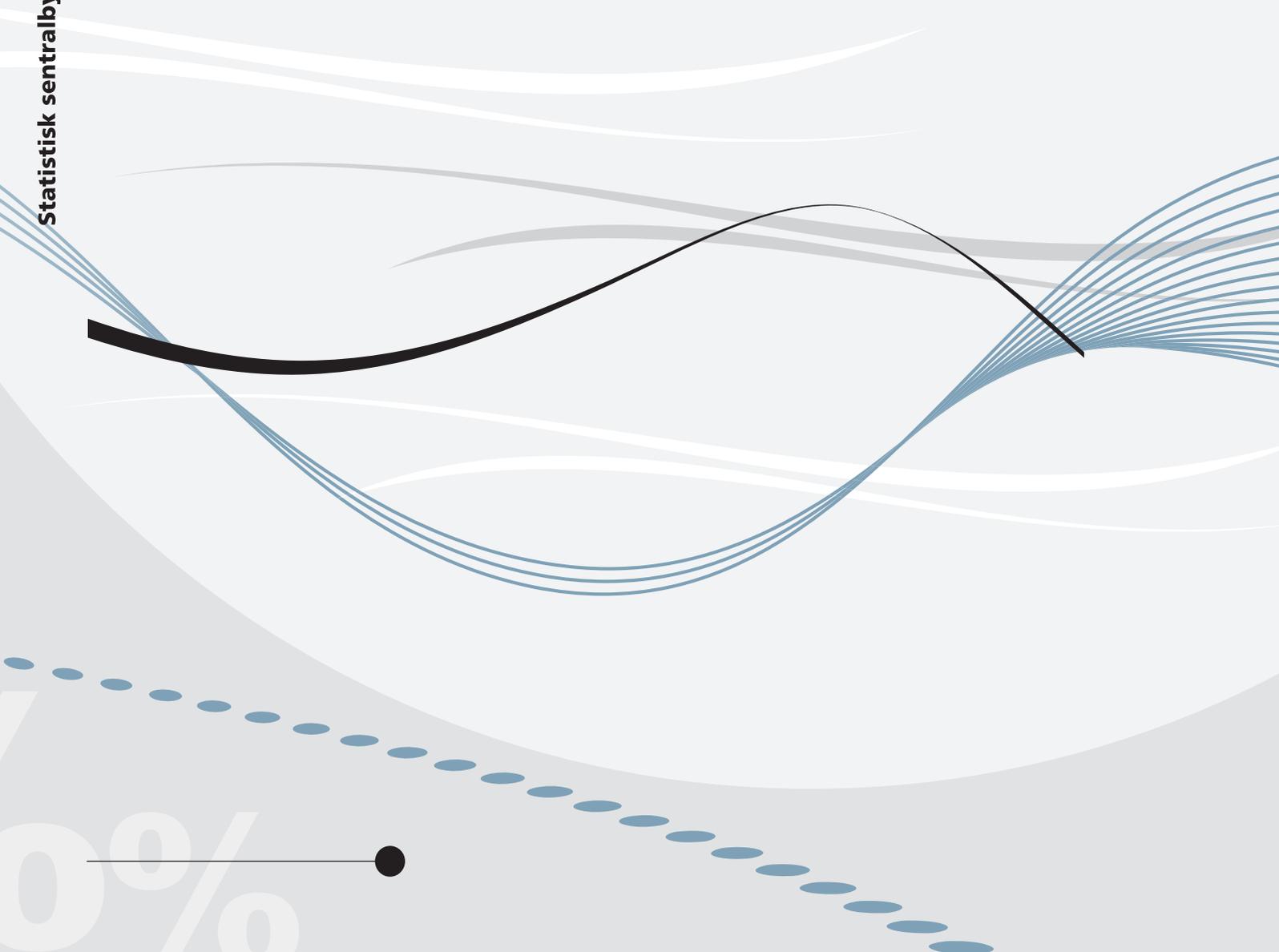


Jørgen Modalsli

**Intergenerational mobility in Norway,
1865-2011**



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Abstract:

There are large differences in intergenerational mobility between countries. However, little is known about how persistent such differences are, and how they evolve over time. This paper constructs a data set of 835,537 linked father-son pairs from census records and documents a substantial increase in intergenerational occupational mobility in Norway between 1865 and 2011. The increase is most pronounced in nonfarm occupations. The findings show that long-run mobility developments previously described for the US and UK are not necessarily representative for other countries, and that high mobility in a given country today need not reflect high mobility before industrialization.

Keywords: Intergenerational mobility, occupations, mobility measurement, economic history

JEL classification: J62, N33, N34

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Sammendrag

Det er store forskjeller i intergenerasjonell mobilitet mellom land, men vi vet lite om hvor persistente slike forskjeller er, og om hvordan de endrer seg over tid. Denne artikkelen utarbeider et datasett med 835 537 far-sønn-par fra norske folketellinger. Artikkelen dokumenterer en vesentlig økning i intergenerasjonell yrkesmobilitet i Norge mellom 1865 og 2011; økningen er tydeligst for ikke-bønder. Funnene viser at den tidligere beskrevne utviklingen i mobilitet i USA og Storbritannia fra 1800-tallet og fremover ikke nødvendigvis er representativ for andre land, og at land med høy intergenerasjonell mobilitet i dag ikke nødvendigvis hadde høy mobilitet før industrialiseringen begynte.

1 Introduction

The spread of the Industrial Revolution from its core areas to other parts of the world from the mid-1800s onward led to massive increases in economic growth and human welfare. This development was accompanied by a decrease in income and wealth inequality in most Western countries, culminating in historically low income inequality in the 1960s. Information on economic inequality and growth does not, however, fully characterize the distribution of welfare across families. If social mobility is low, meaning that individuals' positions are to a large extent determined by that of their parents, not all members of society will be able to participate in the increased opportunities made available by industrialization. Economists often conceptualize this as a “dynasty utility function”, where individuals have preferences not only over their own welfare, but also that of their descendants. Hence, the distribution of economic utility depends on intergenerational mobility. The extent of such mobility is changing over time, as documented by Long & Ferrie (2013): since the late nineteenth century, intergenerational mobility has decreased in the United States and remained relatively stable in the United Kingdom.¹

Constructing estimates of social mobility for time periods earlier than the late twentieth century is a challenging task. To examine the evolution of economic characteristics across generations, one needs data that measures these characteristics consistently across time, along with the possibility to link individuals across generations and time periods. To study the *change* in mobility over time, an even longer time span of observations is needed. However, prior to the 1970s, few population registries were computerized, and even fewer large-scale surveys were conducted.

Some existing studies of trends in mobility rely on databases constructed from preserved records from specific rural regions or small towns.² However, as industrialization and economic development coincided with large population movements from the countryside to cities, estimates of social mobility in such small geographic regions cannot be easily generalized to infer trends in mobility for society as a whole. The use of countrywide, census-based data sets have so far been restricted to analyses of Great Britain and the United States.³

This paper uses full-count digitized historical census data for Norway, and combines it with modern administrative data to construct a database of the occupations of a total of 835,537 father-son pairs spanning 146 years, from 1865 to 2011. Intergenerational occupational mobility is found to increase over the period studied, with the increase being driven by a decrease in the father-son persistence of nonfarm

¹There is also substantial variation in intergenerational mobility across present-day countries (Corak, 2013).

²van Leeuwen & Maas (2010) reviews the historical sociological literature on intergenerational occupational mobility based on such regional databases. Lindahl *et al.* (2015), studying three generational transitions in city of Malmö, find no large changes in intergenerational mobility in earnings. Dribe *et al.* (2012), using data from five rural parishes in southern Sweden, find some evidence of increased occupational mobility over time.

³See Long & Ferrie (2007, 2013), Ferrie (2005), Long (2013). For studies based on other types of sources, see for example Clark & Cummins (2015) (wealth estates) and Boberg-Fazlic & Sharp (2013) (family reconstitution data).

occupations.

This paper contributes to the literature in three ways. The first nationwide long-run data set on intergenerational occupational mobility outside the United States and United Kingdom is presented; this is also the first study to use a consistent methodology in both the nineteenth, twentieth and twenty-first century. In order to analyze this data set, new methodology on the decomposition of measures of intergenerational mobility is developed, highlighting the differential trends in mobility in and outside farming. While the increasing mobility in Norway was driven by decreasing nonfarm father-son persistence, the decrease in mobility in the United States can be attributed to an increase in father-son persistence in farming. Supplementing the Norwegian mobility matrices with occupational mean income data gives an economic interpretation to the increase in occupational mobility, and shows the relative contribution to welfare equalization of changing relative mean occupation incomes and intergenerational mobility. Finally, this paper explores the role of regional economic differences in the change of social mobility over time. In broad groupings of Norwegian regions, few systematic differences in mobility are found, and the extent of neighborhood effects have changed little. Individuals who moved from one region to another experienced higher intergenerational occupational mobility than non-movers.

Long-run changes in social mobility

There is a small but expanding literature on the long-run development of social mobility in Western countries. Long & Ferrie (2013) demonstrate that intergenerational occupational mobility increased in the United States between the nineteenth and twentieth century, using comparable sets of census or survey data for both periods. For England and Wales, however, mobility was lower than in the US in the nineteenth century and remains at about the same level today.⁴ Because of the distinct characteristics of the history of these countries (early Industrial Revolution in Britain and large geographic expansion and immigration in the United States) it is not clear how the results from these countries generalize to other Western countries. By constructing a comparable data series for Norway it is made clear that the stability of intergenerational mobility in Great Britain is not representative for Europe as a whole.

Social mobility in Norway between 1800 and 1950 has earlier been discussed by Semmingsen (1954). Reviewing legal changes and the development of the cross-section income distribution, Semmingsen argues that the move toward a more fluid society started in the eighteenth century, and accelerated through economic liberalization reforms in the nineteenth century. Social circulation is said to have increased from around 1850 onward, driven by industrialization and the increasing integration of Norway into the world market. Moreover, technological advances led to an increasing population growth, putting

⁴Because of data limitations, most historical studies of intergenerational mobility use occupation information. However, using estate data, Clark & Cummins (2015) examine wealth mobility in the United Kingdom and find strong and stable persistence in the correlation between father and son wealth between 1858 and 2012.

old social structures under pressure. In agriculture, rates of self-ownership were high — by 1900, nearly all farms were run by owner-occupiers and there were no large estates of the types seen in Sweden, Denmark and elsewhere in Europe. At the same time, old social classes disappeared (some cottagers were allowed to buy their land and became farmers) and new emerged, in particular the large industrial working class and a new middle class in the cities. The only quantitative studies of early social mobility in Norway known to this author are works on university admissions lists (Palmstrøm, 1935; Aubert *et al.*, 1960) and on the biographies of theological candidates (Mannsåker, 1954). These studies show how the expansion in the number of university students led to a steadily increasing share of students being recruited from middle-class and farmer backgrounds rather than upper-class backgrounds. The present paper supports the assertion of increased nonfarm mobility, and shows that the results from academic elites are representative for the population as a whole. The trend is shown to have continued after 1960. However, the increased persistence in agriculture shown in this paper disagrees somewhat with a general picture of increased social mobility across the board.

Moving toward the latter half of the twentieth century, there are several studies on social mobility in Norway based on large administrative data sets. Bratberg *et al.* (2005) find a stable relationship between parents' and children's earnings (for children born between 1950 and 1965) and find that mobility is high but does not change much over time. Jäntti *et al.* (2006) and Raaum *et al.* (2007) find intergenerational income mobility to be higher in the Scandinavian countries than in the United States and the United Kingdom.^{5,6} The present paper puts these findings in a historical context, by showing that the high social mobility in Norway was not present 150 years ago, and has increased regularly in the intervening period, at the same time as the development of a large set of policies in education and social assistance.

As this paper shows that intergenerational mobility in Norway increased gradually during the entire period studied, it is hard to pinpoint any one economic change that coincided with this development. One change over time that is highlighted by several authors is however decreased within-country regional diversity. Long and Ferrie argue that the fall in mobility in the United States can partly be explained by reduced economic differences between U.S. regions, removing the opportunity to achieve social mobility through geographic migration. Regional differences are also a central theme in the work of Boberg-Fazlic & Sharp (2013), who find moderate differences between the North and South of England in

⁵The evidence using other outcomes than income are more mixed. The relationship between parents' and children's elementary education is studied by Black *et al.* (2005), who find correlations in Norway that are comparable to those in other countries, but use a school reform as an instrument to demonstrate a relatively low causal impact of parents' schooling length on children's outcomes. Dahl *et al.* (2014), using data on Norway between 1989 and 2011, demonstrate that receipt of disability benefits in one generation has a substantial causal impact on the receipt of disability benefit in the next generation.

⁶There is also a substantial sociological literature on intergenerational occupational mobility in Western countries over the last 40-50 years. Breen & Luijkx (2004) find evidence of moderately increasing social mobility ("fluidity") from 1970 onward in many Western countries, though with some exceptions (notably the United Kingdom). Ringdal (2004) confirms this picture for Norway, at least for the association between father's and son's occupation; the evidence for a father-daughter association is weaker.

pre-1850 intergenerational occupational mobility.⁷ In this study of Norway, however, the difference in intergenerational mobility between regions is found to be only moderate, though one can observe a correlation between economic and occupational mobility. This is in line with the studies by Abramitzky *et al.* (2012, 2013) who find evidence of negative selection of transatlantic migrants from late nineteenth-century Norway, suggesting that migration was a way of moving out of adverse economic conditions at home. The present study does not, however, find any signs that differential development of the regions of the country contributed significantly to the increase in intergenerational mobility.

A full review of the development of policies that potentially facilitated occupational mobility in Norway between 1865 and 2011 is beyond the scope of this paper. However, it is worth noting that relatively comprehensive poverty relief systems were in place already in the nineteenth century and that social insurance systems were rolled out gradually from the 1880s onward (Seip, 1994). A comprehensive, unified national social insurance and pension system was however not established until the late 1960s.

Public elementary education was established by law in 1739, and formalized as 7-year primary education for all in 1889. There were several further reforms of primary education, extending the years of schooling or the number of hours taught per year, with reforms in nearly every decade until the establishment of 10-year primary education in 1997. Higher education was less prevalent until the post-World War 2 period, with the share of 19-year olds completing study-track upper secondary school (*examen artium*) not exceeding 10% until 1946. The public lending agency for students was established in 1947, and scholarships made independent of parents' incomes in 1968 (Norwegian Department of Education, 1999, chap. 4).

Finally, the Norwegian agricultural inheritance laws (the *odelsrett* and *åsetesrett*) differ in several ways from similar institutions elsewhere in the world. These laws regulate the ownership of farms and agricultural land, and stipulate that family members (in particular descendants) has a preemptive right of the purchase of farms, and that farms cannot be split into smaller units and divided among inheritors.⁸ One would expect these laws to strengthen persistence in farming in the entire time period studied here.

2 Data and aggregate trends

2.1 Norwegian censuses

The data used in this study comes from the Norwegian censuses of 1865, 1900, 1910, 1960, 1980 and 2011. With the exception of the 2011 census, which was compiled from administrative records by Statistics

⁷Furthermore, Chetty *et al.* (2014) find substantial regional heterogeneity in intergenerational income mobility in present-day United States.

⁸The laws have been in effect since ancient times, with several minor modifications in the time period studied; for a full review, see Norwegian Department of Justice (1972, chap. 1).

Norway, all censuses were conducted by interviews by local officials or by mail-in forms. The 1865-1910 censuses were digitized and occupations coded by a cooperation between the Norwegian National Archives, the University of Tromsø and the University of Minnesota (2014). The 1960 and 1980 censuses were consistently coded in 1984, see Vassenden (1987). In addition, data on occupation mean incomes and municipality mean incomes are obtained from tax statistics; these will be discussed in Section 2.4 below.

To examine social mobility in Norway through the entire industrialization period it is necessary to rely on occupation data rather than on education, incomes or the acceptance of social assistance. Until the mid-twentieth century, the extent of higher education was very low in Norway; in the 1950 census, only 0.13 per cent of the adult population (15 years or older) reported holding a university degree. While the state income tax was introduced as early as 1893 there is to date no large digitized sample of income data available. There is also a lack of micro data on social assistance, though these institutions have existed since the 1860s.

Data from historical Norwegian censuses (for 1865 and 1900) has found some use in economic research, with the most prominent examples being the studies of Abramitzky *et al.* (2012, 2013) on Norway-US migration. The individual records from the 1910 census were released in 2010, but only recently (2014) made available with occupation codes and has not yet seen wide use in research. Modern registry data on Norwegian individuals (data from 1960 onward) has been used extensively in many areas of social sciences ; a partial survey of studies on social mobility is given in Black & Devereux (2011). However, this study is the first to link individuals between the historical samples and modern registry data. It is also, to the knowledge of this author, the first academic study to take advantage of the occupation codes compiled for the 2011 registry-based census of Norway.

