Intergenerational Mobility in Norway, 1865-2011

Jørgen Modalsli

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Intergenerational mobility in Norway, 1865-2011

Jørgen Modalsli*

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Abstract

There are large differences in intergenerational mobility between countries. Little is known, however, 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 non-farm 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.

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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 those of their parents, not all members of society will be able to make use of 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 changes 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, it is necessary to have data that measure these characteristics consistently over time, along with the possibility of linking 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, since 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 has 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 them 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

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

[2]van Leeuwen & Maas (2010) review the historical sociological literature on intergenerational occupational mobility based on such regional databases. Lindahl *et al.* (2015), studying three generational transitions in the 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.

[3]See 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).

non-farm occupations.

This paper contributes to the literature in three ways. It presents the first nationwide, long-run data set on intergenerational occupational mobility outside the United States and United Kingdom; this is also the first study to use a consistent methodology for the nineteenth, twentieth and twenty-first centuries. 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 non-farm 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 provides an economic interpretation of 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 in social mobility over time. Few systematic differences in mobility are found across Norwegian regions, and the extent of neighborhood effects has 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 decreased 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, mobility was lower than in the US in the nineteenth century, and it 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 becomes clear that the stability of intergenerational mobility in Great Britain is not representative of Europe as a whole.

Social mobility in Norway between 1800 and 1950 has previously 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 increasing population growth,

[4]Because 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.

putting 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 type 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 ones 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 admission 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 non-farm mobility and shows that the results for academic elites are representative of 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 the 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). They 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 that it has increased steadily in the intervening period, concurrently with the development of a large range of policies relating to education and social assistance.

Since 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. However, decreased within-country regional diversity is one change over time that is highlighted by several authors. 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, which removes the opportunity to achieve social mobility through geographic migration. Regional differences are also a central theme in the work of

[5] The evidence using other outcomes than income is 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 from between 1989 and 2011, demonstrate that the receipt of disability benefits in one generation has a substantial causal impact on the receipt of disability benefit in the next generation.

[6] There 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 fathers' and sons' occupations; the evidence for a father-daughter association is weaker.

Boberg-Fazlic & Sharp (2013), who find moderate differences between the North and South of England in 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.[8] 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 find any signs that differential development of the country's regions 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. It is worth noting, however, 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 not established until the late 1960s.

Public elementary education was established by law in 1739, and formalized as seven-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 II period, with the share of 19-year-olds completing academic-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 arrangements elsewhere in the world. These laws regulate the ownership of farms and agricultural land, and stipulate that family members (in particular descendants) have a preemptive right to purchase farms, and that farms cannot be split into smaller units and divided among heirs.[9] One would expect these laws to strengthen persistence in farming in the entire time period studied here.

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

[8]A similar correlation has been observed for nineteenth-century United States (Long & Ferrie, 2013; Olivetti & Paserman, 2015); however, Chetty *et al.* (2014b, Appendix H) find no strong evidence for such a correlation in modern U.S. data.

[9]The 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).

2 Data and aggregate trends

2.1 Norwegian censuses

The data used in this study come from the Norwegian censuses of 1865, 1900, 1910, 1960, 1970, 1980, and 2011. With the exception of the 2011 census, which was compiled from administrative records by Statistics Norway, all censuses were based on interviews or mail-in forms. The 1865-1910 censuses were digitized and occupations coded in a collaboration 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; they 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 receipt 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 percent 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 arrangements have existed since the 1860s.

Data from historical Norwegian censuses (for 1865 and 1900) has found some use in economic research, 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 they were only recently (2014) made available with occupation codes and have not yet been widely used in research. Modern registry data on Norwegian individuals (data from 1960 onward) have been used extensively in many areas of the social sciences; a partial survey of studies on social mobility is provided in Black & Devereux (2011). However, this study is the first to link data on individuals from the historical samples with 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 the son of somebody else in the same household. For this reason, occupational information is always taken from two different censuses, using 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 provides us with 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. [10]

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 of constructing a generational database relates to the linkage of individuals across censuses. The Norwegian Central Population Register, which has 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 percent.

Before 1960, there was no national database of individuals in Norway. For this reason, individuals are linked based on names, birth dates, and birthplaces. 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 changes between sources, both because of writing 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 Levensthein algorithm as implemented by Reif (2010). Historically, several systems of family name formation were in use in Norway: inheritance of father's surname, a patronymic based on the father's first name, or the name of the farm of residence (or origin). Last names gradually 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 based 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

[10] Based on registry data from 2011, we can verify that the variation in occupations across cohorts in the "son" generation (holding father's occupation constant) is much lower in this age range than it is below the age of 30 or above age 60. Detailed results are available on request.

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 based 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 basis. Individuals are matched if they have a high score on similarity of first name, last name, birthplace, 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 provided in the Appendix.

The final data consist of occupational cross-sections for men aged 30-60 in 1865, 1900, 1910, 1960, 1970, 1980, and 2011.[11]. This study is restricted to men (fathers and sons) for two reasons. First, most women change their names upon 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	Match-able in t_1	Share found in t_0	Known father in t_0	Matched pop.	Father's 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 are: 1865 to 1900, 1910 to 1960, 1960 to 1980, and 1980 to 2011. The first four

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

lines of Table 1 show 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 shows 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 and 50.7% for 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.[12] From 1960 onward, as a result of the introduction of national identification numbers, individuals are fully matched between censuses.

The third column of Table 1 shows 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 from that census (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 on a smaller sample, where the population was restricted to those who were 0-15 years old at t_0. The match rates for this sample are given in lines five to eight in 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 shows the matched population that can potentially be used for analysis. However, once we restrict the father's age to being 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), this results in a final analysis sample ranging from 58 459 for 1865-1900 to 505 441 for 1980-2011.

There are some differences in matching between occupation groups. Farmers in 1900 are matched to their fathers in 1865 to a larger extent than non-farmers, as are white-collar workers in 1960 to their fathers in 1910. However, changes to the matching algorithm yield very little change in the estimated mobility. Moreover, the metrics of mobility used in this paper are robust to match rates that differ by son's occupation.[13]

[12] Estimates of intergenerational mobility do not change substantially when the thresholds are varied. See the Appendix for calculations based on samples constructed using alternative scoring rules.

[13] For a full tabulation of by-occupation match rates, as well as the robustness check on match rates, see the Appendix.

The matched population can be compared to other studies utilizing individual match rates, namely the studies by Long & Ferrie (2013) and Abramitzky *et al.* (2012). Since 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%; since the data are sampled, they cannot rely on uniqueness for matches with substantial deviations, and the regional dimension in their data is coarser.[14] 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%.

The study of mobility using father-son pairs that is established here can be contrasted with a recent literature that explores mobility trends by examining the joint distribution of surnames and economic outcomes without constructing explicit links.[15] For some countries, this is the only approach possible given the data that are currently available. In many cases, however, such estimates can be difficult to compare; for example, the results of Guell *et al.* (2015) on Spain depend on a "name mutation" parameter that is not directly observed and could vary across countries. Moreover, Chetty *et al.* (2014a, Appendix B) show that estimates based on surnames can potentially be a measure of persistent differences between groups with similar characteristics, rather than of individual intergenerational mobility. Hence, it is preferrable to use direct intergenerational links in situations where they can be feasibly constructed.

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 take 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 manner. 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 it 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

[14] The twentieth-century mobility samples used by Long & Ferrie are derived from survey data based on questions asking respondents to recall father's occupation at an earlier date, and they are therefore not comparable to the type of data utilized here.

