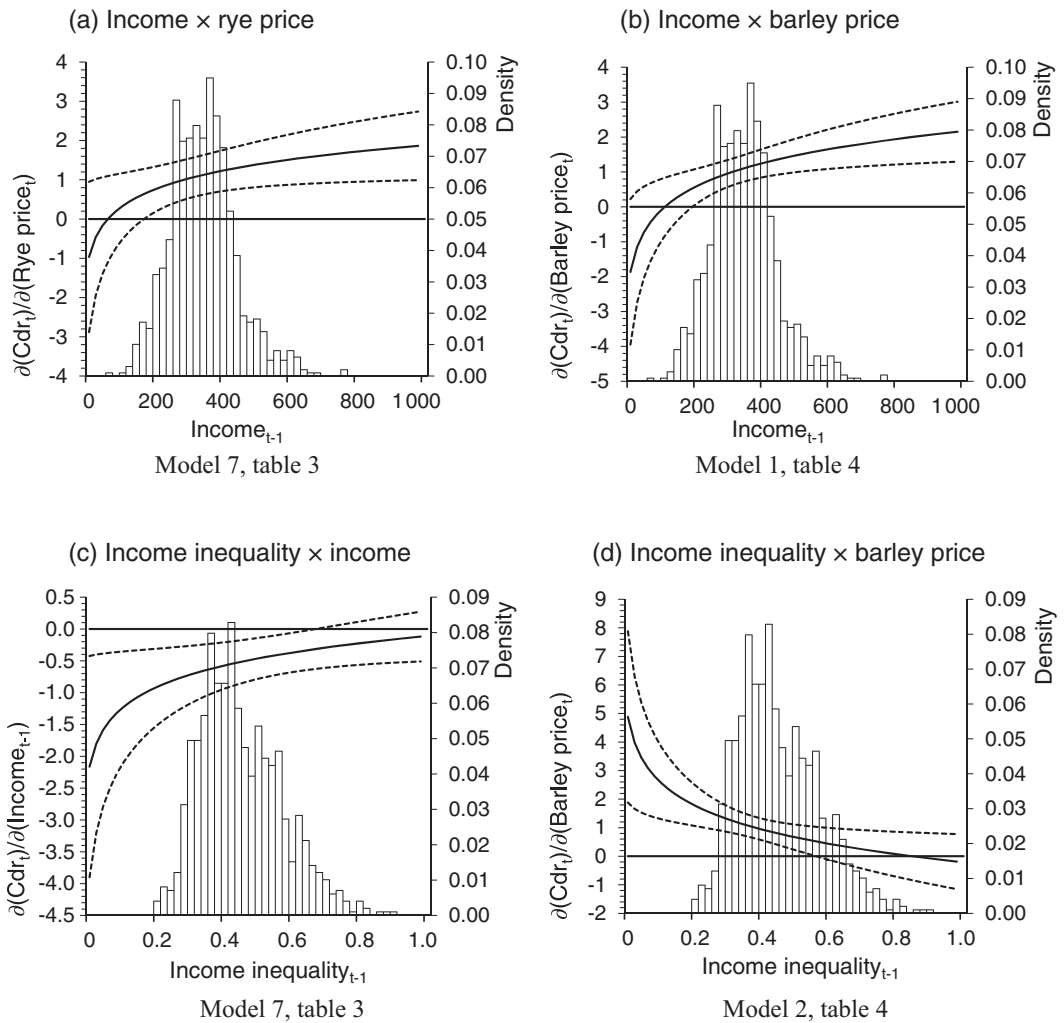


FIGURE 4 The ‘market access’ plots: income, inequality, and grain price. Coefficient estimates are elasticities; models refer to OLS models presented in tables 3 and 4; nominal income in FIM; income inequality in Gini; standard errors are cluster robust. *Sources:* See section III

price has a positive effect on the crude death rate until the Gini levels reach around 0.6 (figure 4d); at higher levels of inequality, barley prices cease to influence crude death rate outcomes. While no statistically significant effect was found for the interaction between inequality and rye price, these plots highlight that price shocks had a toned-down impact on mortality during the 1867/8 income contraction. Contrary to the aggregate effect (table 3, model 1), during the pinnacle of the famine, the estimated effect of price on crude death rates was widely below unity (and often statistically insignificant); a 1 per cent increase in prices led to a crude death rate increase of less than 1 per cent.