2.2 Following families over time

To study intergenerational mobility, it is necessary both to establish family relationships between individuals and to link observations of individuals that are made at different times. If information on the occupation of fathers and sons were taken from the same census, we would have reason to be worried about life-cycle bias. Occupations can change over the life cycle, and in farmer societies the son might not be able to take over the farm until the father reaches a certain age. Moreover, historically the main source of relationship information in the census derives from the household; the father-son links are identified by the family information recorded in the census — individuals listed as a son of somebody else in the same household. For this reason, occupational information is always taken from two different censuses, by the following approach: First, an individual has an observed occupation. Second, we try

to link him to a previous census. Third, in this previous census, we identify his father and record his occupation. This gives us the observation on this father-son pair of occupations. To further minimize the risk of life-cycle bias, only occupation information for an individual between 30 and 60 years of age is used.

The family relationships of people residing together are recorded in the census in all time periods studied here, and can be supplemented with population registry data after 1964. Hence, most of the effort in constructing a generational database relates to the linkage of individuals across censuses. The Norwegian Central Population Register, with unique identification numbers for all individuals living in Norway, was established in 1964 based on the 1960 census. For this reason, linking individuals after 1960 is straightforward and link rates for the 1960-1980 period and the 1980-2011 period are close to 100 per cent.

Before 1960, there was no national database of individuals in Norway. For this reason, linking of individuals are done based on names, birth dates and birth places. The links are based on the full-count historical census micro-data samples of 1865, 1900 and 1910. The census records contain information on, among other things, names, sex, age, place of birth, name of residence location, and occupation. The 1910 census also has information on date of birth. The link to the modern period was established using an extract from the initial version of the Central Population Register with the unique identifier as well as the individual information listed above.

The spelling of first and last names change between sources, both because of enumerating errors and because individuals might change the spelling of their name over time. For this reason, rather than only linking individuals whose names are identically spelled, a metric of the similarity of any two names is calculated using the Levenstein algorithm as implemented by Reif (2010). Historically, several systems of family name formation were in use in Norway: inheritance of father's surname, patronymic based on father's first name or the name of the farm of residence (or origin). Gradually, last names came to be seen as permanent and were inherited directly from the father — this practice was encoded into law in 1923 (Norwegian Department of Justice and Police, 2001, chapter 4). To take account of this variation in naming customs, last-name comparisons are done both on the last names as stated, on the last name stated compared to the farm name in the other period, and on the last name stated compared to a constructed patronymic based on the father's name. Such differences are computed between all pairs of first names and all pairs of last names, and the difference is converted into a score used for considering matches.

Potential matches are also scored based on the similarity of birthplace and of time-of-birth. For the 1865-1900 link only year of birth is available; 1910 and 1960 have complete birth dates. Until 1910 the municipality of birth is recorded, so 1865-1900 can be matched on quite detailed birth locations (there

were 491 municipalities in Norway in 1865), while the 1960 census only has county of birth and hence is matched on that. Individuals are matched if they have a high score on similarity in first name, last name, birth place and birth time, and if they are unique; that is, if there are no other potential matches with similar match quality. No information on the identity of family members or location of residence is used for matching, as this would bias the sample toward non-movers and those with more stable household structures. Further information on the matching method is given in the Appendix.

The final data consists of occupational cross-sections for men aged 30-60 in 1865, 1900, 1910, 1960, 1970, 1980 and 2011.⁹ This study is restricted to men (fathers and sons) for two reasons. First, most women change their names at marriage in Norway, at least historically, and it is hence much harder to match women between the pre-1960 censuses than it is to match men. Second, the economic principles behind the categorization of women’s employment has changed over time, and very few married women report any occupational information before 1970.

t_0-t_1	Matchable in t_1	Share found in t_0	Known father in t_0	Matched pop.	Father age 30-60	Both have occ.	Final sample
1865-1900	246,875	36.9%	71.7%	65,230	91.4%	98.1%	58,459
1910-1960	223,874	50.7%	78.0%	88,470	88.8%	89.6%	70,339
1960-1980	717,678	100.0%	40.3%	289,040	82.3%	84.6%	201,298
1980-2011	883,951	100.0%	93.6%	827,210	80.8%	75.6%	505,441
Alternative sample: age 0-15 at t_0 only							
1865-1900	160,352	37.0%	82.8%	49,059	92.5%	98.1%	44,525
1910-1960	223,874	50.7%	78.0%	88,470	88.8%	89.6%	70,339
1960-1980	154,901	100.0%	80.3%	124,437	97.5%	86.0%	104,402
1980-2011	455,843	100.0%	97.4%	444,175	81.0%	78.5%	282,613
Other studies							
1850-1880	62,811	21.9%	74.2%	9,497	US 1% (1)		
1851-1881		20.3%		14,191	UK 2% (1)		
1865-1900		≈ 5%		20,446	NO/US (2)		

Table 1: Match rates, baseline and alternative sample. Other studies (1) refers to Long and Ferrie 2013; (2) to Abramitzky et al 2012

From the seven census observations, the father-son observations with time differences approximating a generation length is 1865 to 1900, 1910 to 1960, 1960 to 1980 and 1980 to 2011. The first four lines of Table 1 gives the match rates for these samples. Let t_0 denote the first census of the match, where fathers’ occupations are observed, and t_1 denote the second census, where sons’ occupations are observed. The first column states the matchable population — that is, t_1 census records of men between 30 and 60 years of age, born in Norway, who are old enough to have been observed in the t_0 census. The second column gives the share of these individual census records that can actually be matched to the t_0 census using the procedures outlined above. The match rate is 36.9% for the first set of observations

⁹The censuses between 1865 and 1900 and between 1910 and 1960 are not digitized in full count, while the censuses of 1990 and 2001 do not contain information on occupation for the entire population.

and 50.7% in the second. Non-matches occur due to combinations of names and other characteristics being too common, so potential matches cannot be distinguished from each other, from name changes obstructing matches, and from misreporting or misspellings of names above the threshold used in the matching algorithms.¹⁰ From 1960 onward, with the establishment of national identification numbers, individuals are fully matched between censuses.

The third column of Table 1 gives the share of the matched population for which we have the identity of the father at t_0 . Non-matches here are mainly due to the father and son not residing together at t_0 . For this reason, the score is lowest in 1960; the individuals aged 30-60 in 1980 were aged 10-40 in 1960 and so a large number of these would have moved out of their parental home. When the Central Population Register was introduced in 1964, it was to a large extent based on the 1960 census and the family information (derived from co-residence and household positions). After 1964, this information was continuously updated, giving a much higher father-son match rate in 1980. To alleviate the low father-son match in 1960, robustness checks were also conducted with a smaller sample, where the population was restricted to those being 0-15 years old at t_0 . The match rates for this sample is given in lines five to eight of Table 1. The trends described in this paper also hold up for this restricted sample. The Appendix shows results with alternative samples and controls for father's and son's age.

The fourth column of the table gives the matched population that can potentially be used for analysis. However, once we restrict the father's age to be between 30 and 60 at the time of observation (column five) and both father and son actually reporting an occupation and being in the labor force (column six) gives the final analysis sample ranging from 58,459 for 1865-1900 to 505,441 for 1980-2011.

The matched population can be compared to other studies utilizing individual match rates, namely the study by Long & Ferrie (2013) and Abramitzky *et al.* (2012). As methodologies and the way of reporting percentages (counting from t_0 or t_1) differ across studies, not all the columns can be replicated for these studies. Backward match rates in the Long and Ferrie paper are slightly above 20%; as the data is sampled, they cannot rely on uniqueness for matches with substantial deviations, and the regional dimension in their data is coarser.¹¹ Abramitzky *et al.* match the Norwegian census data in t_0 to US census data in t_1 and hence have additional challenges in the form of spelling changes and coarse details of birthplace reporting, bringing average match rates down to around 5%.

¹⁰Estimates of intergenerational mobility do not change substantially when the thresholds are varied. See the Appendix for calculation on samples constructed using alternative scoring rules.

¹¹The twentieth-century mobility samples used by Long & Ferrie are derived from survey data with questions asking respondents to recall father's occupation at an earlier date, and is hence not comparable to the type of data utilized here.

2.3 Changes in the occupation distribution

With the observation sample established as men between 30 and 60 years of age, we can now examine the changes in the cross-section distribution of occupations. Any study of mobility over a long time period has to take into account the large changes in economic environment that takes place over time. In particular, changes in the occupation environment are important determinants of the relationship between parents' and children's employment opportunities.

At this point it is useful to introduce the occupational categories that will be used in this paper, as the changes in the size of the occupational groups reflect the structural change in a clear way. To facilitate comparison across countries, the classification is based on that used in Long & Ferrie (2013).

First, we separate farmers from non-farmers. Farming has historically been the most important occupation in nearly all societies, and still employed a large part of the population in the mid-nineteenth century. There is substantial variation in the economic standing of farmers, however, in most years, census records have no information on farm sizes and auxiliary economic resources such as ownership of forests. Most farmers in Norway are and have been small-scale proprietors with few or no employees. Both owner-occupier farmers and tenant farmers are included in this group.

Second, we separate non-farm work into "white-collar" and "blue-collar" groups. These correspond roughly to a non-manual / manual divide of tasks. The white-collar group includes both elite occupations like business executives and top-level civil servants, and more prevalent occupations like teachers, engineers or salesmen.

The manual occupations are further split into a skilled/semiskilled group that requires education or specialized training, such as for example carpenters and welders, and an unskilled group that depends mainly on pure physical work, including fishermen, cottagers, day laborers and forest workers. These four categories (White collar, Farmers, Manual skilled, Manual unskilled) provide the framework for the occupation analysis.

Any categorization of occupation over such a long time period has to involve some compromises, both because the granularity of classifications change and because of changing task content of occupations. The methodology used in this paper does not depend on any ranking of occupations; in particular, the movement between farming and other occupation groups reflects a sectoral change of the labor force ("horizontal" movement) as much as "vertical" movement between social classes. Similarly, there will be some manual occupations at some points in time that are better-paid than some white-collar occupations. Insufficient data on status changes in fine-grained occupation data, as well as substantial change of occupational classifications over time are the reasons why this paper relies on these four occupation categories. The results are robust to an expansion of the scheme to five categories (splitting

white-collar occupations in “upper” and “lower” occupations). Appendix Tables A1-A4 lists the most prominent occupations in each occupation groups at different points in time.

Figure 1 shows the development of the population share of each of the occupation groups over time in Norway and the United States, in both cases restricted to men between 30 and 60 years of age. We see that there are some similarities in the trends in the two countries. The share of the populations that are farmers decreases from nearly half to nearly none; the change is somewhat faster in the United States. The share of white-collar occupations are increasing, to the extent that more than half of all men in both Norway and the United States now hold these types of occupations. Industrialization is reflected in the trend for the manual skilled workers, where the population share in Norway increases from 18 per cent in 1865 to 42 per cent in 1960, then decreases to 31 per cent in 2011. For most of the time period, there is a downward trend in the number of unskilled workers; this also reflects the decline in the number of farm workers.

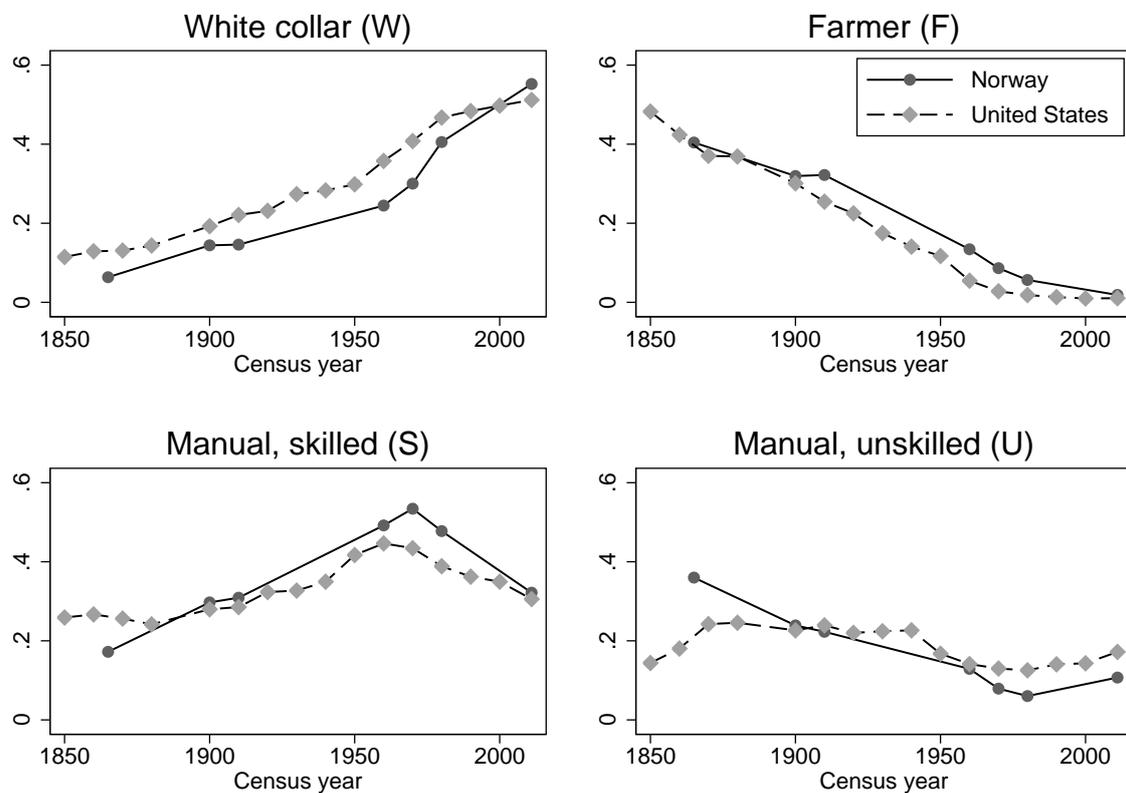


Figure 1: Occupational distributions. Share of men age 30-60 that work in given occupation group, Norway and United States. Sources: Norway: see text, US: author’s calculation from USA IPUMS

It should be noted that the share of farmers in both Norway and the United States in the mid-nineteenth century was much higher than in the “core” European countries. As an example, using a

comparable occupation classification on data for Great Britain in 1851 and 1881 gives a share of farmers of seven and five per cent, respectively, while the share of skilled or semiskilled manual workers is nearly sixty per cent in 1881. A similar exercise of Sweden for 1890 and 1900 gives a farmer share of 28 and 24 per cent, lower than the US and Norway but much higher than Great Britain.

2.4 Mean incomes

The set of occupations presented above captures important transitions between tasks and industries. Occupations is the only variable that is available at the individual level and consistently measured over the entire time period studied, and the categorical analysis that will be presented in the first part of the next section does not rely on any ranking of these occupations with respect to each other.

However, for some analyses, it is desirable to also have income data. While this is not available on an individual level, mean incomes per occupation category can be constructed. Mean income by occupation category for men aged 30-60 for 1980 and 2011 is compiled from individual tax records, on file at Statistics Norway. Furthermore, information on occupation in 1960 is combined with the same individuals' incomes in 1967 (the first available year) and used as an estimate of mean income by occupation in 1960. For 1910, information on incomes by occupation is taken from published tables of mean income by occupation, gender and age (Statistics Norway, 1915). The 1865 data is taken from income categories for 1868 reported in Norwegian Department of Justice (1871).¹²

White-collar mean incomes fell from 2.36 times population mean income in 1865, when the white-collar group was very small, to 1.17 times population mean in 1980, with a moderate increase after this. Manual skilled workers experienced a decline from 1.06 times population mean income in 1910 to 0.61 in 2011. The means for the two remaining groups, farmers and unskilled, generally increased from 1910 to 1980 and fell again from 1980 to 2011. The time trends are shown in Figure A1.

In addition to the countrywide occupation mean incomes, the income mean per municipality is available from the tax statistics, which have run more or less continuously since 1893. The mean incomes are taken from tax publications for 1900, 1910 and 1960, from compilations of individual tax records for 1970 and later, and from the 1868 report cited above for 1865. These numbers give mean income for all taxpayers, and will be used in some regional analyses.

¹²Unlike the other years, the age restriction for the 1865 income data is all men age 25 and above. Moreover, the data is given in income intervals rather than with mean incomes, so some imputation of incomes was necessary. For 1900, no income data was available, and the 1910 income data has been used.

3 Social mobility

3.1 Transition matrices and probabilities

The central unit of analysis for the study of intergenerational mobility is the 4×4 matrix of father's and son's occupation choices. Visual examination of the matrix gives some information of the extent of occupational change between generations.¹³ For example, in the 1865-1900 period, 45.6 per cent of sons belonged to a different occupation group than their father, increasing to 50.2 per cent from 1910 to 1960, 51.5 per cent from 1960 to 1980 and decreasing slightly to 49.7 per cent for the 1980-2011 period.

We can further analyze the occupational choice of sons (indexed by j) given the occupational choice of fathers (indexed by i). Denoting the raw counts in Table A5 by X_{ij} , the probability of a son obtaining occupation j given father's occupation i is

$$p_{ij} = X_{ij} / \sum_{j=1}^4 X_{ij} \quad (1)$$

where the indexing $j = \{1, 2, 3, 4\}$ corresponds to the four occupation groups (White collar, Farmer, Skilled, Unskilled). We can examine the evolution of these probabilities from 1865 to 2011 in Figure 2, where each panel refers to one father's occupation and the line within each panel is the probabilities of son's occupations.