[15] Prominent examples are Guell *et al.* (2015); Collado *et al.* (2013); Clark & Cummins (2015); Clark (2014). Olivetti & Paserman (2015) use a related methodology where they compare averages across first names for the same cohorts at different points in time.

most years, census records contain 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 division 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/semi-skilled group that requires education or specialized training, such as carpenters and welders, and an unskilled group that depends mainly on purely physical work, including fishermen, cottagers, day laborers, and forestry 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 changes and because of the 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 in the labor force ("horizontal" movement) as much as a "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 changes in 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 into "upper" and "lower" occupations). Appendix Tables A1-A4 list the most prominent occupations in each occupation group 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 more rapid in the United States. The share of white-collar occupations is 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 manual skilled workers, where the population share in Norway increases from 18 percent in 1865 to 42 percent in 1960, then decreases to 31 percent in 2011. For most of the period, there is a downward trend in the number of unskilled workers; this also reflects the decline in the number of farm workers.

It should be noted that, in the mid-nineteenth century, the share of farmers in both Norway and

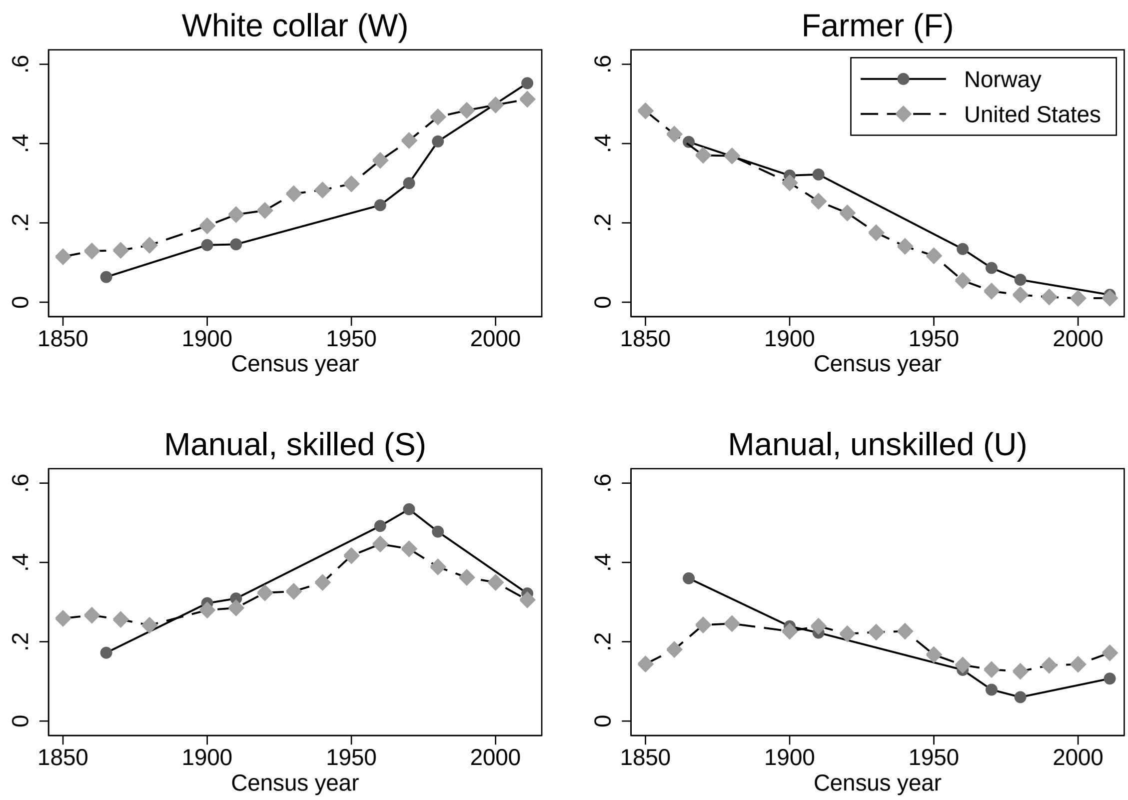


Figure 1: Occupational distributions. Share of men aged 30-60 that work in a given occupation group, Norway and United States. Sources: Norway: see text, US: author's calculation from USA IPUMS

the United States 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 percent, respectively, while the share of skilled or semi-skilled manual workers is nearly sixty percent in 1881. A similar exercise for Sweden for the years 1890 and 1900 gives a farmer share of 28 and 24 percent, respectively, 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. Occupation is the only variable that is available at the individual level and that is 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 in relation to each other.

However, for some analyses, it is desirable to also have income data. While this is not available at the 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 are taken from income categories for 1868 reported in Norwegian Department of Justice (1871).[16]

White-collar mean incomes fell from 2.36 times the population mean income in 1865, when the white-collar group was very small, to 1.17 times the population mean in 1980, with a moderate increase after this. Manual skilled workers experienced a decline from 1.06 times the 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, then fell again from 1980 to 2011. These substantial changes in the income distribution over time show the importance of using income data from several years when imputing occupational status or incomes, as opposed to relying on cross-section data from one year only. 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 been kept 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 the mean income for all taxpayers and will be used in some regional analyses.

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 provides some information about the extent of occupational change between generations.[17] For example, in the 1865-1900 period, 45.6 percent of sons belonged to a different occupation group than their father, increasing to 50.2 percent from 1910 to 1960, 51.5 percent from 1960 to 1980, and decreasing slightly to 49.7 percent for the 1980-2011 period.

We can further analyze the occupational choices 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 entering occupation j given father's occupation i is

[16]Unlike the other years, the age restriction for the 1865 income data is all men aged 25 and above. Moreover, the data are given in income intervals rather than as mean incomes, so some imputation of incomes was necessary. No income data were available for 1900, and the 1910 income data have been used.

[17]The matrices for the four transition periods are presented in Table A5.

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

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 a son's occupation.

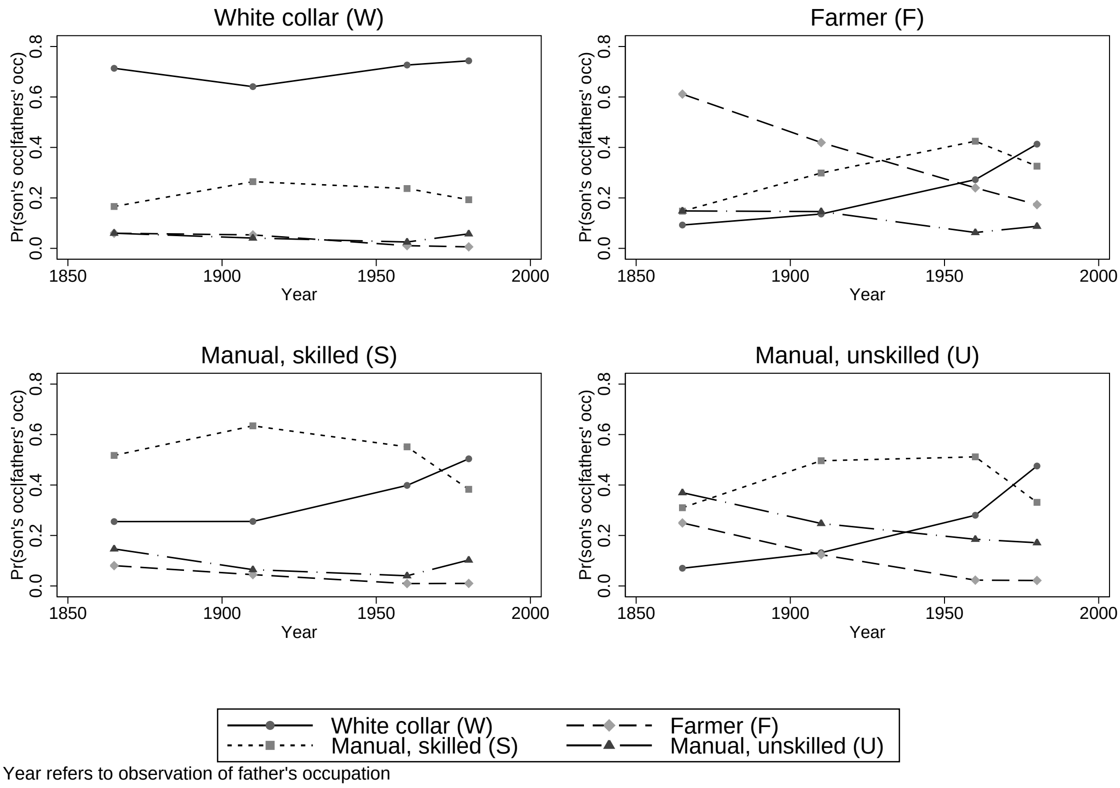


Figure 2: Transition probabilities. Probability of son's occupation (lines), given father's occupation (figure titles)