The lower panel also shows how the effect between household average income and crude death rate depends on the income inequality between households (figure 4c). The effect is stronger the more equally distributed the incomes are, and rises quickly (to about -1) when the Gini coefficient



is at roughly 0.3. The changes in income level cease to affect death rates when the Gini coefficient reaches around 0.7.

We took these results to reflect the composition of the parish aggregate entitlements: the more skewed the income distribution was or the lower the average income, the fewer people were in the market for food, so fewer were affected by changes in price levels. This is reinforced by the fact that in many places, a low average income (figure 1) left sufficient market purchases of grain (at 22–35 FIM per barrel) well beyond the reach of a family of mean household size (approximately 6.5 people), especially if, as generally assumed, we were to take two to three barrels to be the minimum yearly calorific requirements of an adult. Further distributional shifts during the famine resulted in a contraction of disposable incomes, meaning that the price increase in the winter of 1867/8 mattered to fewer people, as many had already dropped out of the markets when the crops failed in September 1867. While anecdotal, the idea that food in the markets was out of reach due to a lack of disposable income (rather than high price *per se*) is actually corroborated by oral accounts, such as one from Jaakkima parish in south-east Finland: ‘Those with money had no worries. They got their grain from St. Petersburg, and there was grain aplenty. But most people lacked money and as a consequence starved’.⁶⁴ Elsewhere, there were newspaper reports that ‘clothes and foodstuffs were cheap, but grain became even more expensive’.⁶⁵ Indeed, the price of many foods (like potatoes, for example) did not go up at such a fast rate, and sometimes even dropped in the poorest parts of the country during the famine. Such behaviour is theoretically possible under a strong income contraction.⁶⁶

VII

This article has focused on a long-standing, yet neglected question: what role does income inequality play in the occurrence and evolution of famines? We tested two hypotheses. The first, the so-called ‘ripple that drowns’ hypothesis, states that high inequality and/or a low income level will increase the severity of output and price shocks. The second suggests that market transmitted shocks, particularly those of price, lose their potency in an environment of high inequality and/or low income. Using unique longitudinal spatial panel data from the Finnish famine of the 1860s, we examined the hypotheses and arrived at the following conclusions.

First, we have shown that inequality as well as income level have a role in determining a region’s mortality response. Shocks are partly intensified and partly hindered by underlying economic constraints. We found that market-transmitted shocks were weakened by a contraction of disposable income in that high inequality and low average income mitigated the effects of price shocks. However, unfavourable changes in income distribution, both in terms of mean and variance, exacerbated declining food availability.

Second, the longitudinal nature of our research setting has allowed us to track feedback loops between different background factors and understand the shifting relationships of the variables

⁶⁴ National Archives in Helsinki, SHS Famine Collection, ‘Joilla oli rahaa, niin niillä ei ollut mitään hätää toimeentulosta. He hakivat viljaa Pietarista, sillä siellä oli viljaa runsaasti. Mutta useammalta puuttui raha ja se oli seurauksena nälkään’.

⁶⁵ ‘Hinnat oli halpoja sekä waate-, että ruokatawaroilla, paitsi jywät pysyi hinnassa, wieläpä kallistuivatki’, *Sanomia Turusta*, 3 Jan. 1868, no 1, p. 2.

⁶⁶ Those who really could not afford grain, for instance, could not turn to cheaper substitutes either. In ‘Entitlements’, Devereux discusses why prices increase when both aggregate demand and food supply are contracting—that is, when normally these two factors should be driving the price in different directions.



during a famine. The results confirm that fluctuations in food availability, income, and price levels, as well as their interactions, were crucial determinants of local famine mortality.

Third, the results were robust when controlled for spatial spill-overs. This is important, as diseases spread via temporary migration are generally considered a principal determinant in historical famine mortality. Based on these results, spill-overs were important in determining local death rates, but year-to-year fluctuations in mortality were invariably due to changes in local economic variables.

These empirical results provide important information on how food markets function during a widespread food security crisis, and how exchange entitlement failures contribute to mortality in such a setting. The results come from a famine that hit an underdeveloped rural economy; further research is required to see the extent to which these results apply to other historical famines, as well as famines in the modern developing world.

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