The upper left panel shows the relative occupation distribution of sons of men with white-collar occupations. For all periods, the share of sons with the same occupation is more than 60%. Around 20% of sons are going into skilled occupations, while there is always a low share of sons going into farming or unskilled occupations.

The upper right panel of Figure 2 shows the occupation choices of sons of farmers. In 1865, agriculture was widespread and 60% of the linked sons of farmers are recorded as farmers in 1900. This share falls dramatically over time but is still 18% for the last period, even though the share employed in farming in 2011 was only around one per cent. The largest non-farm occupation choice for farmer sons is manual skilled occupations until 1980. Over the entire time period, white-collar occupations are gaining ground among sons of farmers, and in the 1980-2011 period, this is the most common form of occupation for this group. The recruitment into unskilled occupations is relatively stable.

Those growing up with fathers who hold skilled manual occupations overwhelmingly choose similar occupations, though the share is steadily declining in the late twentieth century and gradually replaced with white-collar occupations. For sons of unskilled fathers there is also a large propensity to enter into

¹³The matrices for the four transition periods are presented in Table A5.

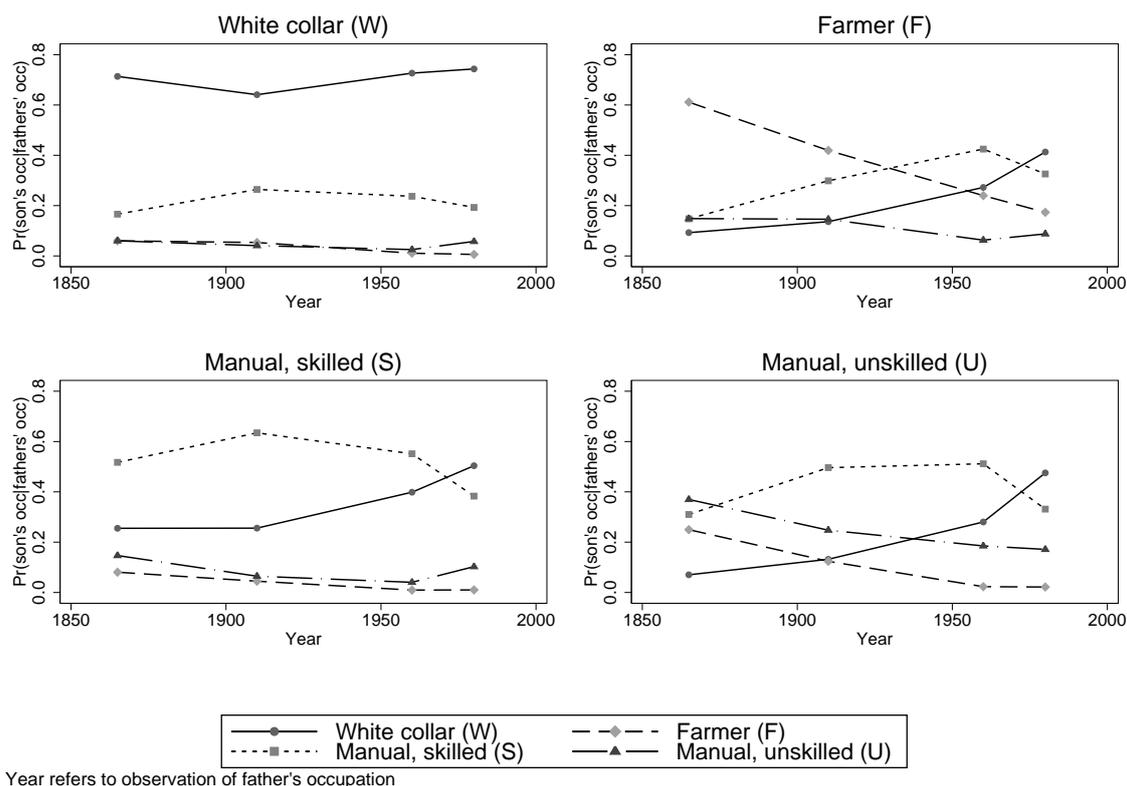


Figure 2: Transition probabilities. Probability of son's occupation (lines), given father's occupation (figure titles)

skilled occupations; after 1900 less than one third of sons of unskilled enter unskilled occupations.

From 1865 to 2011 there was an increase in the probability of switching occupations for all groups except sons of white-collar workers. However, this large increase (mainly from an increase in the probability of sons obtaining white-collar and manual skilled occupations) is related to the development of the occupation distribution in the economy as a whole, as shown in Figure 1. The number of farmers fell sharply over the period we study, but the number of unskilled occupations has also gone down. This reflects changes in the nonfarm sector, but the farm sector also employed a lot of unskilled labor - as hired hands or part of cottager contracts - that disappeared over time. To take account of such changes, it is useful to apply some of the standard tools of categorical analysis.

3.2 Assessing relative mobility

To better understand how intergenerational occupational mobility has changed over time, it is necessary to correct for the change in the marginal occupation distributions. To this purpose, standard two-way odds ratios provide a useful tool. For a father's occupation i , the "advantage" his son has in obtaining

the same occupation i compared to any other occupation can be expressed as a ratio of probabilities $p_{i,i}/(1 - p_{i,i})$. The availability of occupations change over time, and we can hence expect this ratio to be affected by the availability of i occupations compared to other occupations. To account for this change, we compare the probability ratio for sons of i -fathers to similar ratios for non- i fathers, indexed by $\neg i$: $p_{\neg i,i}/(1 - p_{\neg i,i})$. These odds ratios, composed from 2×2 tables of fathers' and sons' occupations collapsed from the 4×4 tables shown above, are denoted

$$\Theta_{2,i} = \log \left(\frac{p_{i,i}/(1 - p_{i,i})}{p_{\neg i,i}/(1 - p_{\neg i,i})} \right) \quad (2)$$

and express the “advantage” a son of a father with occupation i has in obtaining occupation i compared to a son of a father with a different occupation. For each of the four occupations, the trend in Θ_2 is shown in Figure 3.

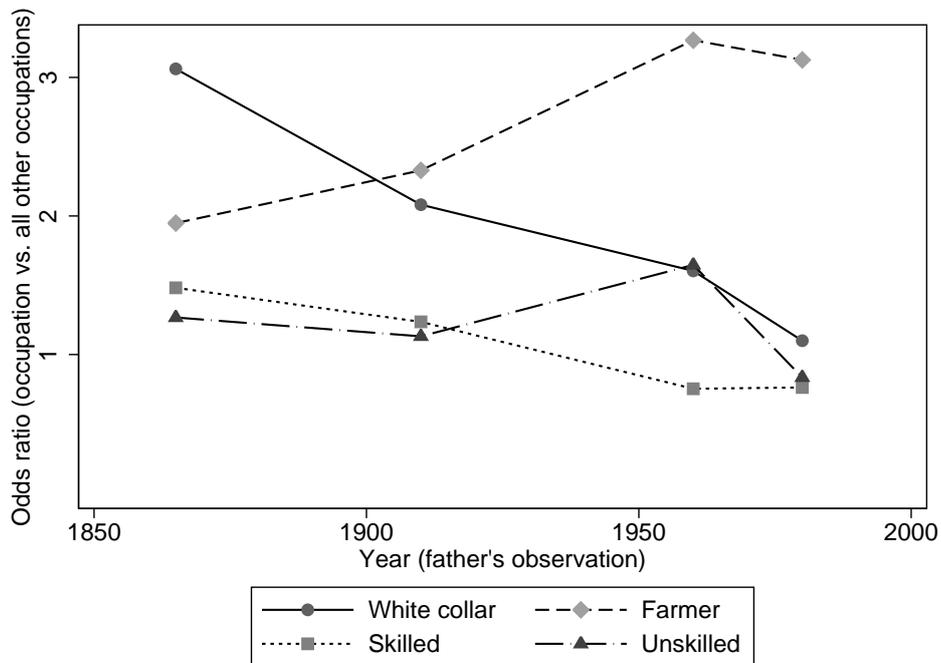


Figure 3: Two-way odds ratios: excess probability for obtaining occupation, given that father had same occupation. For each occupation X , $\log \left(\frac{(p_{X,X}/p_{X,\neg X})}{(p_{\neg X,X}/p_{\neg X,\neg X})} \right)$

The odds ratio for white-collar, starting at $\Theta_{2,W} = 3.1$, shows that sons of white-collar fathers in the first observed generation were $\exp(3.1) = 21$ times more likely than other individuals to obtain white-collar occupations compared to non-white-collar occupations. This advantage gradually disappeared over time, and the odds ratio in 1980-2011 was reduced to 1.1, giving a probability ratio for sons of white-collar that is around three times higher than that of sons of fathers with other occupations.

The figure shows a similar trend for sons of fathers with manual skilled occupations, though starting from a lower level with a more gradual development. For sons of fathers with manual unskilled occupations there is a less clear trend, with persistence being higher for the 1960-1980 father-son pair than for the 1910-1960 pair. Finally, for farmers, the trend is entirely opposite of the other occupations, with an increase from $\Theta_{2,F} = 1.9$ in 1865-1900 to 3.1 in 1980-2011.

3.3 Outside the diagonal: the full set of odds ratios

While two-way odds ratios as presented above correct for changing marginal distributions, the trends in Figure 3 only represent changes in movement into or out of any given occupation. Some changes in social mobility concern movements outside the diagonal of the mobility matrix. For example, from 1960-1980 to 1980-2011 the probability of obtaining a white-collar occupation increased faster for a son of a father in the “manual, unskilled” category than a son of a father in the “manual, skilled” category. Such differences in probabilities outside the diagonal also need to be taken into account in a study of the time trends in intergenerational mobility.

To preserve the restriction that movements between occupation groups cannot necessarily be categorized as upward or downward, we continue to use odds ratios, but move to the full universe of all ratios in the intergenerational mobility matrix. There are a total of 144 such odds ratios for a 4×4 table; however, because of symmetry, only 36 of these are unique. For a set of two father’s occupations (indexed i, l) and two son’s occupations (j, m), the (log) odds ratio Θ_{ijlm} is

$$\Theta_{ijlm} = \log \left(\frac{p_{ij}/p_{im}}{p_{lj}/p_{lm}} \right) \quad (3)$$

If one considers the example where i and j are white-collar occupations and l and m are farming occupations, the nominator of the odds ratio compares the probability that the son of a white-collar father obtains a white-collar occupation to the probability that he obtains a farmer occupation. In 1865, these probabilities were 0.71 and 0.17, respectively. The denominator gives the corresponding ratio for sons of farmers, which is 0.25/0.52. The log odds ratio Θ_{WWFF} is then the ratio of these two ratios, $\log(8.60) = 2.15$.

To compare mobility at different points in space and time, we use the statistic proposed by Altham (1970) and further used by Altham & Ferrie (2007) and Long & Ferrie (2013), to assess the degree to which matrices are different from each other. The distance between two matrices is computed as a constant times the quadratic mean of all differences between the odds ratios obtained from the matrices.¹⁴

¹⁴The constant is $N(N - 1)$, where N is the number of categories in the matrix. While arguments could be made to use

We focus on the comparison between an observed mobility matrix P and a hypothetical matrix J of full mobility, where sons' occupational choice is independent of father's occupations. For J , all log odds ratios Θ are zero. The measure of mobility for a matrix P , where a high number indicates low mobility, is hence

$$d(P, J) = \left(\sum_{i=1}^N \sum_{j=1}^N \sum_{l=1}^N \sum_{m=1}^N [\Theta_{ijlm}^P]^2 \right)^{1/2} \quad (4)$$

The metric $d(P, J)$ (d henceforth) summarizes the distances of odds ratios from zero: if there are large differences in the transition probabilities of sons of fathers with different occupations, a society is said to exhibit low degrees of intergenerational occupational mobility. Zero refers to full mobility, no association between father's and son's occupations, while there is in theory no upper bound on d except for that imposed by the discreteness of the data.¹⁵

The first column of Table 2 below reports the Altham statistic for the Norwegian samples, along with the US and UK estimates from Long & Ferrie (2013). All statistics are significantly different from zero at the 1% level using the χ^2 test proposed by Altham & Ferrie (2007). The Altham statistic d for the 1865-1900 father-son pair in Norway was 24.2. This is comparable to the 1851-1881 statistic for UK (at 22.7), and much higher (indicating lower intergenerational mobility) than nineteenth-century United States which has $d = 11.9$ (for 1850-1880) and $d = 14.6$ (1880-1900). Mobility in Norway increased over time, with the Altham statistic down to 20.3 for the 1910-1960 period. However, for the 1960-1980 father-son pair, the statistic was up to 22.3, to fall again to 19.2 in 1980-2011. There was a strong increase in the US Altham statistic from the nineteenth to the twentieth century, with the 1950s-1970s statistic at 20.8. For the UK, there was also a small increase.

It follows from these numbers that there was an increase in intergenerational occupational mobility in Norway from the nineteenth to the twentieth century, compared to a strong decrease in the United States and a moderate decrease in the United Kingdom. However, as the Altham statistic d combines information on all odds ratios of a mobility matrix in a single number, it is hard to disentangle entirely what these changes reflect. Xie & Killewald (2013) and Hout & Guest (2013) challenge the use of

the geometric mean directly, that is, dividing the Altham statistics reported here by 12, this paper uses the original scaling to ease the comparisons to previous studies.

¹⁵Alternatively, one can compare two matrices P and Q directly by calculating (as in Long and Ferrie)

$$d(P, Q) = \left(\sum_{i=1}^N \sum_{j=1}^N \sum_{l=1}^N \sum_{m=1}^N [\Theta_{ijlm}^P - \Theta_{ijlm}^Q]^2 \right)^{1/2}$$

This distance does not, however, give any explicit ordering of the matrices with respect to intergenerational occupational mobility. Such comparisons are reported in the Appendix, Table A6. Note that because of the multidimensional nature of the matrix comparisons, in general, $d(P, Q) \neq |d(P, J) - d(Q, J)|$.

this metric, arguing that low mobility among farmers is given undue weight in the estimation of social mobility. For the Norwegian data, this would mean that the high persistence among farmers is taken to contribute to low social mobility today, even as the economic role of farmers has greatly diminished.

To examine in more detail which occupational categories contribute to the mobility metric d , we can classify the odds ratios by whether they involve farmers or not. Each odds ratio is a comparison of a pair of fathers' occupations and a pair of sons' occupations. In a set of four occupations there are six pairs, half of which will contain any one category. As half of the odds ratios involve farmers in one of the father's occupations and half involve farmers in one of the son's occupations, we have four categories with nine odds ratios in each.¹⁶

We start with the odds ratios that do not compare farmers at all: the comparisons between white-collar and skilled (WS), white-collar and unskilled (WU) and skilled and unskilled (SU) fathers paired with the WS, WU and SU comparisons for sons (nine odds ratios in total). Here the increasing mobility trend in Norway is evident in nearly all odds ratios: they move closer to zero as time passes. If we compare nonfarm probability ratios for sons of white-collar workers to those of sons of skilled workers, the difference is disappearing rapidly - and monotonously - in Norway between 1865 and 2011. In the US and UK, however, there is a slight increase. Mobility is increasing over time also for other comparisons of nonfarm fathers and nonfarm sons. For example, the probability of obtaining a white-collar occupation over an unskilled manual occupation in the late nineteenth century was more than 60 times higher for the son of a white-collar worker than for a son of an unskilled manual worker in Norway 1865-1900 ($\Theta_{WWUU} = 4.13$), while the corresponding numbers for the UK and the US are around 20 and 7. Between 1960 and 1980, the difference was still as high as 19 in Norway, higher than both other countries, but it decreased to around 4 by the end of the time period studied. This is another expression of the trend of increasing intergenerational mobility in Norway.

When we move to the odds ratios comparing nonfarm fathers (WS, WU, SU, as above) to farmer vs. nonfarmer sons — farmer-white collar (FW), farmer-skilled (FS) and farmer-unskilled (FU) — the trend in Norway is similar to that in the comparisons between nonfarm fathers: on average, the absolute value

¹⁶ The 36 unique odds ratios are combination of six pairs of fathers' and sons' occupations. Using W, F, S, U as shorthand for white-collar, farmer, skilled and unskilled occupations, respectively, define the set $\mathcal{A} = \{WS, WU, SU, FW, FS, FU\}$. Let $\sum_{(i,l) \in \mathcal{A}}$ denote the sum over terms where i is W, W, S, F, F, F and l is S, U, U, W, S, U . We can then rewrite the Altham statistic as sums over odds ratios comparing fathers' and sons' occupation pairs

$$d(P, J) = 4 \left(\sum_{(i,l) \in \mathcal{A}} \sum_{(j,m) \in \mathcal{A}} [\Theta_{ijlm}]^2 \right)^{1/2}$$

The multiplication by 4 results from only considering the 36 unique odds ratios rather than the full set of 144 odds ratios. For example, $\Theta_{WFSU} = \Theta_{SUWF} = -\Theta_{WUSF} = -\Theta_{SFWU}$; only Θ_{WFSU} is included in the sum here while all four are included in Equation (4).