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 enter 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 in 2011 was only around one percent. The largest non-farm occupation choice for farmers' sons is manual skilled occupations until 1980. Over the entire time period, white-collar occupations gain ground among sons of farmers, and in the 1980-2011 period, this is the most common type of occupation for this group. The recruitment into unskilled occupations is relatively stable.

Those growing up with fathers who have skilled manual occupations overwhelmingly choose similar occupations, though the share steadily declines in the late twentieth century and is gradually replaced by white-collar occupations. For sons of unskilled fathers, there is also a large propensity to enter into skilled occupations; after 1900, less than one-third of sons of unskilled fathers 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 entering white-collar or 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 decreased. This reflects changes in the non-farm 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. Standard two-way odds ratios provide a useful tool in this context. For a father's occupation i, the "advantage" his son has in relation to entering 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 changes 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

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

and express the "advantage" a son of a father with occupation i has in relation to entering 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.

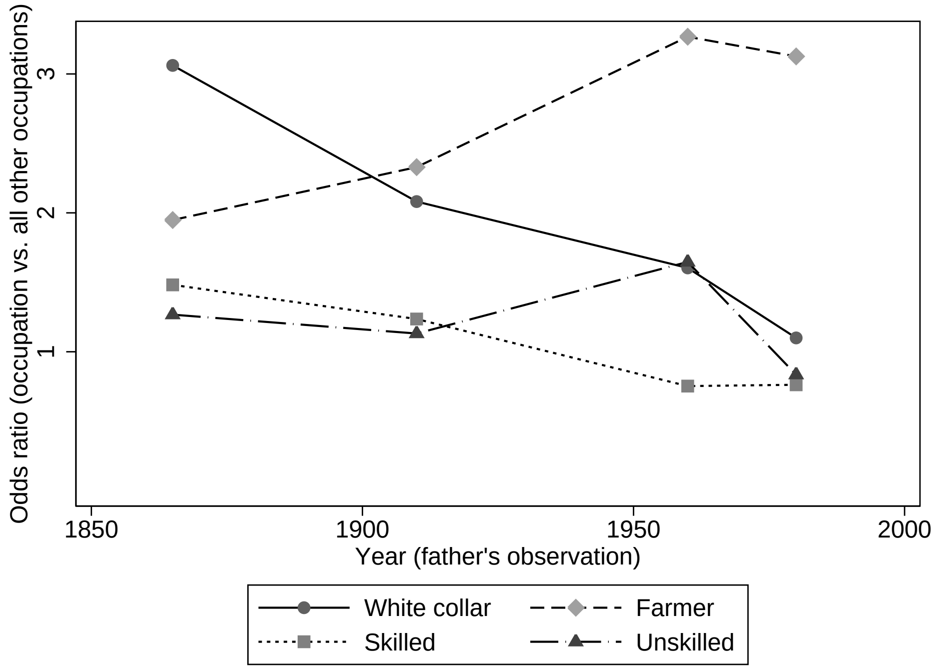


Figure 3: Two-way odds ratios: excess probability of entering occupation, given that father had same occupation. For each occupation X, $\log\left((p_{X,X}/p_{X,\neg X})/(p_{\neg X,X}/p_{\neg X,\neg X})\right)$

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 enter white-collar occupations compared to non-white-collar occupations. This advantage gradually disappeared over time, and the odds ratio in the period 1980-2011 was reduced to 1.1, giving a probability ratio for sons of white-collar fathers 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 and with a more gradual development. For sons of fathers with manual unskilled occupations, the trend is less clear, with persistence being higher for the 1960-1980 father-son pair than for the 1910-1960 pair. Finally, for farmers, the trend is entirely the 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 entering a white-collar occupation increased faster for a son of a father in the "manual, unskilled" category than for 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

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

If we consider 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 of the son of a white-collar father entering a white-collar occupation to the probability that he will enter 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.[18] We focus on the comparison between an observed mobility matrix P and a hypothetical matrix J of full mobility, where a son's occupational choice is independent of father's occupation. 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

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

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 a low degree of intergenerational occupational mobility. Zero refers to full mobility, that

[18] The constant is $N(N-1)$, where N is the number of categories in the matrix. While arguments could be made for using the geometric mean directly, that is, dividing the Altham statistics reported here by 12, this paper uses the original scaling to facilitate comparisons to previous studies.

is, no association between fathers' and sons' occupations, while there is in theory no upper bound on d except for that imposed by the discreteness of the data.[19]

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 24.1. This is comparable to the 1851-1881 statistic for the 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 increased to 22.3, before falling 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.[20]

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 fully disentangle what these changes reflect. Xie & Killewald (2013) and Hout & Guest (2013) challenge the use of 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 though 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.[21]

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

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

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, $d(P,Q) \neq |d(P,J) - d(Q,J)|$.

[20] Using a multinomial logit model (see Section 4.2) we can control for the age composition of the father and son populations when calculating the Altham statistics for the Norwegian data. As shown in further detail in Appendix A.6 (Table A8), this hardly changes the Altham statistic; for the four periods, it is 24.1, 20.4, 21.9, and 18.9, respectively.

[21] The 36 unique odds ratios are combinations 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

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 non-farm probability ratios for sons of white-collar workers to those of sons of skilled workers, the difference disappeared rapidly - and monotonously - in Norway between 1865 and 2011. In the US and UK, however, there is a slight increase. Mobility also increases over time for other comparisons of non-farm fathers and non-farm sons. For example, the probability of entering 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 the son of an unskilled manual worker in Norway in the period 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 period studied. This is another expression of the trend of increasing intergenerational mobility in Norway.

When we move to the odds ratios comparing non-farm fathers (WS, WU, SU, as above) to farmer vs. non-farmer sons — farmer-white collar (FW), farmer-skilled (FS) and farmer-unskilled (FU) — the trend in Norway is similar to that in the comparisons between non-farm fathers: on average, the absolute value of odds ratios decrease. There is, however, a substantial difference between sons of farmer and white-collar fathers in terms of the probability of entering a white-collar occupation in all periods. In the UK, there is little change on average, while, in the US, odds ratios comparing non-farmer fathers to farmer/non-farmer sons are increasing slightly over time. Similarly, if we compare farm and non-farm fathers (FW, FS, FU) to non-farm 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 non-farming for sons of farmers and sons of non-farmers. The aggregate squared difference of these odds ratios captures most of the particularly high persistence in 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 percent (300 of 19.1^2) was driven by low mobility among farmers. This

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

The multiplication by four 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 are further illustrated in the Appendix, Figure A2.

highlights the main challenge of using a non-weighted metric for mobility, since the farm group in the final period has a very low share of total population. This 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 non-farmers for both fathers and sons, we aggregate these odds ratios to a "non-farm" version of the Altham statistic, d^N. The remaining odds ratios compare the probability ratio of entering a farm occupation compared to a non-farm occupation for sons of farmers to the similar ratio for sons of non-farmers. The root of the sum of squares of these nine odds ratios is denoted d^F.[22]