The set of thirty-six odds ratios, its division into groups and their relative development is further illustrated in the Appendix, Figure A2.

of odds ratios decrease. There is, however, a substantial difference between sons of farmer and white-collar fathers in the probability of obtaining a white-collar occupation in all periods. In the UK, there is little change on average, while in the US, odds ratios comparing nonfarmer fathers to farmer/nonfarmer sons are increasing slightly over time. Similarly, if we compare farm and nonfarm fathers (FW, FS, FU) to nonfarm sons (WS, WU, SU), the average absolute odds ratio decreases in Norway and remains stable in the UK and US.

Finally, we compare the probability ratios between farming and nonfarming for sons of farmers and sons of nonfarmers. The aggregate squared difference of these odds ratios capture most of the particularly high persistence in the farming occupations. In 1865, the square of the Altham statistic $d(P, J)$ was $24.1^2 = 580$, of which 228, or around one third, was driven by these farm-farm comparisons. In the final period, more than eighty per cent (300 of 19.1^2) was driven by low mobility among farmers. This highlights the main challenge of using a non-weighted metric for mobility, as the farm group in the final period has a very low share of total population, and is an important reminder that a study of the separate odds ratios is required.

As there are strong similarities between the 27 odds ratios not including differences between farmers and nonfarmers both for fathers and sons, we aggregate these odds ratios to a “nonfarm” version of the Altham statistic, d^N . The remaining odds ratios compare the probability ratio of obtaining a farm occupation compared to a nonfarm occupations for sons of farmers to the similar ratio for sons of nonfarmers. The root of the sum of squares of these nine odds ratios is denoted d^F .¹⁷

From the definition of the Altham statistic it follows that the Euclidean distance between a point (d^F, d^N) given by these two indices and $(0,0)$ is equal to the aggregate statistic, $d = \sqrt{(d^N)^2 + (d^F)^2}$, as they are both partial sums of the squared odds ratios. This also facilitates a graphical exposition of the changes in mobility in Norway, the United States and the United Kingdom between the nineteenth and twentieth century. Figure 4 shows d^N on the vertical axis and d^F on the horizontal axis. The distance from $(0,0)$ to the country observations the figure denotes aggregate mobility as measured by the Altham statistic.¹⁸

¹⁷In the notation of Footnote 16, \mathcal{A} can be partitioned into two mutually exclusive subsets: the nonfarm comparison set is $\mathcal{N} = \{WS, WU, SU\}$ and the farm comparison set is $\mathcal{F} = \{FW, FS, FU\}$. The farm component d^F is the aggregate of odds ratios comparing farmers to nonfarmers both for fathers and sons, while the nonfarm component d^N is the aggregate of the remaining components.

$$d^F = 4 \left(\sum_{(i,l) \in \mathcal{F}} \sum_{(j,m) \in \mathcal{F}} [\Theta_{ijlm}]^2 \right)^{1/2}$$

$$d^N = 4 \left(\sum_{(i,l) \in \mathcal{N}} \sum_{(j,m) \in \mathcal{N}} [\Theta_{ijlm}]^2 + \sum_{(i,l) \in \mathcal{F}} \sum_{(j,m) \in \mathcal{N}} [\Theta_{ijlm}]^2 + \sum_{(i,l) \in \mathcal{N}} \sum_{(j,m) \in \mathcal{F}} [\Theta_{ijlm}]^2 \right)^{1/2}$$

¹⁸Figure 4 is not directly comparable to the two-dimensional plot comparing mobility matrices in Altham & Ferrie (2007). Altham and Ferrie’s plot uses multidimensional scaling to achieve the best possible approximation to the correct distance between the matrices shown. In the figure shown here, on the other hand, only the distance between the individual matrices

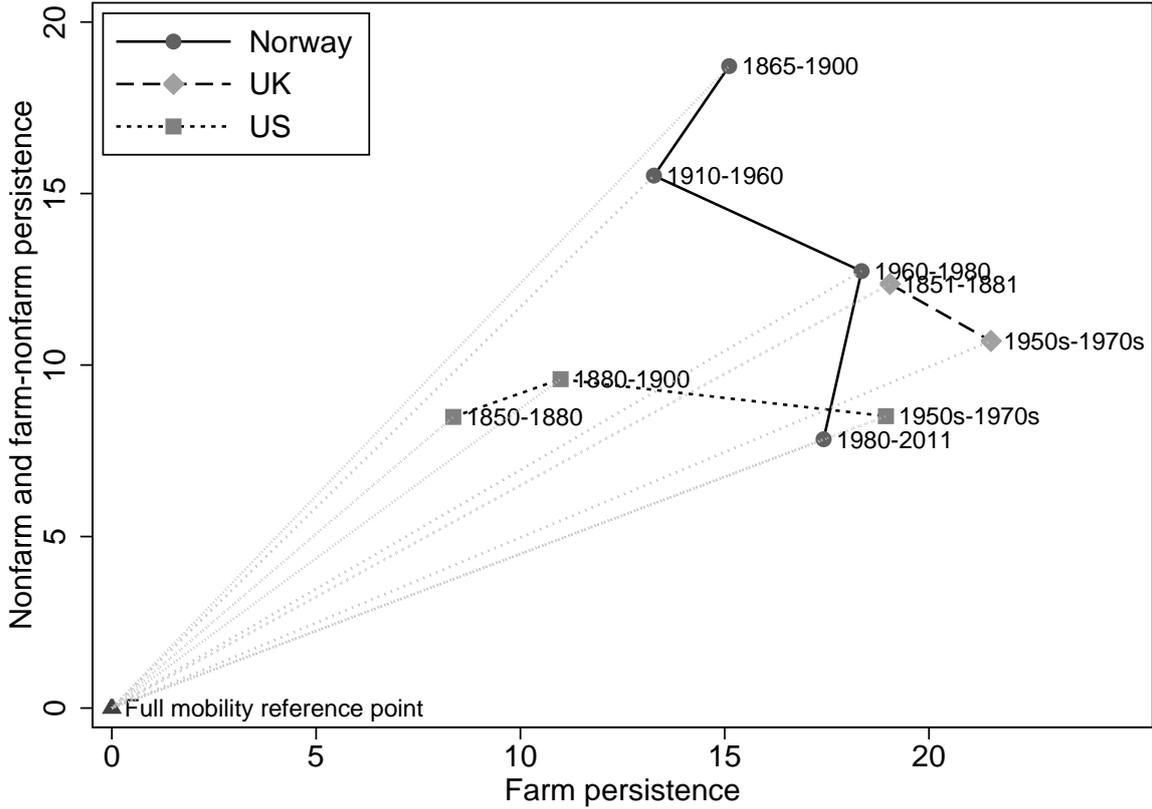


Figure 4: Two components of the Altham statistic, change over time

Farm and farm-nonfarm persistence d^N was extremely high in Norway compared to the United Kingdom and United States in the nineteenth century. As shown in Figure 4, d^N in 1865-1900 was 18.7, much higher than in either the United States ($d^N = 8.5$) or the United Kingdom ($d^N = 12.4$). Over time, persistence fell, to 15.5 in 1910-1960, 12.7 in 1960-1980 and 7.8 in 1980-2011. In contrast, U.S. nonfarm mobility in the 1950s-1970s was at the same level as in 1850-1880, at $d^N = 8.5$.

On the other hand, farm persistence in Norway increased from $d^F = 15.1$ in the first period to $d^F = 17.4$ in the final period. A dramatic change is seen in the United States; the decomposition used here shows that nearly all the decrease in intergenerational occupational mobility from the nineteenth to the twentieth century came from increasing persistence among farmers. Hence, the aggregate trends of increasing mobility in Norway and decreasing mobility in the United States (shown as a movement toward the (0,0) point in Figure 4) represent not only opposing, but fundamentally different trends. In Norway, nonfarm mobility increased substantially while farm mobility showed a moderate decrease; in the United States, nonfarm mobility was stable while farm mobility decreased substantially.

Compared to Norway and the United States, the changes in the United Kingdom between the nine- and $J(0,0)$ is given weight — and is shown exactly — while the distance between matrices is not to scale.

teenth and twentieth century are small. There was a small increase in nonfarm mobility and a small decrease in farm mobility.

Country and time	Altham statistic			Share off diagonal M' with marg. dist adjusted to			Over-repr. at diag. $\sum s_{ii}$
	Conventional $d(P, J)$	Nonfarm d^N	Farm d^F	NO10-60	NO80-11	US50-80	
Norway 1865 - 1900	24.1***	18.7	15.1	0.481	0.403	0.369	1.6
Norway 1910 - 1960	20.4***	15.5	13.3	0.502	0.430	0.387	1.8
Norway 1960 - 1980	22.3***	12.7	18.3	0.488	0.453	0.362	1.5
Norway 1980 - 2011	19.1***	7.8	17.4	0.538	0.497	0.393	1.3
US 1850 - 1880	11.9***	8.5	8.4	0.573	0.493	0.454	1.3
US 1880 - 1900	14.6***	9.6	11.0	0.546	0.465	0.423	1.6
US 1952 - 1972	20.8***	8.5	18.9	0.533	0.486	0.383	1.4
UK 1851 - 1881	22.7***	12.4	19.0	0.482	0.458	0.355	1.5
UK 1952 - 1972	24.0***	10.7	21.5	0.501	0.453	0.358	1.3
Change in mobility, Norway 1865-2011	+	+	-	+	+	+	+

Table 2: Estimates of intergenerational mobility, 1865-2011

These results on intergenerational mobility do not depend exclusively on the metric used here. Table 2 also shows estimates of intergenerational occupational mobility using a set of different metrics used in the literature. Columns 3 to 5 show the share of the individuals in the matrix having different occupations than their fathers when the matrices are adjusted to have similar marginal frequencies, as described in Mosteller (1968) and Altham & Ferrie (2007). For nearly all such adjustments there is an increase in the share off the main diagonal between 1865-1900 and 1980-2011 in Norway.¹⁹ The seventh column shows the weighted average of “over-representation” of individuals along the diagonal of the matrix compared to what a model of occupational independence would show; a higher number corresponds to lower mobility. Using this methodology gives the same trends as the main specification, though the sign of the comparison between 1865-1900 and 1910-1960 in Norway reverses. These alternative approaches are described in more detail in the Appendix.

3.4 Mobility as income jumps

So far the analysis has not been based on any *sorting* of occupation categories by economic status. Mobility as expressed by individual odds ratios or the Altham statistic can be interpreted both as vertical and horizontal changes. However, using the occupation mean incomes presented in Section 2.4, one can approach the question of how changing occupation mobility has affected mobility in income.

From the set of occupation mean incomes and the population distribution over these occupations, we can construct between-occupation Gini coefficients for the populations examined in the transition

¹⁹The one exception is forcing the marginal distributions to match 1865-1900, which gives roughly the same off-diagonal shares in 1865-1900 and 1980-2011 (a difference of 0.2%). This is because this particular adjustment greatly increases the weight put on farmers.

matrices. These coefficients, which disregard any income variation inside the occupation groups, follow the N -shape often described in the literature (Roine & Waldenström, 2015), with an increase from 15.7 in 1865 to 23.1 in 1910, decreasing to 16.0 in 1960 and 7.9 in 1980 and finally increasing to 11.5 in 2011. The development over time is to a large extent driven by the difference between the mean white-collar income and the population mean, as well as the size of the white-collar group.

To examine occupation-induced economic mobility, a natural starting point is to consider the distribution of income changes between generations. Let (y_q^F, y_q^S) denote the mean incomes of the occupations held by father-son pair q (observed at the census years of fathers and sons), and let (\bar{y}^F, \bar{y}^S) denote the corresponding population mean incomes. The income jump Δ_q is then defined as the change in income (relative to mean income) from father to son:

$$\Delta_q = \frac{y_q^S}{\bar{y}^S} - \frac{y_q^F}{\bar{y}^F} \quad (5)$$

Scaling both incomes sets average income growth to zero and is equivalent to choosing fathers as base and re-scaling incomes of sons by the average growth rate.²⁰ We can then compare this change in average income over time to the between-occupation Gini coefficients of fathers and sons, respectively.

Time period	Between-occ. income Gini		Average absolute income difference $ \Delta $	Average inc. diff. for sons of			
	Fathers	Sons		W Δ^W	F Δ^F	S Δ^S	U Δ^U
1865-1900	12.9	24.6	0.40	-0.43	-0.14	0.49	0.21
1910-1960	24.5	17.2	0.33	-0.79	0.24	-0.05	0.30
1960-1980	16.6	7.9	0.24	-0.45	0.28	0.02	0.28
1980-2011	8.0	11.2	0.18	-0.10	0.18	0.04	0.16

Table 3: Cross-section income inequality and average father-son income difference, by time period and father’s occupation

The results from this exercise is given in Table 3. The first two columns show between-occupation Gini coefficients among the fathers and sons in the sample. The third column shows the mean absolute income difference $|\Delta|$ between fathers and sons.²¹ The dispersion in income changes decreases over time; between 1865 and 1900 the mean absolute income difference was forty per cent of mean income, down to eighteen per cent in 1980-2011. The distribution of the population to groups of negative and positive dispersion also changes over time. Only 32 per cent of sons of 1865 fathers observe higher mean occupation income than their fathers, while 62 per cent of sons of 1980 fathers have higher mean incomes.

²⁰Equation (5) can be expressed in terms of mean income in father’s generation as $\frac{1}{\bar{y}^F} \left(\frac{1}{g} y_q^S - y_q^F \right)$ or equivalently in terms of mean income in son’s generation as $\frac{1}{\bar{y}^S} (y_q^S - g y_q^F)$, where the growth rate $g = \frac{\bar{y}^S}{\bar{y}^F}$.

²¹As Equation (5) scales fathers’ and sons’ incomes by the population mean, the mean value of Δ across the population is by definition zero.

The largest positive income jumps are obtained when sons of non-white collar fathers obtain white-collar occupations. This explains the large positive income shock in the first period, where the white-collar group was still relatively small and with very high mean incomes. There was a substantial decrease in farmer relative incomes between 1865 and 1900, giving negative income jumps for more than three fourths of sons of farmers.

Table 3 also shows the average income change between father and son given father's occupation. The income change is a combination of the change in income for those not changing occupation and the income jumps of those who change occupations. In the first time period, the highest "father" incomes are held by farmers and white-collar workers, giving negative mean income changes for these groups; similarly, the improvement in average wages for manual skilled workers gives positive income for sons of S fathers. While there is high mobility out of farming in all periods, farmer incomes are lowest, relatively speaking, in 1910 and 1960, giving high positive income changes for sons of farmers in these periods. From 1910 onward, sons of skilled workers on average do not experience large income changes from their fathers. There is substantial mobility both into higher- and lower-paid occupations, and on average these sons' income changes cancel out. Sons of unskilled fathers on average always experience substantial income growth.

It is evident that the average change of income has gone down at the same time that intergenerational occupational mobility has increased. This apparent paradox is partly explained by decreasing income inequality; over time, the occupational income distribution becomes more compressed, decreasing the income gain or loss an individual experiences by moving to a different occupation group than his father. This is more formally addressed in the next subsection.

3.5 The contribution of mobility to income equalization across dynasties

As mentioned in the Introduction, intergenerational mobility matters for the evaluation of the distribution of economic utility when considered across several generations. When we have data on the occupational mean income of both fathers and sons, we can approximate a "dynasty income distribution" by studying the distribution of income calculated over several generations. This distribution is affected both by the distribution of income in any given generation and by intergenerational mobility — how occupations change across generations in a given dynasty.

We can conceptualize the utility of a dynasty (from the father's point of view) as a simple two-generation utility function

$$U_{\text{dynasty}} = u(c_{\text{father}}) + \beta u(c_{\text{son}}) \quad (6)$$

where U is the total dynastic utility, u is a period utility function, and β is the discount rate. For the time period studied here, the operationalization has to be more pragmatic: father's and son's consumption is proxied by the mean income of their occupation category at the census year. In this way, we get a metric of the utility of individual father-son pairs, measured consistently over time.

To simplify the exposition, linear utility functions will be used and the discount rate set to the inverse of the aggregate growth rate of the economy g , giving father and son relative wages similar weights. That is, we consider the distribution of *dynastic income* Y :

$$Y = y_f + \frac{1}{g} y_s \quad (7)$$

and note that Y is proportional to the sum of the incomes within each generation scaled by the generation mean, $\frac{y_f}{\bar{y}_f} + \frac{y_s}{\bar{y}_s}$.

This dynastic income Y is then the object of analysis. How has the distribution of Y changed over time? Again we measure the dispersion of occupational mean incomes by the Gini coefficient — in this case, it is then a Gini coefficient of dynastic incomes. The dynastic Gini is 16.4 in the 1865-1900 period, 19.0 in 1910-1960, 11.1 in 1960-1980 and 8.4 in 1980-2011. In a similar way to the cross-section Gini coefficients, it shows increasing inequality from the first to the second period and decreasing inequality thereafter. There is now no increase in the final time period; while the sons in the final generation experience higher cross-section inequality than the preceding generation, they are coupled with a father generation of very low inequality.

At the same time as the decrease in dynastic income Gini coefficients, cross-section inequality fell and intergenerational mobility increased. We now attempt to answer the question of which of these two phenomena contributed most to the decrease in the dynastic Gini. This question is similar to the study of institutional factors and the wage distribution by DiNardo *et al.* (1996) and on marital matching and inequality by Eika *et al.* (2014), and a similar nonparametric approach will be used here. Fundamentally, by adjusting wage sets and mobility matrices separately, we can assess how much of the change in inequality that is due to changes in mobility and the wage structure, respectively.

The dynastic income distribution can be conceptualized as follows: for a given 4×4 mobility matrix M linking father's occupation at t_0 to son's occupation at t_1 , we apply the mean occupation income in

t_0 to the fathers and the mean occupation income at t_1 to the sons. The counterfactual analysis then *either* consists of replacing the occupational income distributions with counterfactuals and keeping the mobility matrix, *or* replacing the mobility matrix and keeping the marginal income distributions. In both cases the marginal distributions of individuals at t_0 and t_1 is preserved.

To preserve marginal distributions when considering counterfactual social mobility, the algorithm of Mosteller (1968) is applied. By selectively multiplying rows or columns of the mobility matrix by constants, the marginal distributions of the counterfactual matrix can be set to fit the actual marginal distributions, with the odds ratios and hence d^N , d^F and the Altham statistic $d(P, J)$ remaining at the counterfactual level.

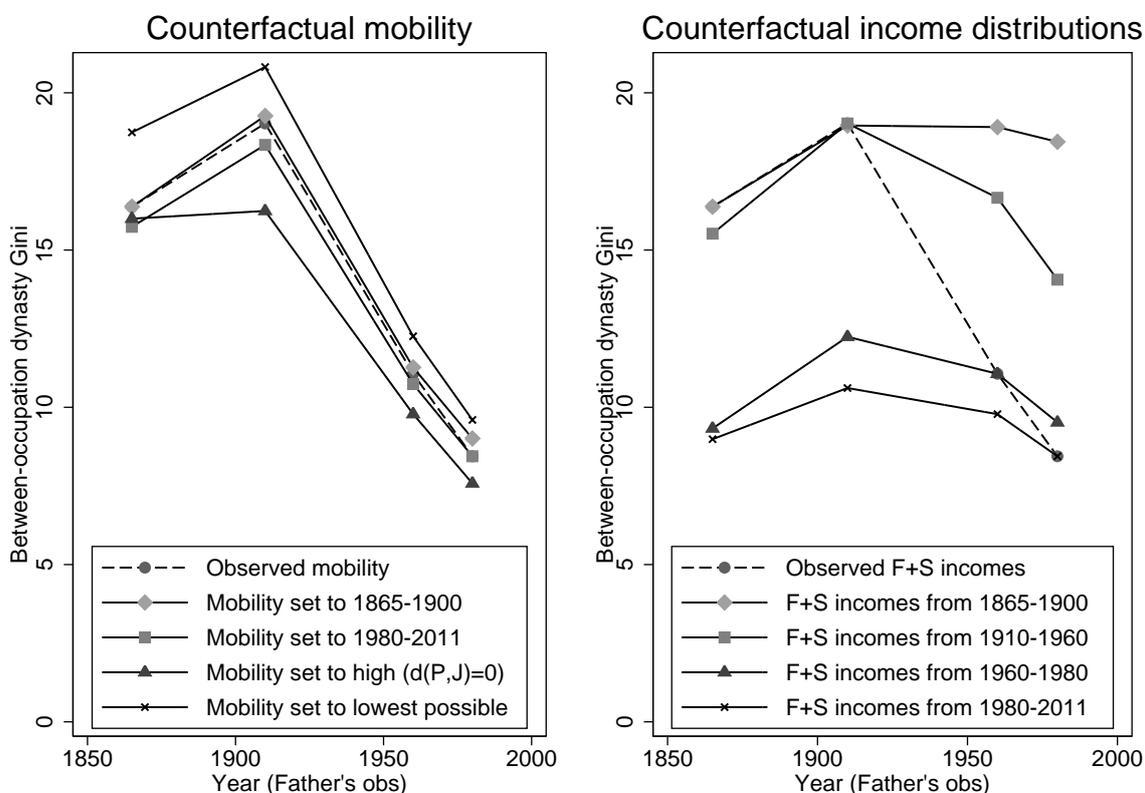


Figure 5: Counterfactual between-occupation dynasty (father+son) Gini coefficients. Left panel: using observed occupation distributions and incomes, keeping mobility constant over time. Right panel: using observed occupation distributions and mobility matrices, keeping fathers' and sons' income distributions constant over time.

The results of this procedure is presented in Figure 5. We first consider the counterfactual mobility matrices, shown in the left panel. The dotted line shows the observed dynastic income inequality, with mobility matrices being as observed in the data. If we fix mobility at any of the observed four matrices discussed in this paper, there is no large change in the level of the dynastic Gini coefficient; the periods

with highest and lowest mobility are shown in the figure, and it is clear that both lie quite close to the actual observed dynastic inequality. We also consider the most mobile society we can imagine, where all odds ratios are zero and there is no impact of father’s occupation on son’s occupation — $d(P, J) = 0$. We now observe slightly lower dynastic income inequality, with the Gini coefficient going from the observed 19.0 in 1910-1960 to 16.2 with full mobility. Similarly, we consider a mobility-minimizing matrix and find that the maximal feasible dynastic Gini given the actual marginal income distribution is 20.8 in 1910-1960.

It is evident from the left panel that replacing the mobility matrix with a counterfactual — either one from data or hypothetical “extreme” matrices — does not greatly affect dynastic income inequality. In all cases the Kuznetsian hump-shape is preserved. In 1960-1980 and 1980-2011 the difference is never more than two Gini points. In the earliest two periods the results are somewhat different: the 1865-1900 actual dynastic Gini is quite close to that which would be obtained if there was perfect mobility, while the distance is almost three Gini points in the 1910-1960 periods.

In the right panel, the actual mobility matrices are always used, but the father and son income distributions (that is, the ratio of occupation mean incomes to the population mean) are replaced with counterfactual distributions. It is evident from the panel that there is a large effect on the dynastic Gini coefficient from changing the income distributions. While the inverse-U shape is preserved in all cases, the levels are highly dependent on the marginal distributions used. The uppermost line in the figure fixes the incomes at the 1865-1900 level. High white-collar incomes in particular contribute to dynastic inequality in this counterfactual scenario being above Gini=16 in all time periods. The slightly more equal 1910-1960 income distribution also gives high income inequality in all periods. In contrast, the 1960-1980 and 1980-2011 income distributions give a more egalitarian distribution of dynastic income.

This decomposition exercise shows that while there has been substantial increase in intergenerational mobility in Norway over the time period studied, the change in the between-occupation income distribution is quantitatively more important when explaining changes in the dynastic income distribution. Because of data limitations, however, the analysis here does not incorporate within-occupation income inequality.

4 Geographical determinants of intergenerational mobility

The previous section has established that mobility increased in Norway from 1865 to 2011; occupational choice became less dependent on father’s occupation, with the exception of farmers. The transformation trends described in the Introduction and illustrated by the changing occupation distributions in Figure 1 did not take place all across the country at the same time. Cities grew fast, with associated diversity

in economic activity, while some areas remained rural and dependent on agriculture for a long time. The purpose of this section is to examine to what extent the observed changes in occupational mobility were driven by changes in the geographic makeup of economic activity in Norway.

To examine geographical determinants of intergenerational occupational mobility, the municipalities of Norway have here been grouped into 160 clusters of municipalities to obtain regional units (“regions” henceforth) that are constant over time.²² To the regional differences can be added some covariates from published statistics, such as the mean incomes described above. On the regional level, there is often not enough individuals for all 16 cells in the mobility matrix to be populated, making calculation of the Altham statistic impossible. For this reason, we start the regional analysis by examining Altham statistics for larger regions, defined by various economic characteristics.

4.1 Regional differences in mobility

There are several hypotheses that can be made regarding the connection between economic development and social mobility, of which this section is only able to scratch the surface. First, as it is now established that increased social mobility and economic development have occurred in parallel in Norway, it would not be surprising if this also held in cross-section; that is, if regions with a higher degree of urbanization or higher income growth experienced higher social mobility. Second, industrialization and economic development led to massive population movements. One would expect that those with higher propensity to move location also had higher propensity to choose a different occupation than their father. Finally, there was substantial emigration from Norway to the US and Canada between 1865 and 1930. While we cannot observe the outcomes of the emigrants directly, we can compare mobility in regions with high and low overseas emigration rates.

The nonfarm and farm components of the Altham statistic (d^N and d^F) for these subpopulations is given in Table 4. The first line of the table shows the reference total for the country as a whole, with a steadily increasing nonfarm intergenerational occupational mobility ($d^N = 18.7$ in 1865-1900 to $d^N = 7.8$ in 1980-2011) and a decrease in farm mobility ($d^F = 15.1$ in 1865-1900 to $d^F = 17.4$ in 1980-2011).

First, we consider local regions with cities/towns and completely rural areas separately. We find that there is only a very small difference in nonfarm mobility d^N between rural and urban areas, and that both rural and urban mobility is similar to the country as a whole. For the farm component there is a larger difference, with urban areas (which include farming areas close to cities and towns) exhibiting more persistence in farming in all periods. One possible explanation for this difference is that near-city areas (counted as urban regions here) have more established, larger farms and a larger population in

²²There have been large changes to the municipality structure of Norway during the period studied here. For this reasons, municipalities are aggregated into units that are stable over time. Sources for the municipal covariates are given in the Appendix.

		Nonfarm mobility d^N				Farm mobility d^F			
		1865-1900	1910-1960	1960-1980	1980-2011	1865-1900	1910-1960	1960-1980	1980-2011
Reference		18.7	15.5	12.7	7.8	15.1	13.3	18.3	17.4
	Rural (R)	17.1	16.0	13.4	7.9	11.7	9.6	16.0	15.4
	Urban (U)	18.0	14.8	12.3	7.7	15.8	14.8	19.4	18.7
Local inc. growth	Below mean	19.0	15.1	12.5	7.9	15.1	15.6	18.8	18.1
	Above mean	18.1	15.2	12.5	7.8	15.1	9.8	18.0	16.7
Geographic mobility	Nonmover (R)	17.5	16.7	14.6	8.7	11.5	9.9	16.3	15.1
	Nonmover (U)	19.2	15.9	13.3	8.6	17.2	16.7	20.6	19.7
	Mover ($R \rightarrow R$)	19.3	16.3	10.8	6.0	8.4	5.6	6.9	10.5
	Mover ($R \rightarrow U$)	14.9	12.1	10.2	5.7	7.9	7.2	10.3	10.0
	Mover ($U \rightarrow R$)	15.4	12.0	9.7	5.6	7.5	6.4	14.0	10.9
	Mover ($U \rightarrow U$)	15.4	11.5	8.4	5.4	9.2	7.5	10.1	10.6
Local emigr. rate	Low	18.5	15.8			14.8	11.8		
	High	18.9	14.4			15.4	14.7		

Table 4: Mobility indices d^N and d^F (components of the Altham statistic) for subsamples of the total population

nonfarm occupations. This could mean that the farmer population in these areas on average enjoy a more exclusive social status, and hence exert a larger influence on sons' occupations than the more heterogeneous rural farmer population.

Second, we group local regions by income growth, and consider high- and low-growth regions (those with income growth above and below the mean) separately. Again, we find very small differences, if any at all, in the nonfarm mobility component. However, high income-growth areas have less persistence among farmers. High income-growth areas are to a large extent rural, as the rural-urban income gap was much higher in the nineteenth century than it is today. Furthermore, there is a systematic correlation between the level of income in a given municipality and nearly all the farm-farm odds ratios, indicating that farm mobility was lowest in high-income regions.²³

Farmer persistence in rural areas could be lower because of migration patterns. The movement of people from the countryside to cities and suburban areas is substantial in the entire period studied here. Given a fixed number of farms, if this migration is drawn from all layers of society, one will observe higher mobility into farming in the sending compared to the receiving region. We can examine this more closely by moving from groupings of region of origin to a grouping of individual by their realized movement decisions. If we maintain the rural-urban distinction, we have two groups of nonmovers and four groups of movers. Mobility metrics for each of the six mover groups is given in Table 4. It is clear that movers experience higher occupational mobility than nonmovers: individuals more likely to change occupation is more likely to move, and vice versa. However, mobility for those who move from one rural area to another looks more like mobility for nonmovers in the two first periods studied.

²³The results from such a regression analysis are presented in the Appendix, Table A7

Finally, we can examine whether there is any association between intergenerational mobility and international emigration. Using statistics on overseas emigration by municipality obtained from the Norwegian National Data Service (NSD), average annual emigration rates are computed for the 1865-1900 and the 1910-1930 periods (transatlantic migration from Norway fell to a negligible level after 1930). Regions are then grouped according to whether they had emigration rates above or below the mean. The expected difference in mobility depends on the characteristics of emigration: if the “poor but industrious” emigrate, we would expect within-region social mobility to be lower, as the potentially upward mobile population is smaller. If, on the other hand, it is the well-off that emigrate, more high-status occupations would be available for those in farming and unskilled occupations, leading to higher mobility.

From the last rows of Table 4 it is evident that the difference in d^N between the high- and low-emigration regions is not very large. There is slightly lower mobility in the high-emigration regions in the 1865-1900 period, while the difference is opposite in the next period. Farm mobility d^F is always higher in the low-emigration regions. As mobility is similar in high- and low-emigration regions, we can draw the preliminary conclusion that emigration did not substantially affect intergenerational occupational mobility in Norway. There could, however, be differential effects within each occupation group that are not picked up here.

The small differences in mobility between regions with different levels of economic development suggest that the increase in mobility over time is not driven by regional convergence. Analysis of odds ratios (presented in the Appendix) finds no systematic evidence of consistent relationships between economic development and specific odds ratios across local regions. However, there could still be local conditions that affect the patterns of intergenerational mobility. Identifying such neighborhood effects is the topic of the next section.

4.2 Neighborhood effects

Neighborhood effects in intergenerational mobility have been explored in a range of studies, summarized in Solon (1999) and Black & Devereux (2011). Neighborhood effects are typically considered as an extension of sibling correlations in income; however, with a limited number of categories, this is not a straightforward process for the occupational data used here. The idea behind the effects, are, however, similar: If you live in a rural area, you are more likely to have a farmer father. You are also more likely to take a farmer occupation, as those jobs are more widely available.

This section introduces a way of correcting for region of origin, using the covariate-adjusted Altham statistic described in Modalsli (2015). Occupational choice is interpreted as resulting from a multinomial logit model, with dummy variables for father’s occupation as individual control variables. The estimated

system consists of three equations for the four occupations, with white-collar occupations being the reference category. Individuals are indexed by q , while $\mathbf{D}_q = \{D_F, D_S, D_U\}$ characterizes father's occupation, $\beta_k = \{\beta_k^F, \beta_k^S, \beta_k^U\}$ is the associated parameter vector and \mathbf{X}_q is a vector of other individual covariates with associated parameters γ_k .

$$\log \left(\frac{Pr(Occ_q = k)}{Pr(Occ_q = W)} \right) = \alpha_k + \beta'_k \mathbf{D}_q + \gamma'_k \mathbf{X}_q + \epsilon_{k,q} \quad k = F, S, U \quad (8)$$

It follows from Equation (4) that the Altham statistic now can be expressed exclusively using the β coefficients:

$$d(P, J) = \left(\sum_{i=1}^N \sum_{j=1}^N \sum_{l=1}^N \sum_{m=1}^N [(\beta_j^i - \beta_m^i) - (\beta_j^l - \beta_m^l)]^2 \right)^{1/2} \quad (9)$$

If we omit the \mathbf{X} covariates, the estimated odds ratios and Altham statistic are similar to those studied in Section 3.3. To examine the effect of neighborhoods, we can make use of the available data on municipal covariates: the employment shares of each of the four occupation groups (from the Census), and the mean incomes for each region. The results of each of these adjustments are presented in Table 5. The table also presents 95% confidence intervals, obtained by bootstrapping the Altham statistics using the covariance matrices obtained from the multinomial logit estimation.