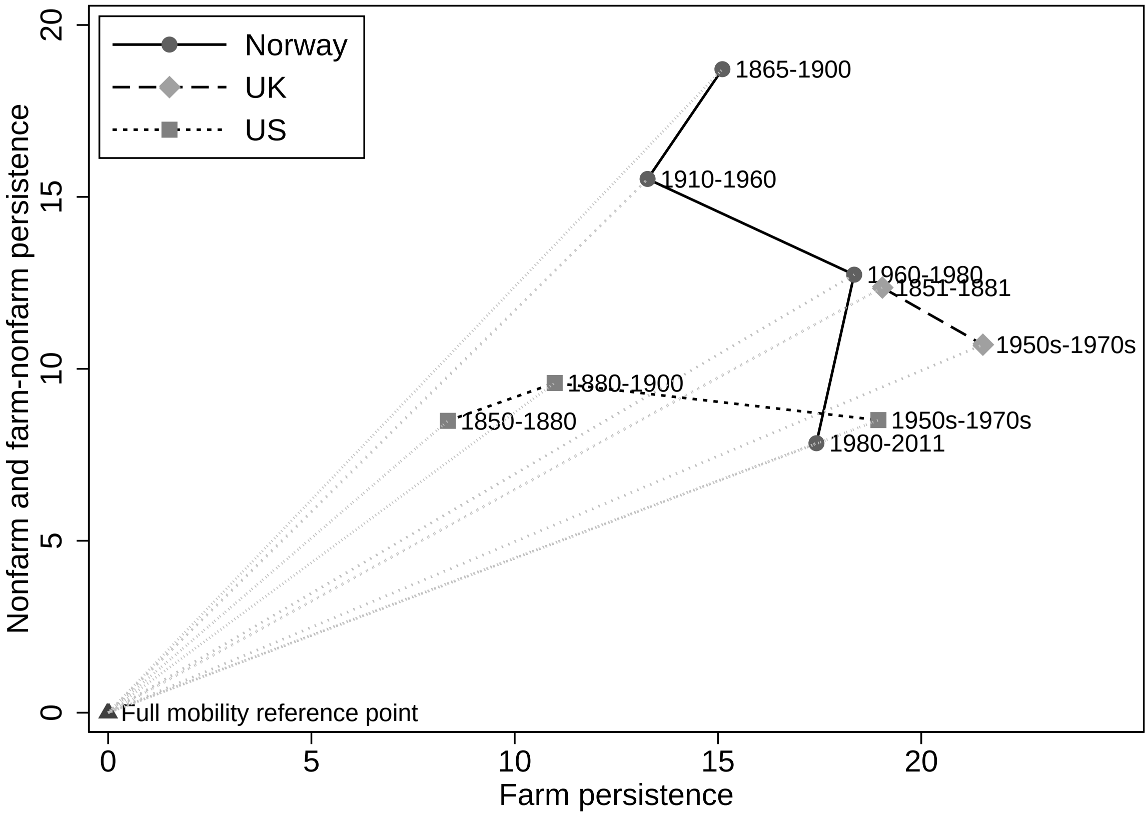


Figure 4: Two components of the Altham statistic, change over time

From the definition of the Altham statistic, it follows that the Euclidean distance between a point

[22]In the notation of Footnote 21, $\mathcal{A}$ can be partitioned into two mutually exclusive subsets: the non-farm 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 non-farmers for both fathers and sons, while the non-farm component d^N is the aggregate of the remaining components.

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

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

(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 centuries. 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 in the figure denotes aggregate mobility as measured by the Altham statistic.[23]

Farm and farm-non-farm 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 was 18.7 in the period 1865-1900, 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. non-farm 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, non-farm mobility increased substantially while farm mobility showed a moderate decrease; in the United States, non-farm mobility was stable, while farm mobility decreased substantially.

Compared to Norway and the United States, the changes in the United Kingdom between the nineteenth and twentieth centuries are small. There was a small increase in non-farm mobility and a small decrease in farm mobility.

These results for 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 4 to 6 show the share of the individuals in the matrix who have 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.[24] 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

[23]Figure 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 and J (0,0) is given weight — and is shown exactly — while the distance between matrices is not to scale.

[24]The one exception is when the marginal distributions are forced 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 placed on farmers.

Country and time	Altham statistic Conventional $d(P, J)$	Nonfarm d^N	Farm d^F	Share off diagonal M' with marg. dist adjusted to NO10-60	NO80-11	US50-80	Over-repr. at diag. $\sum s_{ii}$	Altham with 5 categories
Norway 1865 - 1900	24.1***	18.7	15.1	0.481	0.403	0.369	1.6	43.8***
Norway 1910 - 1960	20.4***	15.5	13.3	0.502	0.430	0.387	1.8	36.4***
Norway 1960 - 1980	22.3***	12.7	18.3	0.488	0.453	0.362	1.5	34.5***
Norway 1980 - 2011	19.1***	7.8	17.4	0.538	0.497	0.393	1.3	28.6***
US 1850 - 1880	11.9***	8.5	8.4	0.573	0.493	0.454	1.3	21.8***
US 1880 - 1900	14.6***	9.6	11.0	0.546	0.465	0.423	1.6	26.4***
US 1952 - 1972	20.8***	8.5	18.9	0.533	0.486	0.383	1.4	31.1***
UK 1851 - 1881	22.7***	12.4	19.0	0.482	0.458	0.355	1.5	41.2***
UK 1952 - 1972	24.0***	10.7	21.5	0.501	0.453	0.358	1.3	37.5***
Change in mobility, Norway 1865-2011	+	+	-	+	+	+	+	+

Table 2: Estimates of intergenerational mobility, 1865-2011

corresponds to lower mobility. Using this methodology yields the same trends as the main specification, though the sign of the comparison between 1865-1900 and 1910-1960 in Norway reverses. Finally, we can follow Long & Ferrie (2013) and use a five-way classification of occupations as a robustness check, where we split the white-collar group into a "high" and "low" category. The resulting Altham statistics are shown in the eighth column, which shows monotonically increasing intergenerational mobility in Norway. 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 as both vertical and horizontal changes. However, using the occupation mean incomes presented in Section 2.4, we 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 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 in 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:

$$\Delta_q = \frac{y_q^S}{\bar{y}^S} - \frac{y_q^F}{\bar{y}^F} \tag{5}$$

Scaling both incomes sets average income growth to zero andis equivalent to choosing fathers as the base and re-scaling incomes of sons by the average growth rate.[25] 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 $\lvert\Delta\rvert$	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 are shown 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.[26] The dispersion in income changes decreases over time; between 1865 and 1900 the mean absolute income difference was forty percent of mean income, decreasing to eighteen percent in 1980-2011. The distribution of the population between groups of negative and positive dispersion also changes over time. Only 32 percent of sons of 1865 fathers have higher mean occupation income than their fathers, while 62 percent of sons of 1980 fathers have higher mean incomes.

The largest positive income jumps are obtained when sons of non-white-collar fathers enter 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 farmers' relative incomes between 1865 and 1900, resulting in negative income jumps for more than three-quarters 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, resulting in negative mean income changes for these groups;

[25] Equation (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, correspondingly, in terms of mean income in son's generation as $\frac{1}{\bar{y}^S}\left(y_q^S - g y_q^F\right)$, where the growth rate $g = \frac{\bar{y}^S}{\bar{y}^F}$.

[26] As Equation (5) scales fathers' and sons' incomes by the population mean, the mean value of Δ across the population is by definition zero.

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 in income has decreased at the same time as 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

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

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 in 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 will be set to the inverse of the aggregate growth rate of the economy g, giving relative wages of fathers and sons similar weights. That is, we consider the distribution of *dynastic income* Y:

$$Y = y_f + \frac{1}{g} y_s \tag{7}$$

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, there is increasing inequality from the first to the second period and decreasing inequality thereafter. There is now no increase in the final (1980-2011) time period, as the fathers in this sample lived in a time of very low income inequality, which moderates the higher inequality experienced by their sons.

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 of 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 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 are 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.

The results of this procedure are 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

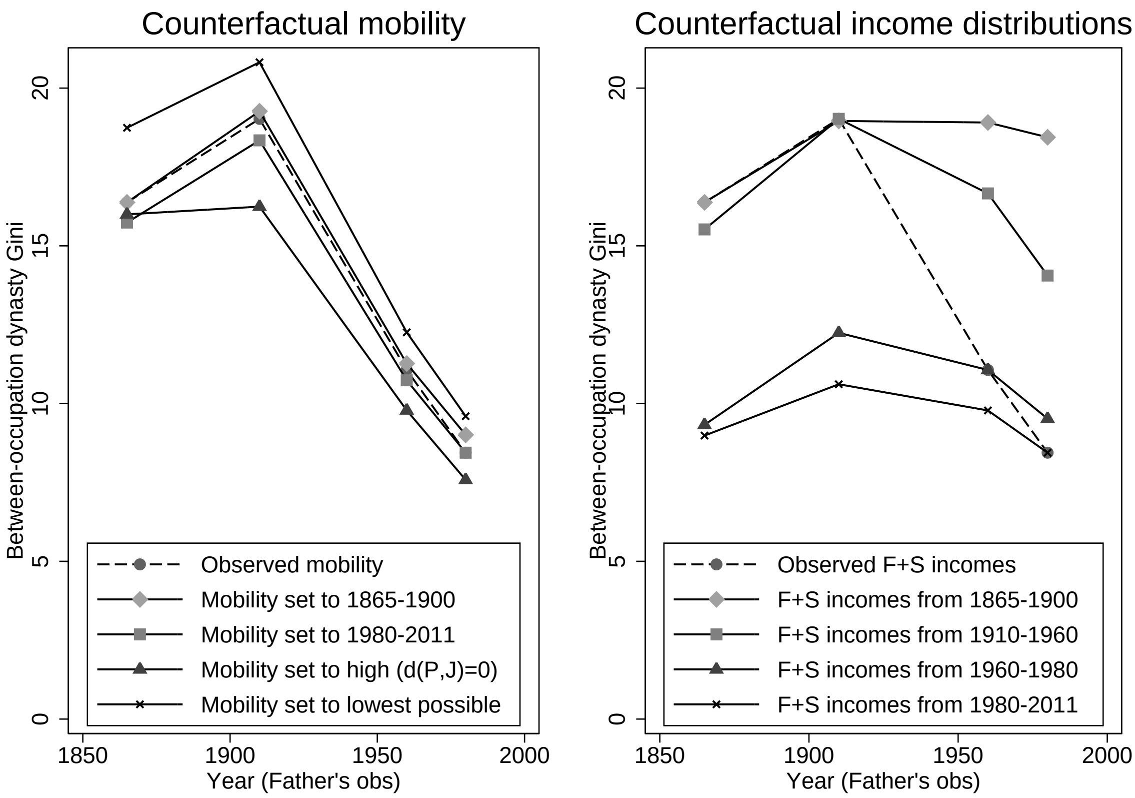


Figure 5: Counterfactual between-occupation dynasty (father+son) Gini coefficients. Left panel: using observed occupation distributions and incomes, keeping mobility constant over time. Right panel: using observed occupation distributions and mobility matrices, keeping fathers' and sons' income distributions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

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 one — 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 actual dynastic Gini for the period 1865-1900 is quite close to that which would be obtained if there were perfect mobility, while the distance is almost three Gini points during the 1910-1960 period.

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 by 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 being above Gini=16 in all time periods in this counterfactual scenario. The slightly more equal 1910-1960 income distribution also yields high income inequality in all periods. In contrast, the 1960-1980 and 1980-2011 income distributions result in a more egalitarian distribution of dynastic income.

This decomposition exercise shows that, while there has been a 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 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 rapidly, 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 the extent to which 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.[27] To the regional differences can be added some covariates from published statistics, such as the mean incomes described above. At the regional level, there are often not enough individuals for all 16 cells in the mobility matrix to be populated, making calculation of

[27] There have been large changes in the municipal structure of Norway during the period studied here. For this reason, municipalities are aggregated into units that are stable over time.

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, and this section is only able to scratch the surface in this regard. 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 a higher propensity to move location would also have a 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 non-farm 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 steadily increasing non-farm 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).

		Non-farm 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	Non-mover (R)	17.5	16.7	14.6	8.7	11.5	9.9	16.3	15.1
	Non-mover (U)	19.2	15.9	13.3	8.6	17.2	16.7	20.6	19.7
	Mover ($R \to R$)	19.3	16.3	10.8	6.0	8.4	5.6	6.9	10.5
	Mover ($R \to U$)	14.9	12.1	10.2	5.7	7.9	7.2	10.3	10.0
	Mover ($U \to R$)	15.4	12.0	9.7	5.6	7.5	6.4	14.0	10.9
	Mover ($U \to U$)	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

First, we consider local regions with cities/towns and completely rural areas separately. We find that there is only a very small difference in non-farm 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 non-farm occupations. This could mean that the farmer population in these areas on average enjoys a more exclusive social status, and hence exerts 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 non-farm 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.[28]

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, we will observe higher mobility into farming in the sending than in the receiving region. We can examine this more closely by moving from groupings of region of origin to a grouping of individuals by their realized movement decisions. If we maintain the rural-urban distinction, we have two groups of non-movers and four groups of movers. Mobility metrics for each of the six mover groups are provided in Table 4. It is clear that movers experience higher occupational mobility than Non-movers: individuals more likely to change occupation are more likely to move, and vice versa. However, mobility for those who move from one rural area to another looks more like mobility for non-movers in the first two periods studied.

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 period and the 1910-1930 period (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 upwardly 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

[28]The results from such a regression analysis are presented in the Appendix, Table A7

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 the 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. An 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 on 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 such effects is similar, however: If you live in a rural area, you are more likely to have a farmer father. You are also more likely to have a farming occupation, as such 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 $\boldsymbol{\gamma}_k$.

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

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

coefficients:

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

If we omit the **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)
Non-farm 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 are at the regional level, standard errors will be clustered on 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 decreases. This reflects the fact that some of the effects previously ascribed to father's occupation are now taken up instead 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, it decreases 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 the fact 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 to father's occupation. The effect is small, however, 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 were the case, we would expect the correction to matter more in the early periods, when there was greater 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 non-farm occupations. In this way, the development differs 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.*, 2014b), we might 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 suggests some persistence effect of childhood region, this element is relatively constant over the entire period studied. Differences in non-farm 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 non-farm 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 the result of 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 the expansion of university and college education. Future work will attempt to map more carefully the effect of the expansion of education 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 result is robust to a large set of sample restrictions as well as alternative ways of measuring mobility, and it 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.

References

Abramitzky, Ran, Boustan, Leah Platt, & Eriksson, Katherine. 2012. Europe's Tired, Poor, Huddled Masses: Self-Selection and Economic Outcomes in the Age of Mass Migration. *American Economic Review*, **102**(5), 1832–1856.

Abramitzky, Ran, Boustan, Leah Platt, & Eriksson, Katherine. 2013. Have the poor always been less likely to migrate? Evidence from inheritance practices during the age of mass migration. *Journal of Development Economics*, **102**, 2–14.

Altham, Patricia M E. 1970. The Measurement of Association of Rows and Columns for an $r \times s$ Contingency Table. *Journal of the Royal Statistical Society Series B*, **32**(1), 63–73.