	Time period	(1) No controls	(2) No controls, clustered SE	(3) Local mean income	(4) Employment shares	(5) Regional dummies
Altham stat. $d(P, J)$	1865-1900	24.1 (23.5 – 24.6)	24.1 (22.9 – 25.3)	22.0 (21.0 – 22.9)	20.9 (19.8 – 22.3)	20.7 (19.4 – 22.0)
	1910-1960	20.4 (20.1 – 20.8)	20.4 (19.3 – 21.6)	18.2 (17.6 – 18.9)	17.8 (17.8 – 17.8)	17.8 (17.1 – 18.4)
	1960-1980	22.3 (22.1 – 22.6)	22.3 (21.1 – 23.5)	21.3 (20.6 – 22.0)	19.9 (19.2 – 20.7)	20.0 (19.3 – 20.8)
	1980-2011	19.1 (18.9 – 19.3)	19.1 (18.3 – 20.0)	18.1 (17.4 – 18.9)	16.8 (16.2 – 17.4)	17.1 (16.4 – 17.7)
Nonfarm d^N	1865-1900	18.7 (17.9 – 19.4)	18.7 (17.3 – 19.9)	17.3 (16.4 – 18.5)	16.3 (14.9 – 17.6)	16.0 (14.6 – 17.4)
	1910-1960	15.5 (14.9 – 16.0)	15.5 (14.2 – 16.7)	14.2 (13.0 – 15.5)	13.8 (13.8 – 13.8)	13.7 (12.7 – 14.9)
	1960-1980	12.7 (12.4 – 13.2)	12.7 (11.6 – 13.9)	11.5 (10.7 – 12.4)	11.0 (10.3 – 11.9)	11.1 (10.3 – 12.0)
	1980-2011	7.8 (7.5 – 8.2)	7.8 (7.2 – 8.5)	7.3 (6.7 – 8.0)	7.0 (6.5 – 7.6)	7.0 (6.5 – 7.7)
Farm d^F	1865-1900	15.1 (14.3 – 15.6)	15.1 (13.9 – 16.9)	13.6 (12.1 – 14.7)	13.2 (12.0 – 14.5)	13.1 (11.9 – 14.8)
	1910-1960	13.3 (12.9 – 13.7)	13.3 (11.5 – 15.2)	11.4 (10.0 – 12.9)	11.3 (11.3 – 11.3)	11.3 (10.0 – 12.7)
	1960-1980	18.3 (18.0 – 18.7)	18.3 (16.7 – 19.8)	17.9 (16.6 – 19.0)	16.6 (15.4 – 17.7)	16.6 (15.3 – 17.8)
	1980-2011	17.4 (17.1 – 17.7)	17.4 (16.4 – 18.4)	16.6 (15.6 – 17.6)	15.3 (14.5 – 16.1)	15.6 (14.7 – 16.4)

Table 5: Estimates of social mobility in Norway when controlling for regional background. 95% confidence intervals in parentheses, standard errors clustered on region in columns 2-5

The first column reports the baseline Altham statistic for Norway and the corresponding confidence intervals. It is evident that the intervals are relatively small. As all covariates used in this section is

at the regional level, standard errors will be clustered at regions; the second column of Table 5 reports the baseline estimates with such clustering. This expands the confidence intervals somewhat, but most differences between time periods can still be clearly distinguished.

Adding one variable for the local mean income does increase the measured social mobility — the Altham statistic goes down. This reflects that some of the effects previously ascribed to father’s occupation is now rather taken up by the coefficient on regional mean income. The reduction is not large — for the 1865-1900 period, the Altham statistic is reduced from 24.1 to 22.0, while for the 1980-2011 period, from 19.1 to 18.1. However, the 95%-intervals for the statistic do not overlap in any of the periods. Correcting for occupation shares by adding occupation shares for the occupation categories (with W as reference category) further increases estimated mobility.

Finally, the entire regional variation can be taken out by adding a dummy variable for each region. When this is done, the Altham statistic decreases by approximately 3 in all periods. The decrease reflects that odds ratios are, on average, closer to zero within local regions than in the country as a whole; hence, the mobility statistic calculated without controls attributes some between-region variation in occupation choice as arising from father’s occupation. The effect is, however, small, and does not change the time trend in intergenerational occupational mobility in Norway. The effect is similar across the sub-components d^F and d^N .

The correction for neighborhood effects does lead to an increase in the estimate of intergenerational occupational mobility. However, as this increase is roughly similar in all time periods studied, there is no evidence that changes in regional economic composition drove the changes in intergenerational mobility. If this was the case, we would expect the correction to matter more in the early periods, when there was larger regional economic heterogeneity in Norway. For this reason, we conclude that the increasing trend in mobility is not primarily driven by regional convergence.

5 Concluding comments

The results presented in this paper show that the importance of family background, as measured by father’s occupation, has decreased over time in Norway. This increase in intergenerational mobility is driven by decreased persistence in nonfarm occupations. In this way, the development is different from the previously-documented decrease in mobility in the United States, which is shown here to derive mainly from an increase in father-son persistence in farming.

Given the large geographic differences in intergenerational mobility that have been found in present-day United States (Chetty *et al.*, 2014), one could expect disappearing regional economic differences to be driving at least parts of the differences in intergenerational mobility over time. However, while

adding controls for regional elements suggest some persistence effect of childhood region, this element is relatively constant over the entire period studied. Differences in nonfarm mobility (which drives all of the decrease in aggregate mobility) between regions of the country are not particularly pronounced. Regional diversity did play a role in the sense that geographic mobility appears to have facilitated occupational mobility. This is in line with the results of Abramitzky *et al.* (2012, 2013), who find suggestive evidence of a similar mechanism working at the international level in the late nineteenth century.

As the change in mobility (in particular mobility between nonfarm occupations) increases steadily during the entire 146 years studied here, it is not likely that any single reform can explain the difference between high persistence in nineteenth-century Norway and low persistence today. Controlling for regional differences does not remove the time trend in mobility. Hence, we draw the conclusion that the increase in mobility was likely a result several factors, including technological change and a gradual increase in formal education. The Norwegian welfare state has expanded enormously in the period studied. The quality and scale of elementary education increased continuously over the first 100 years, followed by high-school reforms and expansion of university and college education. Future work will attempt to map out more carefully the effect of education expansion on intergenerational mobility. Moreover, increases in old-age, disability and unemployment insurance, health care and other reforms are likely to have had substantial impacts on intergenerational mobility. Low mobility in farming occupations is consistent with a mobility-reducing role of Norwegian agricultural inheritance laws.

The present paper is the first to show a radical change in intergenerational mobility in a European country. This stands in contrast to the thesis by Clark (2014) that mobility is driven by fundamental processes that do not change over time. While there may be some one-off effect from particular reforms that have been enacted in the period under study, particularly with respect to education, the continuous decrease in the measured odds ratios does suggest a secular trend in intergenerational mobility. This does not necessarily imply that mobility will continue to increase in the future; after all, income inequality in the Scandinavian countries decreased for roughly a full century before starting to increase again in the 1980s. As the outcomes for children born in the 1980s and 1990s are not observed yet, it remains to be seen whether increasing income inequality will be accompanied by a decrease in intergenerational mobility.

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Appendix

A Descriptive statistics and robustness analysis

A.1 Occupation definitions

Tables A1-A4 show the most prominent occupation group within each of the four occupation categories used in this paper. To save space, 1910 is not shown; there are no large differences between the 1900 and 1910 occupation distribution. Occupations in 1910 and earlier are coded using HISCO; 1960-1980 using NYK (Norsk Yrkesklassifisering / Norwegian Occupation Classification; see Vassenden (1987)); 2011 using a simplified version of the most recent Norwegian Classification of Occupations (STYRK).

A.2 Transition matrices and occupation mean wages

The raw counts of the four transition matrices used in the main specification are shown in Table A5. Occupation mean wages are plotted in Figure A1.

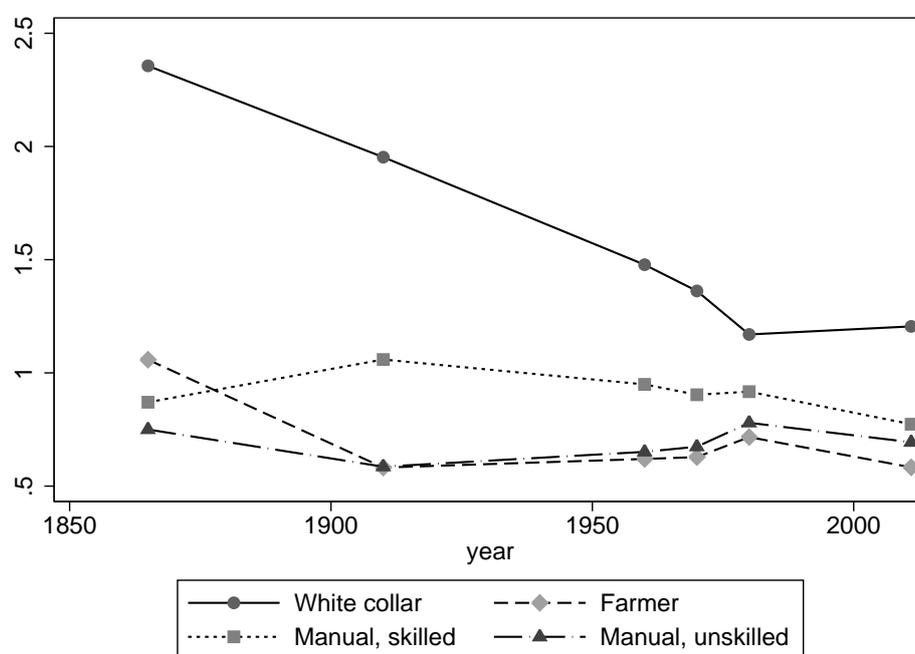


Figure A1: Mean income (1910-2011: men aged 30-60; 1865: men aged 25 years and above), by occupation group, scaled to population mean in each year

A.3 Other measures of social mobility

This subsection elaborates on the metrics used in the four rightmost columns of Table 2.

A straightforward way of collapsing father-son occupation matrices is to calculate some summary statistic on the numbers in the table. The description in Section 3.1 implicitly took the share of individuals off the main diagonal of the table, as a metric of mobility: if more sons are different from their fathers, mobility can be said to be higher.

Year & class.	Code	Description	N
1865 (HISCO)	<i>41010</i>	Dealer, merchant etc. (wholesale and retail trade)	3887
	<i>4220</i>	Ship's masters and captains (sea)	1518
	<i>4230</i>	Ship's masters and captains (sea or inland waterways)	1398
	<i>4250</i>	Ship's navigating officers and ship's mates	1013
	<i>13210</i>	Teachers (unspecified)	766
		Total	
1900 (HISCO)	<i>41010</i>	Dealer, merchant etc. (wholesale and retail trade)	9458
	<i>4220</i>	Ship's masters and captains (sea)	4854
	<i>4250</i>	Ship's navigating officers and ship's mates	3550
	<i>13230</i>	Teachers (primary)	2843
	<i>45120</i>	Salespeople, wholesale or retail trade	2119
		Total	
1960 (NYK)	<i>111</i>	Business leaders	15877
	<i>003</i>	Engineers nfs	13828
	<i>302</i>	Retailers	13576
	<i>294</i>	Insurance bank officials	12750
	<i>06</i>	Ship officers	7832
		Total	
1980 (NYK)	<i>111</i>	Business leaders	37601
	<i>003</i>	Engineers nfs	27802
	<i>064</i>	Teachers (vocational)	14358
	<i>002</i>	Engineers and head engineers	11895
	<i>331</i>	Sales clerks (office)	11170
		Total	
2011 (STYRK)	<i>13AA</i>	Managing directors	57223
	<i>31AA</i>	Engineers (academic)	44374
	<i>351A</i>	ICT occupations	33284
	<i>21AA</i>	Engineers (technical)	27505
	<i>341A</i>	Sales consultants	26553
		Total	

Table A1: Occupation definitions: Most prominent groups in occupation group White collar, and total individuals in occupation group. Men 30-60 as observed in census year

Year & class.	Code	Description	N
1865 (HISCO)	<i>61110</i>	General farmers and farmers nfs	93802
	<i>61320</i>	Farmer and fisherman	3715
	<i>61400</i>	Farm managers, formen and supervisors nfs	633
	<i>61260</i>	Livestock farmers	132
	<i>61240</i>	Market gardeners	8
		Total	
1900 (HISCO)	<i>61110</i>	General farmers and farmers nfs	80341
	<i>61320</i>	Farmer and fisherman	21568
	<i>61400</i>	Farm managers, formen and supervisors nfs	944
	<i>61260</i>	Livestock farmers	131
	<i>61240</i>	Market gardeners	103
		Total	
1960 (NYK)	<i>401</i>	Farmers, small farmers	83212
	<i>403</i>	Gardeners etc	1775
	<i>406</i>	Supervisors, forestry	1245
	<i>407</i>	Fur breeders	673
	<i>402</i>	Foresters	611
		Total	
1980 (NYK)	<i>401</i>	Farmers, small farmers	32823
	<i>403</i>	Gardeners etc	1597
	<i>404</i>	Supervisors, agriculture	753
	<i>405</i>	Supervisors, horticulture	393
	<i>406</i>	Supervisors, forestry	330
		Total	
2011 (STYRK)	<i>61AA</i>	Farmers, farm managers	13462
	<i>6210</i>	Foresters	2065
		Total	

Table A2: Occupation definitions: Most prominent groups in occupation group Farmers, and total individuals in occupation group. Men 30-60 as observed in census year

Year & class.	Code	Description	N
1865 (HISCO)	95420	Carpenters	6944
	98120	Seamen	5507
	80100	Boot and shoe makers and repairers	4142
	73200	Sawyers and other titled wood/sawmill operatives	2609
	79120	Tailors and tailoresses	2204
		Total	41884
1900 (HISCO)	95420	Carpenters	11188
	80100	Boot and shoe makers and repairers	7167
	98120	Seamen	6216
	73200	Sawyers and other titled wood/sawmill operatives	6171
	95110	Mason nfs or combined	3088
		Total	95928
1960 (NYK)	774	Builders (wood)	27244
	644	Truck and lorry drivers	23371
	753	Machine and engine repairmen	19487
	75	Iron- and metalworkers	16506
	882	Warehouse workers	15144
		Total	323240
1980 (NYK)	774	Builders (wood)	25675
	644	Truck and lorry drivers	22702
	753	Machine and engine repairmen	18620
	793	Stone and cement workers	12505
	761	Electricians	12261
		Total	309177
2011 (STYRK)	7115	Carpenters	31228
	8332	Lorry and truck drivers	19788
	741A	Electricians	17196
	81BB	Operators nfs	15125
	532A	Auxiliary nurses, health secretaries etc	14932
		Total	267380

Table A3: Occupation definitions: Most prominent groups in occupation group Manual (skilled), and total individuals in occupation group. Men 30-60 as observed in census year

Year & class.	Code	Description	N
1865 (HISCO)	61115	Husbandmen or cottars	46184
	64100	Fishermen	7604
	99140	Day labourers (e.g., journalier)	7058
	54010	Servants nfs	6709
	62110	Farm workers, specialisation unknown	6192
		Total	87512
1900 (HISCO)	61115	Husbandmen or cottars	14586
	62110	Farm workers, specialisation unknown	13927
	64100	Fishermen	13736
	61330	Cottar and fisherman	5811
	63120	Lumbermen, loggers and kindred workers	4931
		Total	77144
1960 (NYK)	432*	Fishermen	29888
	441	Forestry workers	16361
	413	Horticulture workers	15369
	412	Animal workers	3853
	931	Caretakers etc	3278
		Total	84873
1980 (NYK)	931	Caretakers etc	7602
	431	Fishermen nfs	6969
	441	Forestry workers	3027
	911	Kitchen workers	2827
	430	Fish skippers etc	2012
		Total	39041
2011 (STYRK)	5153	Caretakers	12984
	931A	Helpers in industry nfs	12711
	711A	Road workers	10755
	9112	Cleaners	7470
	5311	Child care assistants	6061
		Total	89011

Table A4: Occupation definitions: Most prominent groups in occupation group Manual (unskilled), and total individuals in occupation group. Men 30-60 as observed in census year

Son's occupation:	Father's occupation:				Col sum
	W	F	S	U	
White collar (W)	2231	3148	1566	1068	8013
Farmer (F)	188	20790	495	3797	25270
Manual, skilled (S)	519	5016	3174	4712	13421
Manual, unskilled (U)	188	5046	901	5620	11755
Row sum	3126	34000	6136	15197	58459

(a) 1865 - 1900

Son's occupation:	Father's occupation:				Col sum
	W	F	S	U	
White collar (W)	6604	3550	6000	1386	17540
Farmer (F)	552	10936	1054	1302	13844
Manual, skilled (S)	2724	7787	14886	5210	30607
Manual, unskilled (U)	423	3805	1519	2601	8348
Row sum	10303	26078	23459	10499	70339

(b) 1910 - 1960

Son's occupation:	Father's occupation:				Col sum
	W	F	S	U	
White collar (W)	32009	11216	37176	6389	86790
Farmer (F)	476	9878	899	527	11780
Manual, skilled (S)	10449	17485	51430	11665	91029
Manual, unskilled (U)	1117	2589	3775	4218	11699
Row sum	44051	41168	93280	22799	201298

(c) 1960 - 1980

Son's occupation:	Father's occupation:				Col sum
	W	F	S	U	
White collar (W)	152363	14264	119788	13433	299848
Farmer (F)	1259	5983	2417	615	10274
Manual, skilled (S)	39538	11253	91062	9365	151218
Manual, unskilled (U)	11817	3029	24416	4839	44101
Row sum	204977	34529	237683	28252	505441

(d) 1980 - 2011

Table A5: Transition matrices

Altham & Ferrie (2007) propose a method to adjust this off-diagonal metric for changing marginal distributions, based on an algorithm given in Mosteller (1968). By a series of multiplications of rows and columns, the underlying mobility structure of the matrix is preserved while the marginal distributions are changed to become constant across tables.

As described in the main text, these adjusted off-diagonal shares are reported in Table 2.

While the unadjusted diagonal is increasing between 1865 to 1980, there is a slight decrease in the latter period. Fixing the marginal distributions to that of the Norwegian matrices of 1910-1960 or 1980-2011 gives increasing mobility from the first to second and the third to fourth period, with a decrease between the two middle periods. Using the nineteenth-century US marginal distributions or the Norwegian 1865-1900 distribution (not shown), gives decreasing mobility between the first two periods.

An examination of the off-diagonal shares, while easy to understand, does not present a clear definition of what we would expect of “full mobility”, nor is the row-column transformation intuitive to understand. An approach frequently used in the sociology literature is the “independence model” (applied to Long and Ferrie’s mobility data by Xie & Killewald (2013); for an example of use in economics, see Eika *et al.* (2014) on marital matching). Simply put, one compares the actual count for a given cell to an expected frequency. The expected frequency is found by multiplying the marginal distributions for fathers and

sons. Formally,

$$s_{ij} = \frac{P(F = i \cap S = j)}{P(F = i) \cdot P(S = j)} \quad (10)$$

A society with no association between fathers' and sons' occupation would have expected and actual frequencies equal — $s = 1$ for all i, j . In the Norwegian data, we observe that along the diagonal, the actual frequencies are always higher than the expected; $s_{ij} > 1$ when $i = j$. Outside the diagonal, we mainly observe $s < 1$. However, for some combinations, such as fathers with unskilled manual occupations and sons with skilled manual occupations, the counts outside the diagonal are also higher than predicted by the independence model (that is, $s > 1$).

Following Eika *et al.* (2014), we can use the weighted average of s along the diagonal as a summary measure of mobility; a higher number means less mobility as the cell counts on the diagonal are further from what the independence model would predict. The average is shown in the rightmost column of Table 2, and has a range from 1.8 in the 1910-1960 period to 1.3 in the 1980-2011 period, showing an increase in intergenerational occupational mobility over time.

Comparison between Norway, the United States, and England/Wales

Table 2 also gives estimates for the United Kingdom and the United States, based on the data in Long & Ferrie (2013). It is evident that nineteenth-century United States had far higher mobility than Norway (M'_{US1880} at 0.454 vs. 0.369 for Norway; $d(P, J)$ at 11.9 vs. 24.1); indeed, by some measures, Norway also had lower mobility than England and Wales in this period. However, while the shape of mobility in the United States decreased sharply over the next century (as emphasized by Long & Ferrie (2013)), mobility in Norway increased. While we do not have completely up-to-date observations for the US or England/Wales, the 1980-2011 value for Norway points toward higher mobility than any of the other two countries had in the 1950s-1970s period.

	1865 - 1900	1910 - 1960	1960 - 1980	1980 - 2011	US 1850 - 1880	US 1880 - 1900	US 1952 - 1972	UK 1851 - 1881	UK 1952 - 1972
1910 - 1960	5.9***								
1960 - 1980	10.0***	7.9***							
1980 - 2011	13.1***	11.7***	7.7***						
US 1850 - 1880	16.2***	11.1***	12.9***	12.7***					
US 1880 - 1900	11.0***	7.2***	9.2***	8.4***	6.3**				
US 1952 - 1972	12.9***	11.5***	7.9***	4.0***	13.6***	9.1***			
UK 1851 - 1881	12.0***	10.1***	4.7**	8.8***	13.2***	10.3***	9.4***		
UK 1952 - 1972	14.9***	12.6***	8.3***	9.9***	15.3***	12.2	7.9	8.9***	

Table A6: Difference between mobility matrices

Table A6 shows the difference between the mobility matrices of Norway, the United States and the United Kingdom. The Norwegian matrices that are closer in time are more similar to each other than those further away. The distance between the first and last Norwegian matrix is comparable to the distance between the two U.S. matrices. Nineteenth-century Norway appears qualitatively different from

all the non-Norwegian samples, with differences of more than 12 in all cases. The modern Norwegian samples are similar to the US OCG sample, with a difference of only 3.9 between the 1980-2011 Norwegian sample and the 1950s-1970s U.S. sample. Asterisks denote whether differences are significant based on the χ^2 metric of Altham & Ferrie (2007) (* = 0.10; ** = 0.05; *** = 0.01).

A.4 Odds ratio components: a six-way categorization

To examine in more detail which occupational category cells contribute to the preferred mobility metric $d(P, J)$, we examine the 36 components, each a combination of one of six pairs of father’s occupation and six pairs of son’s occupations. To simplify the discussion, these components will be aggregated up into six groups, where we in each group consider the sum of the squared distance of the log odds ratios from zero as in Equation (4). The development over time in each group is shown in Figure A2.

The first three terms together encompass all terms that include neither farmer fathers or farmer sons. This is important as the role of farming has changed greatly over the period under study, and particularities in the role of recruitment to farmer occupations can influence the measured mobility.

The fourth category groups all the comparisons of farmer and nonfarmer fathers where no farmer son probabilities are considered. Then, for the three comparisons of farmer and nonfarmer sons, shown to the right in the table in Figure A2, the terms are aggregated into two large groups depending on whether farmers are also considered on the father side.

The resulting time trends in the sums of squared terms are shown in Figure A2. As the aggregation shows distance from the no-association matrix, a lower number means higher mobility. The top row shows the three aggregations without probabilities into and out of farming. Similar calculations from the US and UK samples are also shown. The year on the x axis refers to the observation of father’s occupation. This is the basis for the discussion of odds ratio components in Section 3.3.

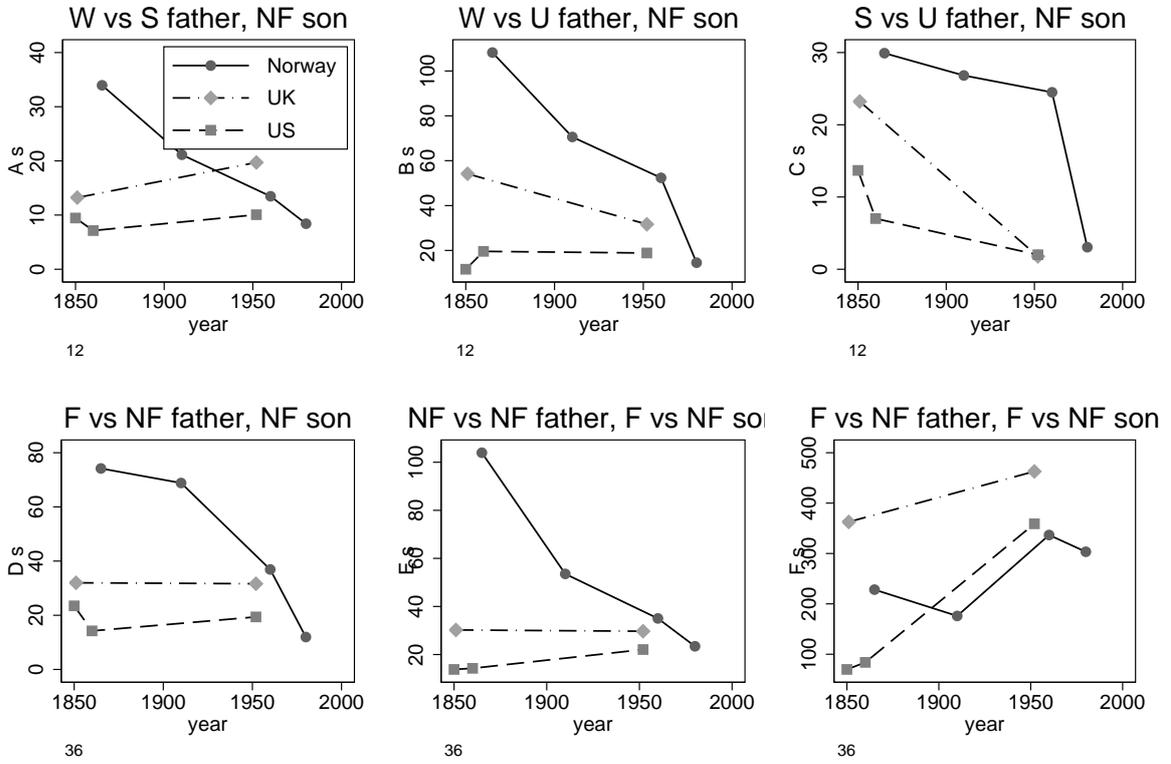
A.5 Odds ratios and local economic features

This section explores the relationship between mobility and regional mean income at the level of each odds ratio rather than the Altham statistic aggregates. Having a set of relatively small regions means that not all cells of the 4×4 matrix will be populated in all regions. In fact, only the very largest regions have all cells at all times. However, when considering odds ratios separately we get a reasonably high number of observations for each “individual” odds ratio.

The means of local odds ratios, calculated as differences in son’s opportunities given that they grow up in the same local region, are systematically lower than the odds ratios for the countries as a whole, though not by a large margin. For example, it is 19 times more likely for the son of a white-collar worker than the son of an unskilled worker to become a white-collar rather than skilled worker in the 1865-1900 period for the country as a whole ($\Theta_{WWUS} = 2.93$) while the local average is 12 ($\hat{\Theta}_{WWUS} = 2.47$) This is unsurprising, as the national metric also captures differences arising from differences in the local environments people grow up in. We now proceed to regress the local odds ratios for municipalities on the municipal mean incomes, scaled to the national mean:

$$\Theta_{ijlm,r} = \alpha + \beta y_r + \epsilon_r \tag{11}$$

where r identifies regions. The coefficients β are shown in Table A7.



W=White-collar, S=Skilled, U=Unskilled, F=Farmer, NF=Not Farmer (=W, S or U)

Group definitions:

Father's occupation	Son's occupation					
	WS	WU	SU	FW	FS	FU
WS	(1) W vs S father, nonfarmer son			(5) Nonfarmer vs nonfarmer father, farmer vs nonfarmer son		
WU	(2) W vs U father, nonfarmer son					
SU	(3) S vs U father, nonfarmer son					
FW	(4) Farmer vs nonfarmer father, nonfarmer son			(6) Farmer vs nonfarmer father, nonfarmer son		
FS						
FU						

Figure A2: Odds ratio components: Grouping and development over time. d^N is terms (1) to (5) in the table, d^F is terms (6).

For the groups not including farmer fathers or farmer sons (1-3 in Figure A2), only a few relationships return significant coefficients. Again taking the example $\frac{WW/WS}{UW/US}$ in 1865-1900, an increase in local mean income of 1 percentage point of the national mean increases the log odds ratio by 0.88 percentage points (significant at the 1% level). This falls to 0.63 by the second period, and there is a negative and insignificant effect in the last two periods. The positive coefficient reported in the first two periods suggest that areas with higher mean incomes have lower social mobility. However, because of the lack of significant coefficients for nonfarm relationships it is hard to turn this into a general statement on the relationship between mean income and mobility in pre-1960 Norway.

For comparisons involving farmer fathers, however (Group 6 in Figure A2), nearly all odds ratios are significantly correlated with local mean income. Moreover, all significant coefficients are positive, meaning the excess probability of a farmer father to have a farmer son, compared to other occupations, is positive. The effects persist into the last time period studied, and is in several cases highest in this period. The log odds ratio for the son of a farmer becoming a farmer rather than a white-collar worker, compared to the son of a white-collar worker (Θ_{FFWW}) in the 1980-2011 period is 3.93, and an increase of local mean income of one percentage point increases this ratio by 1.96 percentage point.

Odds ratio Θ	1865-1900			1910-1960			1960-1980			1980-2011		
	Θ Ctr	Θ Loc	$\delta\Theta/\delta y$									
Group 1												
(WW/WS)/(SW/SS)	2.17	2.14	0.21	1.79	1.75	0.65***	1.44	1.54	-0.18	1.07	1.00	0.13
(WW/WU)/(SW/SU)	1.93	1.90	-0.31	1.37	1.29	0.25	1.07	0.88	0.24	0.97	0.89	0.19
(WS/WU)/(SS/SU)	-0.24	-0.33	0.03	-0.42	-0.41	-0.40	-0.38	-0.57	0.31	-0.11	-0.10	0.06
Group 2												
(WW/WS)/(UW/US)	2.93	2.47	0.88***	2.21	2.24	0.63**	1.72	1.73	-0.24	0.99	0.89	-0.12
(WW/WU)/(UW/UU)	4.13	3.35	-0.15	3.38	3.00	-0.26	2.94	2.34	-0.04	1.54	1.16	-0.07
(WS/WU)/(US/UU)	1.19	0.57	-0.36	1.17	0.80	-0.72**	1.22	0.66	-0.05	0.55	0.26	0.11
Group 3												
(SW/SS)/(UW/US)	0.76	0.67	0.38	0.41	0.50	-0.13	0.28	0.22	-0.25	-0.09	-0.11	-0.18
(SW/SU)/(UW/UU)	2.20	1.56	-0.21	2.00	1.70	-0.43	1.87	1.37	-0.29	0.57	0.24	-0.06
(SS/SU)/(US/UU)	1.44	0.82	-0.31	1.59	1.24	-0.22	1.59	1.16	-0.17	0.66	0.35	0.10
Group 4												
(FW/FS)/(WW/WS)	-1.92	-1.52	-0.41	-1.67	-1.50	-0.53**	-1.56	-1.39	0.16	-1.11	-0.84	-0.09
(FW/FU)/(WW/WU)	-2.94	-2.21	0.09	-2.82	-2.16	-0.80**	-1.89	-1.41	-0.72**	-1.01	-0.79	-0.47**
(FS/FU)/(WS/WU)	-1.02	-0.48	0.03	-1.15	-0.70	-0.10	-0.33	-0.07	-1.14***	0.11	0.05	-0.27
(FW/FS)/(SW/SS)	0.25	0.34	0.28	0.12	0.22	0.29	-0.12	0.14	0.09	-0.04	0.16	0.03
(FW/FU)/(SW/SU)	-1.02	-0.47	0.27	-1.44	-0.86	-0.06	-0.82	-0.55	-0.20	-0.04	0.12	-0.35*
(FS/FU)/(SS/SU)	-1.27	-0.75	-0.03	-1.57	-0.99	-0.45*	-0.70	-0.67	-0.55**	-0.00	-0.05	-0.16
(FW/FS)/(UW/US)	1.01	1.10	0.41**	0.54	0.75	0.08	0.16	0.34	-0.07	-0.12	0.04	-0.17
(FW/FU)/(UW/UU)	1.18	1.18	0.06	0.56	0.85	-0.43*	1.05	0.82	-0.41	0.53	0.35	-0.37
(FS/FU)/(US/UU)	0.17	0.16	-0.47***	0.02	0.17	-0.59***	0.89	0.46	-0.58*	0.65	0.28	0.04
Group 5												
(WF/WW)/(SF/SW)	-1.32	-1.23	0.40	-0.74	-0.90	0.42*	-0.49	-0.04	-0.36	-0.90	-0.59	-0.24
(WF/WS)/(SF/SS)	0.85	1.01	0.24	1.05	0.85	0.85***	0.96	1.42	-0.51	0.18	0.43	-0.38*
(WF/WU)/(SF/SU)	0.61	0.57	0.20	0.63	0.50	0.73**	0.58	0.86	0.01	0.07	0.33	-0.33
(WF/WW)/(UF/UW)	-3.72	-2.79	-0.04	-2.42	-1.98	0.30	-1.71	-1.25	-0.73*	-1.71	-1.46	-0.24
(WF/WS)/(UF/US)	-0.79	-0.18	0.36	-0.21	0.28	0.37	0.01	0.44	-1.06**	-0.72	-0.55	-0.39
(WF/WU)/(UF/UU)	0.40	0.32	-0.25	0.96	1.10	0.24	1.23	1.18	-1.26**	-0.17	-0.29	-0.41
(SF/SW)/(UF/UW)	-2.40	-1.50	-0.52	-1.68	-1.10	-0.16	-1.23	-1.18	-0.69	-0.82	-0.95	0.18
(SF/SS)/(UF/US)	-1.64	-0.86	-0.17	-1.26	-0.55	-0.35	-0.95	-0.98	-0.74*	-0.90	-1.06	0.00
(SF/SU)/(UF/UU)	-0.20	-0.02	-0.45*	0.33	0.62	-0.57**	0.65	0.21	-1.12**	-0.25	-0.72	0.31
Group 6												
(FF/FW)/(WF/WW)	4.35	3.50	0.45	3.61	2.78	1.36***	4.08	2.99	2.48***	3.93	3.19	1.96***
(FF/FS)/(WF/WS)	2.43	1.94	0.35	1.94	1.31	0.96***	2.52	1.61	3.10***	2.82	2.35	1.94***
(FF/FU)/(WF/WU)	1.41	1.42	0.33	0.79	0.72	0.69**	2.19	1.67	1.98***	2.92	2.43	1.64***
(FF/FW)/(SF/SW)	3.03	2.24	0.54*	2.87	1.96	1.77***	3.60	2.90	2.18***	3.03	2.58	1.88***
(FF/FS)/(SF/SS)	3.28	2.47	0.76***	2.99	2.09	2.05***	3.48	3.00	2.38***	3.00	2.75	1.76***
(FF/FU)/(SF/SU)	2.01	1.72	0.79***	1.42	1.18	1.60***	2.77	2.30	2.44***	2.99	2.72	1.63***
(FF/FW)/(UF/UW)	0.62	0.51	0.17	1.19	0.86	1.54***	2.37	1.76	1.81***	2.22	1.65	1.77***
(FF/FS)/(UF/US)	1.64	1.55	0.59***	1.73	1.45	1.65***	2.53	2.09	1.83***	2.09	1.65	1.37***
(FF/FU)/(UF/UU)	1.81	1.68	0.11	1.75	1.64	1.05***	3.42	2.57	1.21**	2.75	2.01	1.63***

Table A7: Local drivers of odds ratios

A.6 Robustness

Table A8 calculates the Altham statistic d and subcomponents d^N and d^F using the multinomial logit model with controls for age (reference specification in the first column). As is evident from the table, this does not change the level of mobility reported in the reference specification without such controls.