Altham, Patricia M E, & Ferrie, Joseph P. 2007. Comparing Contingency Tables: Tools for Analyzing Data from Two Groups Cross-Classified by Two Characteristics. *Historical Methods*, **40**(1), 3–16.

Aubert, Vilhelm, Torgersen, Ulf, Tangen, Karl, Lindbekk, Tore, & Pollan, Sonja. 1960. Akademikere i norsk samfunnsstruktur 1800-1950. *Tidsskrift for samfunnsforskning*, **1**, 185–204.

Black, Sandra, & Devereux, Paul. 2011. Recent Developments in Intergenerational Mobility. *Handbook of Labor Economics*, **4b**, 1487–1541.

Black, Sandra E, Devereux, Paul J, & Salvanes, Kjell G. 2005. Why the Apple Doesn't Fall Far: Understanding Intergenerational Transmission of Human Capital. *American Economic Review*, **95**(1), 437–449.

Boberg-Fazlic, Nina, & Sharp, Paul. 2013. North and South: Social Mobility and Welfare Spending in Preindustrial England. *EHES Working Paper*, **37**(apr).

Bratberg, Espen, Nilsen, Øivind Anti, & Vaage, Kjell. 2005. Intergenerational earnings mobility in Norway: Levels and trends. *Scandinavian Journal of Economics*, **107**(3), 419–435.

Breen, Richard, & Luijkx, Ruud. 2004. Social Mobility in Europe between 1970 and 2000. *In:* Breen, R (ed), *Social Mobility in Europe*. OUP.

Chetty, R., Hendren, N., Kline, P., Saez, E., & Turner, N. 2014a. Is the United States still a Land of Opportunity? Recent Trends in Intergenerational Mobility. *American Economic Review: Papers and Proceedings*, **104**(5), 141–147.

Chetty, Raj, Hendren, Nathaniel, Kline, Patrick, & Saez, Emmanuel. 2014b. Where is the land of opportunity? The geography of intergenerational mobility in the United States. *Quarterly Journal of Economics*, **129**(4), 1553–1623.

Clark, Gregory. 2014. *The Son Also Rises: Surnames and the History of Social Mobility*. Princeton University Press.

Clark, Gregory, & Cummins, Neil. 2015. Intergenerational Wealth Mobility in England, 1858-2012: Surnames and Social Mobility. *Economic Journal*, **125**(582), 61–85.

Collado, M Dolores, Ortuño-Ortín, Ignacio, & Romeu, Andrés. 2013. Long Run Intergenerational Social Mobility and the Distribution of Surnames. *University of Murcia Working paper*, **2**.

Corak, Miles. 2013. Income Inequality, Equality of Opportunity, and Intergenerational Mobility. *Journal of Economic Perspectives*, **27**(3), 79–102.

Dahl, Gordon B., Kostol, Andreas R., & Mogstad, Magne. 2014. Family Welfare Cultures. *Quarterly Journal of Economics*, **129**(4), 1711–1752.

DiNardo, J, Fortin, Nicole M, & Lemieux, Thomas. 1996. Labor market institutions and the distribution of wages. *Econometrica*, **64**(5), 1001–1044.

Dribe, Martin, Helgertz, Jonas, & van de Putte, Bart. 2012. Intergenerational social mobility during modernization: A micro-level study of two communities in southern Sweden 1830-1968. *Working paper*.

Eika, Lasse, Mogstad, Magne, & Zafar, Basit. 2014. Educational Assortative Mating and Household Income Inequality. *NBER Working Paper*.

Ferrie, Joseph P. 2005. The End of American Exceptionalism ? Mobility in the United States Since 1850. *Journal of Economic Perspectives*, **19**(3), 199–215.

Guell, M., Rodriguez Mora, J. V., & Telmer, C. I. 2015. The Informational Content of Surnames, the Evolution of Intergenerational Mobility, and Assortative Mating. *The Review of Economic Studies*, **82**(2), 693–735.

Hout, Michael, & Guest, Avery. 2013. Intergenerational Occupational Mobility in Great Britain and the United States since 1850: Comment. *American Economic Review*, **103**(5), 2021–2040.

Jäntti, Markus, Røed, Knut, Naylor, Robin, Björklund, Anders, Bratsberg, Bernt, Raaum, Oddbjørn, Österbacka, Eva, & Eriksson, Tor. 2006. American Exceptionalism in a New Light : A Comparison of Intergenerational Earnings Mobility in the Nordic Countries , the United Kingdom and the United States. *IZA Discussion Paper*, **1938**.

Lindahl, Mikael, Palme, Mårten, Massih, Sofia Sandgren, & Sjögren, Anna. 2015. Long-term intergenerational persistence of human capital: an empirical analysis of four generations. *Journal of Human Resources*, **50**(1).

Long, Jason. 2013. The surprising social mobility of Victorian Britain. *European Review of Economic History*, **17**, 1–23.

Long, Jason, & Ferrie, Joseph. 2007. The path to convergence: Intergenerational occupational mobility in Britain and the US in three eras. *Economic Journal*, **117**, 61–71.

Long, Jason, & Ferrie, Joseph. 2013. Intergenerational Occupational Mobility in Great Britain and the United States since 1850. *American Economic Review*, **103**(4), 1109–1137.

Mannsåker, Dagfinn. 1954. *Det norske presteskapet i det 19. hundreåret: sosialhistoriske studiar*. Norske samlaget.

Modalsli, Jørgen. 2015. Estimating occupational mobility with covariates. *Economics Letters*, **133**, 77–80.

Mosteller, Frederick. 1968. Association and estimation in contingency tables. *Journal of the American Statistical Association*, **63**(321), 1–28.

Norwegian Department of Education. 1999. Nyttige lærepenger: Om utdanningsfinansieringen gjennom Lånekassen. *Norges Offentlige Utredninger*, **33**.

Norwegian Department of Justice. 1871. *Tabeller til oplysning om stemmerets- indtægts- og skatteforholdene i Norge i aaret 1868*. Norges Officielle Statistik B no. 3.

Norwegian Department of Justice. 1972. Om odelsretten og åsetesretten. *Norges Offentlige Utredninger*, **22**.

Norwegian Department of Justice and Police. 2001. Lov om personnavn: Tradisjon, liberalisering og forenkling [Law for personal names: Tradition, liberalization and simplification]. *NOU*, **1**.

Olivetti, Claudia, & Paserman, M Daniele. 2015. In the Name of the Son (and the Daughter): Intergenerational Mobility in the United States, 1850-1930. *American Economic Review*, **105**(8), 2695–2724.

Palmstrøm, Henrik. 1935. Om en befolkningsgruppes utvikling gjennom de siste 100 år. *Statsøkonomisk tidsskrift*, 161–370.

Raaum, Oddbjørn, Bratsberg, Bernt, Røed, Knut, Osterbacka, Eva, Eriksson, Tor, Jantti, Markus, & Naylor, Robin A. 2007. Marital Sorting , Household Labor Supply , and Intergenerational Earnings Mobility across Countries. *The B . E . Journal of Economic Analysis & Policy: Advances*, **7**(2).

Reif, Julian. 2010. *STRGROUP: Stata module to match strings based on their Levenshtein edit distance*. Statistical Software Components, Boston College Department of Economics.

Ringdal, Kristen. 2004. Social Mobility in Norway 1973-95. *Pages 251–267 of:* Breen, R (ed), *Social Mobility in Europe*. OUP.

Roine, Jesper, & Waldenström, Daniel. 2015. Long run trends in the distribution of income and wealth. *Handbook of Income Distribution*, **2A**, 469–592.

Seip, Anne Lise. 1994. *Sosialhjelpsstaten blir til: norsk sosialpolitikk 1740-1920*. 2 edn. edn. Oslo: Gyldendal.

Semmingsen, Ingrid. 1954. Standssamfunnets oppløsning i Norge. *Ståndssamhällets upplösning i Norden*, **1**, 49–86.

Solon, Gary. 1999. Intergenerational mobility in the labor market. *Handbook of Labour Economics*, **3**, 1761–1800.

Statistics Norway. 1915. *Indtægts- og formuesforhold efter skatteligningen 1911 i forbindelse med Folketællingen 1910*. Norges Officielle Statistik VI no. 24.

The Digital Archive (The National Archive), Norwegian Historical Data Centre (University of Tromsø) and the Minnesota Population Center. 2014. *National samples of the 1865, 1900 and 1910 Censuses of Norway, Version 2.0.* Tromsø: University of Tromsø.

van Leeuwen, Marco H.D., & Maas, Ineke. 2010. Historical Studies of Social Mobility and Stratification. *Annual Review of Sociology*, **36**(1), 429–451.

Vassenden, Kåre. 1987. Folke- og boligtellingene 1960, 1970 og 1980: Dokumentasjon av de sammenlignbare filene. *Rapporter, Statistisk Sentralbyrå*, **2**.

Xie, Yu, & Killewald, Alexandra. 2013. Intergenerational Occupational Mobility in Great Britain and the United States Since 1850: Comment. *American Economic Review*, **103**(5), 2003–2020.

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.

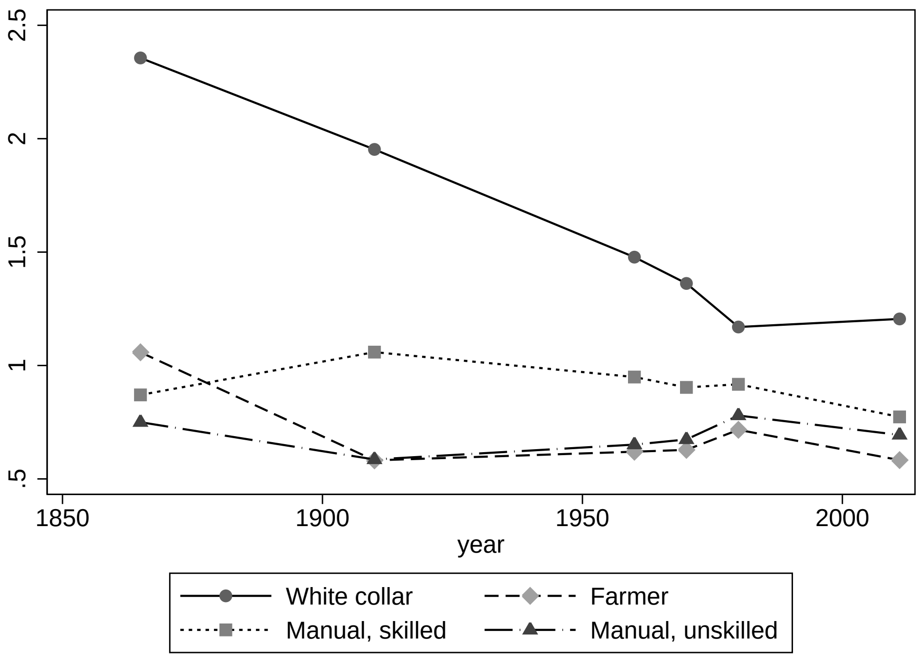


Figure A1: Mean income (1910-2011: men aged 30-60; 1865: men aged 25 years and above), by occupation group, scaled to population mean in each year

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)	*41010*	Dealer, merchant etc. (wholesale and retail trade)	3887
	4220	Ship's masters and captains (sea)	1518
	4230	Ship's masters and captains (sea or inland waterways)	1398
	4250	Ship's navigating officers and ship's mates	1013
	13210	Teachers (unspecified)	766
		Total	15442
1900 (HISCO)	*41010*	Dealer, merchant etc. (wholesale and retail trade)	9458
	4220	Ship's masters and captains (sea)	4854
	4250	Ship's navigating officers and ship's mates	3550
	13230	Teachers (primary)	2843
	45120	Salespeople, wholesale or retail trade	2119
		Total	46517
1960 (NYK)	*111*	Business leaders	15877
	003	Engineers nfs	13828
	302	Retailers	13576
	294	Insurance bank officials	12750
	06	Ship officers	7832
		Total	161503
1980 (NYK)	*111*	Business leaders	37601
	003	Engineers nfs	27802
	064	Teachers (vocational)	14358
	002	Engineers and head engineers	11895
	331	Sales clerks (office)	11170
		Total	262472
2011 (STYRK)	*13AA*	Managing directors	57223
	31AA	Engineers (academic)	44374
	351A	ICT occupations	33284
	21AA	Engineers (technical)	27505
	341A	Sales consultants	26553
		Total	458873

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)	*61110*	General farmers and farmers nfs	93802
	61320	Farmer and fisherman	3715
	61400	Farm managers, formen and supervisors nfs	633
	61260	Livestock farmers	132
	61240	Market gardeners	8
		Total	98290
1900 (HISCO)	*61110*	General farmers and farmers nfs	80341
	61320	Farmer and fisherman	21568
	61400	Farm managers, formen and supervisors nfs	944
	61260	Livestock farmers	131
	61240	Market gardeners	103
		Total	103136
1960 (NYK)	*401*	Farmers, small farmers	83212
	403	Gardeners etc	1775
	406	Supervisors, forestry	1245
	407	Fur breeders	673
	402	Foresters	611
		Total	88734
1980 (NYK)	*401*	Farmers, small farmers	32823
	403	Gardeners etc	1597
	404	Supervisors, agriculture	753
	405	Supervisors, horticulture	393
	406	Supervisors, forestry	330
		Total	36669
2011 (STYRK)	*61AA*	Farmers, farm managers	13462
	6210	Foresters	2065
		Total	15527

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: W	F	S	U	Col sum
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: W	F	S	U	Col sum
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: W	F	S	U	Col sum
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: W	F	S	U	Col sum
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 the 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.

While easy to understand, an examination of the off-diagonal shares 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, the actual count for a given cell is compared to an expected frequency. The expected frequency is found by multiplying the marginal distributions for fathers and sons. Formally,

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

In a society with no association between fathers' and sons' occupation expected and actual frequencies would be expected to be 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 ones; $s_{ij} > 1$ 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 since 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 to be 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 U.S. 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 occupation. 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 nor 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 non-farmer fathers where no farmer son probabilities are considered. Then, for the three comparisons of farmer and non-farmer sons shown on 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. Since 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 U.S. 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.