	Time period	Reference	Dummy for father's age	Dummy for son's age	Both dummies
$d(P, J)$	1865-1900	24.1 (23.6 – 24.6)	24.1 (23.6 – 24.6)	24.1 (23.6 – 24.5)	24.1 (23.7 – 24.7)
	1910-1960	20.4 (20.1 – 20.8)	20.4 (20.1 – 20.7)	20.4 (20.1 – 20.7)	20.4 (20.1 – 20.8)
	1960-1980	22.3 (22.1 – 22.6)	21.9 (21.6 – 22.2)	22.0 (21.8 – 22.3)	21.9 (21.7 – 22.2)
	1980-2011	19.1 (18.9 – 19.3)	18.8 (18.6 – 19.0)	19.0 (18.7 – 19.2)	18.9 (18.7 – 19.1)
d^N	1865-1900	18.8 (18.1 – 19.5)	18.8 (18.0 – 19.4)	18.8 (18.2 – 19.4)	18.8 (18.2 – 19.5)
	1910-1960	15.5 (15.1 – 16.0)	15.5 (15.0 – 16.0)	15.5 (15.0 – 16.1)	15.5 (15.0 – 16.0)
	1960-1980	12.7 (12.4 – 13.2)	12.7 (12.3 – 13.1)	12.6 (12.2 – 13.0)	12.6 (12.2 – 13.0)
	1980-2011	7.8 (7.5 – 8.3)	7.8 (7.4 – 8.2)	7.8 (7.4 – 8.1)	7.8 (7.4 – 8.2)
d^F	1865-1900	15.1 (14.6 – 15.7)	15.1 (14.4 – 15.6)	15.0 (14.4 – 15.6)	15.1 (14.5 – 15.8)
	1910-1960	13.3 (12.8 – 13.7)	13.3 (12.8 – 13.8)	13.3 (12.9 – 13.7)	13.3 (13.0 – 13.7)
	1960-1980	18.3 (17.9 – 18.7)	17.9 (17.4 – 18.3)	18.1 (17.7 – 18.5)	18.0 (17.5 – 18.4)
	1980-2011	17.4 (17.1 – 17.8)	17.1 (16.8 – 17.4)	17.3 (17.0 – 17.6)	17.2 (16.9 – 17.5)

Table A8: Age robustness.

Table A9 shows mobility metrics for the sample restrictions described in Section B.1. There are no large changes in the estimated mobility statistics, though the 1960-1980 estimate is slightly lower when restricting the sample to those 0-15 years of age in 1960.

Time period	Sample	Number of obs.	$d(P, J)$	d^N	d^F
1865 - 1900	Reference	58459	24.11	18.76	15.15
1865 - 1900	Age 0-15 at t_0 only	44525	24.07	19.10	14.65
1865 - 1900	Including immigrants	58477	24.12	18.76	15.15
1911 - 1960	Reference	70339	20.42	15.52	13.26
1911 - 1960	Age 0-15 at t_0 only	70339	20.42	15.52	13.26
1911 - 1960	Including immigrants	70611	20.41	15.52	13.26
1960 - 1980	Reference	201298	22.34	12.74	18.35
1960 - 1980	Age 0-15 at t_0 only	104402	21.31	11.51	17.94
1960 - 1980	Including immigrants	203369	22.34	12.73	18.36
1980 - 2011	Reference	505441	19.10	7.84	17.42
1980 - 2011	Age 0-15 at t_0 only	282613	19.15	8.11	17.35
1980 - 2011	Including immigrants	514722	19.15	7.81	17.48

Table A9: Sample selection robustness

Table A10 shows results when some occupations are coded differently. The first row shows the reference estimates. In the second row, cottagers are coded as farmers rather than manual unskilled workers (this only affects the first two time periods). In the third row, “lower white collar” workers (defined as in Long and Ferrie (2013)) are are grouped together with skilled manual workers rather than with the “upper white collar” workers. As is evident from the table, the overall results are not greatly affected by these substantial recodes.

Time period	Recode	$d(P, J)$	d^N	d^F
1865-1900	Reference	24.1	18.8	15.1
1865-1900	Code cottagers as F instead of U	22.0	16.8	14.2
1865-1900	Code “lower white collar” as S instead of W	24.1	18.5	15.3
1910-1960	Reference	20.4	15.5	13.3
1910-1960	Code cottagers as F instead of U	19.9	14.8	13.3
1910-1960	Code “lower white collar” as S instead of W	20.9	16.2	13.3
1960-1980	Reference	22.3	12.7	18.3
1960-1980	Code cottagers as F instead of U	22.3	12.7	18.3
1960-1980	Code “lower white collar” as S instead of W	22.6	13.4	18.2
1980-2011	Reference	19.1	7.8	17.4
1980-2011	Code cottagers as F instead of U	19.1	7.8	17.4
1980-2011	Code “lower white collar” as S instead of W	19.6	8.2	17.8

Table A10: Robustness: Occupation recode

B Matching of individuals across censuses

B.1 Variables

In all sources, age, sex, occupation and the municipality of residence is available. In addition, the following information is used:

- Census of 1865, 1900 and 1910:
 - First name
 - Last name
 - Name of place of residence
 - Information on family relationship of those who reside together
 - Birth year
 - Birth month and date (only available in 1910)
 - Municipality of birth
- Census of 1960:
 - Birth county
 - Whether born in rural or urban municipality
 - Birth year, month and date
 - First name *
 - Last name *
 - Father-son linkages *

The variables marked with an asterisk (*) is obtained from the Central Population Register (as of 1964, but including those deceased 1960-64) and linked by the national ID number. All data post 1960 is linked by the national ID number. In the following, the combination of 1960 Census and 1964 Population Register information will be referred to as the “1960 Census”.

B.2 Linkage

For 1960 onward, all linkage is through the national ID number and is for all practical purposes complete. There are some missing father-son combinations for those not living together in the 1960 Census, see Table 1. This section concerns the pre-1960 linkage.

Identifying information

Consecutive censuses are linked by personal information: name, birth time and birth place.

For the 1865-1900 link, the following information was used:

- First name
- Last name as stated in census
- Last name constructed as patronymic

- Last name constructed from place name
- Birth year
- Municipality of birth

Norwegians were not mandated to have a fixed family name until 1925. Before this, naming customs varied. Among the upper classes, families had used fixed last names since the 1700s. In cities, this was increasingly common also among the lower classes. In rural areas, one could use the name of the farm of birth or residence, or a patronymic (name of father + “sen”). Over the generations, these farm names or patronymics became attached to families and transmitted unchanged from fathers to children. Unlike other European countries, the custom of using occupation names (Smith etc) as family names has not been widespread in Norway.²⁴

To account for the changing last name practices, the information in the censuses are used to construct patronymics (using the first name of the father) and place-based names (using the farm names) is also used here. Last names in period 1 is compared to last names, patronymics and place names in period 2, and vice versa. Last names as stated in censuses are also compared directly. The best of these five possible matches is chosen to “score” the last name as given below.

Municipalities that changed borders between censuses are merged if the border change (or split/merger) affected more than x per cent of the population. The municipality code is replaced with a new code for the merged units, removing bad scores that are due to changes in the administrative structure.

For the 1910-1960 comparison, the following information is used:

- First name
- Last name as stated in census
- Last name constructed as patronymic (only 1910)
- Last name constructed from place name (only 1910)
- Birth year, birth month, birth date
- County of birth
- Whether born in rural or urban municipality

In this case, there are only three possible last name scores.

The 1960 census did not record municipality of birth. Rather, the county of birth was recorded, combined with information on whether one was born in the municipality where one resided, in a different rural municipality, or in a different urban municipality. To avoid overmatching of non-movers, only the rural/urban distinction and the county distinction is used here. Municipalities in 1910 are grouped by county and rural/urban status for this comparison. Because birth dates (not only birth years) were recorded in 1910, this is not a large problem in terms of identification.

²⁴For a review of Norwegian naming history (in Norwegian), see *NOU 2001: 1 Lov om personnavn*, section 4, available at <http://www.regjeringen.no/en/dep/jd/dok/nouer/2001/nou-2001-1/5.html?id=376516>

Sample selection

Because of the changing last names of women, only men are matched.

To match as many individuals as possible, a large set of cohorts were included in the match procedure:

- 1865: born after 1800
- 1900: born after 1800
- 1910: born after 1860 (for link to 1960)
- 1960: born after 1860 and before 1912

The age intervals allow for a small mis-measurement of birth years.

Standardization and formatting

The 1865-1910 files are obtained from the North Atlantic Population Project (www.nappdata.org). The 1960-2011 files are stored at Statistics Norway. Names are converted to lower case. Norwegian special characters (æ, ø, å) are stored as “x” in the 1865 and 1900 censuses and “a” in the 1910 census. To improve matching, they are converted to “a” in all censuses. Special characters are removed from the name fields, and some substitutions were made where similar names are sometimes spelled differently (such as “ch” for “k”).

Patronymics for the 1865-1910 censuses were constructed by identifying the father from the “poploc” variable, taking the father’s first name and adding “sen” to the end. For “Ola” and “Ole” the last name is set to “Olsen”.

B.3 Matching algorithm: Calculating differences in identifying information

Because of the large sizes of the match files, conventional match programs are overwhelmed. To improve running time and improve flexibility in formulating match rules (detailed below), all distances between matches were pre-calculated. For each piece of identifying information (as listed in Section B.2 above) and year, a file with all unique occurrences was constructed. Then, all occurrences in year A were compared to all occurrences in year B for all variables. Points were assigned in the following way:

Strings (names)

The Levenshtein distance between any two strings are calculating using a command included in the `strgroup` package for Stata (written by Julian Reif, University of Chicago). The Levenshtein algorithm counts the minimum number of letter removals, additions or swaps needed to go from one string to another. The distance between the strings is divided by the length of the shortest string to get the final score. Only matches with name scores less than 0.3 are considered.

Scores are denoted D_F (first names), D_{L-CC} (last names), D_{L-PC} (patronymic in first period, last name in second period), D_{L-LC} (location name in first period, last name in second period), D_{L-CP} and D_{L-CL} .

Birth years

The score is the absolute value of the birth year in the two sources, and is considered if the difference is five years or less. The score is denoted D_Y .

Birth dates (1910-1960 only)

The score is 0 if birth year, month and date all match; 1 if any two of (year,month,date) matches. If birth date and month match, 1/100 times the absolute difference in birth years is added. The score is 2 if only the year matches. In all other cases the match is not considered. The score is denoted D_D .

Municipality of birth

Municipalities are aggregated to avoid mismatches due to border changes and mergers. There were 491 municipalities in 1865 and 594 in 1900. For the 1865-1900 match, 455 municipality clusters (groups of municipalities) were constructed; these then have the same borders in 1865 and 1900.

The score is set to 0 if the municipality cluster matches; 1 if the cluster is different but the county matches; 2 if both periods have missing birth municipality and 3 if one of the periods has a missing birth municipality. The score is denoted D_M .

County and urbanity of birth (1910-1960 only)

The score is set to 0 if the county of birth as well as the “urbanity” of birth (ie whether reported as rural or urban) matches, to 4 if the county doesn’t match and to 0.5 if the county matches but not the “urbanity”.

B.4 Aggregating match scores

With the above qualifications, all matches between the compared censuses are considered. First, the two lists are merged by potentially similar first names ($D_F < .3$), then the scores for other matches are added. The last name score is constructed as $D_L = \min(D_{L-CC}, D_{L-PC}, D_{L-LC}, D_{L-CP}, D_{L-CL})$ for 1865-1900, 1900-1910 and 1865-1910 and as $D_L = \min(D_{L-CC}, D_{L-CP}, D_{L-CL})$ for 1910-1960. Matches that are not considered (too different birth times or $D_L > .3$) are removed from the data set.

These scores are then combined to create an aggregate score by the following formula for 1865-1900, 1900-1910 and 1865-1900. To balance the impact of name changes to differences in other characteristics, name differences were multiplied by 8.

$$D = 8 \cdot D_F + 8 \cdot D_L + D_Y + D_M \quad (12)$$

and the following for 1910-1960:

$$D = 8 \cdot D_F + 8 \cdot D_L + D_D + D_C \quad (13)$$

The score D states the difference between one observation from each time period. Clearly, we want to pick the pairs of observation with low difference. However, we also have to evaluate the degree of *uniqueness* of each pair. For each observation i from time t , rank the candidates from period $t - 1$ in descending order by score. Each $t - 1$ candidate j will now have a difference score $D_{i,j}$. The uniqueness parameter R_i is then the difference between the (i, j) combination score $D_{i,j}$ and the score of the next best option (i, j') , $D_{i,j'}$. A higher value of R_i means the match is more clearly better than other candidate matches. A similar uniqueness score R_j can be calculated from the viewpoint of the $t - 1$ data set.

For a candidate to be accepted, restrictions are placed on the difference score and the uniqueness of each pair of observations. As the matching procedure is computationally intensive, a limited set of combinations are considered. Two different approaches with respect to uniqueness are tried; one where the limit of R is increasing with D (that is, more uniqueness is required if the match score is relatively poorer) and one where the limit of R is the same regardless of the requirement on D . In both cases, the match procedure is run iteratively; after each round, all accepted matches are removed and the metrics are re-calculated.

The first round consists of all perfect matches: those where name, birth place and birth time match perfectly ($D_{i,j} = 0$) and there are no other potential candidates for match (that is, no candidate pairs where the composite scores are below the consideration thresholds described in Section B.3 above).

From the second round onward, the allowable difference is increased in increments of 0.5. The allowable non-uniqueness is set to 0.5 for the second round and then increased by 0.25 in each iteration. Thus, the second round has the requirement $D_{i,j} \leq 0.5, R_i \geq 0.5, R_j \geq 0.5$, the third round $D_{i,j} \leq 1.0, R_i \geq 0.75, R_j \geq 0.75$ and so on. Visual inspection of the results show that the number of potential erroneous matches start to appear around the sixth or seventh iteration. For this reason, the match procedure is stopped after round 5, with the final requirement being $D_{i,j} \leq 2.0, R_i \geq 1.25, R_j \geq 1.25$. The details of the matching algorithm do not affect the mobility estimates. Table A11 shows the Altham statistic $d(P, J)$ for five levels of “stopping”. While there is some systematic variation in the Altham statistic, it is much lower than the differences across time periods, and the difference between the matrices is not significant (using chi-square tests as in Long and Ferrie (2013) to distinguish different matrices). Table A11 also shows the results for a case where the uniqueness requirements R_i, R_j are not tightened as the difference criterion is relaxed; also in this case, there are no large differences in the results.

Min. diff.	Increasing			Constant		
	Obs.	$d(P, J)$	p -val.	Obs.	$d(P, J)$	p -val.
1865-1900						
1.0	50,345	24.31	0.993	50,571	24.29	0.896
1.5	53,920	24.43	0.997	55,365	24.36	0.933
2.0	58,477	24.12		62,317	23.78	
2.5	60,224	24.00	1.000	64,825	23.61	1.000
3.0	61,751	23.90	0.999	68,000	23.21	0.868
1910-1960						
1.0	52,471	20.66	0.988	52,652	20.64	0.979
1.5	62,558	20.53	0.999	63,848	20.53	0.997
2.0	70,611	20.41		72,577	20.35	
2.5	73,562	20.33	1.000	75,878	20.27	1.000
3.0	75,125	20.33	1.000	77,727	20.26	1.000

Table A11: Match robustness. Main specification set in bold type. p -val. refers to the result of a χ^2 -test of whether the mobility matrix obtained by this matching rule differs from the reference case.

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