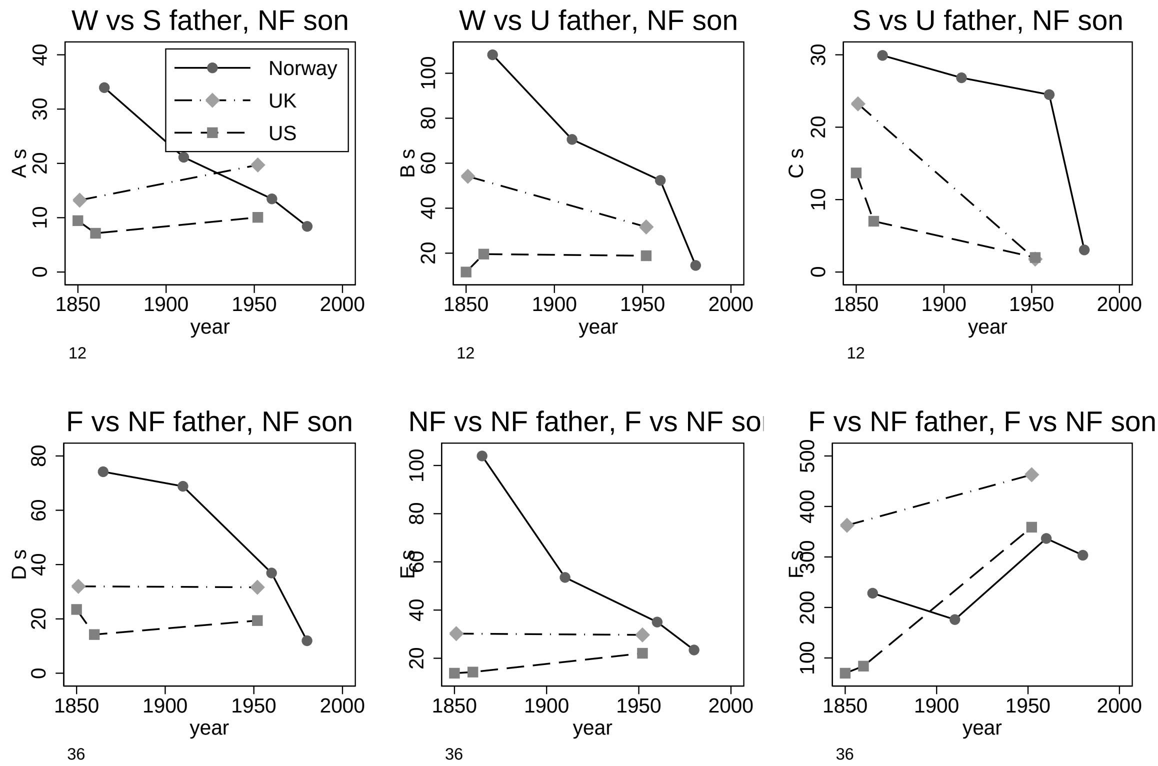
A.5 Odds ratios and local economic features

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 in 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 a skilled worker in the 1865-1900 period for the country as a whole ($\Theta_{WWUS} = 2.93$), while the local average is 12 ($\tilde{\Theta}_{WWUS} = 2.47$) 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:

<table>
<tr><td rowspan="8">Father's occupation</td><td></td><td colspan="6">Son's occupation</td></tr>
<tr><td></td><td>WS</td><td>WU</td><td>SU</td><td>FW</td><td>FS</td><td>FU</td></tr>
<tr><td>WS</td><td colspan="3">(1) W vs S father, non-farmer son</td><td colspan="3" rowspan="3">(5) Non-farmer vs non-farmer father, farmer vs non-farmer son</td></tr>
<tr><td>WU</td><td colspan="3">(2) W vs U father, non-farmer son</td></tr>
<tr><td>SU</td><td colspan="3">(3) S vs U father, non-farmer son</td></tr>
<tr><td>FW</td><td colspan="3" rowspan="3">(4) Farmer vs non-farmer father, non-farmer son</td><td colspan="3" rowspan="3">(6) Farmer vs non-farmer father, non-farmer son</td></tr>
<tr><td>FS</td></tr>
<tr><td>FU</td></tr>
</table>

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 suggests that areas with higher mean incomes have lower social mobility. However, because of the lack of significant coefficients for non-farm 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 having a farmer son, compared to other occupations, is positive. The effects persist into the last time period studied, and are 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}), is 3.93 in the 1980-2011 period, and an increase in local mean income of one percentage point increases this ratio by 1.96 percentage point.

	1865-1900			1910-1960			1960-1980			1980-2011		
Odds ratio Θ	Θ Ctr	Θ Loc	$\delta\Theta/\delta y$	Θ Ctr	Θ Loc	$\delta\Theta/\delta y$	Θ Ctr	Θ Loc	$\delta\Theta/\delta y$	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 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.

Because of data limitations, the time intervals between the observations of fathers and sons are not constant throughout the time period studied in this paper. Table A11 shows that differences in time span and measurement age do not substantially alter the results. The upper two panels of the table shows the sub-components d^F and d^N, while the lower panel shows the overall Altham statistic $d(P,J)$.

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

For each row, a specific five-year age group for fathers and sons has been selected, within the previously established 30-60 year age interval. For a given father age category, sons' ages up to 10 years lower and 10 years higher are considered. Estimates are calculated when the combination of age groups contains at least 400 father-son pairs. Furthermore, two additional matches with higher age differences are included; the 1865-1910 as an alternative to 1865-1900, and 1970-2011 as an alternative to 1980-2011.

Within each age restriction (row), the overall tendency of mobility development is preserved: a decrease in the value of d^N (increased non-farm mobility) between each time period, a lower value of d^F (decreased farm mobility) between the first and last time period, and an overall decrease in $d(P,J)$ (increased mobility) over time.

		Non-farm mobility d^N						Farm mobility d^F					
Age interval father	Age interval son	1865 to 1900	1865 to 1910	1910 to 1960	1960 to 1980	1980 to 2011	1970 to 2011	1865 to 1900	1865 to 1910	1910 to 1960	1960 to 1980	1980 to 2011	1970 to 2011
30-34	30-34					7.9	9.1					15.5	13.3
30-34	35-39	18.9				8.9	9.0	14.4				17.8	14.8
30-34	40-44	18.6				7.5	9.5	15.8				17.4	16.3
35-39	30-34				11.6	8.9	6.8				17.2	16.2	11.6
35-39	35-39	18.0			10.3	8.8	7.3	14.7			18.3	17.0	13.5
35-39	40-44	19.3				7.8	8.9	15.5				18.3	14.8
35-39	45-49	20.6	18.4			8.1	8.8	15.4	14.9			19.2	16.5
40-44	30-34				11.4	8.3					17.4	16.8	
40-44	35-39	21.0			12.9	8.3	12.7	14.5			18.2	17.0	17.5
40-44	40-44	21.6			14.9	8.8	8.4	15.9			13.9	17.8	16.2
40-44	45-49	19.2	19.3			7.6	8.2	16.1	14.3			19.4	15.0
40-44	50-54	19.9	20.1	15.0		7.0	7.8	16.5	16.7	12.3		17.9	16.6
45-49	35-39	16.7			12.7	7.5		12.9			18.8	15.6	
45-49	40-44	20.3			12.8	8.6	7.4	14.6			18.5	16.8	14.4
45-49	45-49	20.2	17.3		15.5	7.5	7.9	14.9	13.9		15.8	17.7	15.8
45-49	50-54	17.5	19.6	15.5		7.5	7.5	17.4	14.7	13.2		18.3	16.5
45-49	55-59	23.9	17.4	14.3		5.8	7.7	20.8	15.4	12.7		18.6	17.3
50-54	40-44	17.4			15.1	7.3		13.3			19.9	17.2	
50-54	45-49	23.3	19.6		13.7	8.6	7.4	18.1	12.4		18.6	15.9	14.4
50-54	50-54	18.1		16.1	13.3	7.6	7.7	14.7		8.7	16.2	17.3	15.7
50-54	55-59	17.1	17.9	15.8		8.2	7.9	18.1	15.7	11.5		16.8	15.9
55-59	45-49	19.9			14.6	8.5	9.4	10.5			16.3	15.8	13.1
55-59	50-54	20.1	20.8		14.3	8.0	7.4	14.9	10.8		15.9	16.2	14.7
55-59	55-59	17.9	19.4			7.8	8.2	15.6	11.2			17.4	14.3
Reference		18.8	17.7	15.5	12.7	7.8	7.8	15.1	14.6	13.3	18.3	17.4	15.8
Ref2 (0-15)		19.1	17.8	15.5	11.5	8.1	7.9	14.7	14.6	13.3	17.9	17.3	15.6

		Overall mobility $d(P,J)$					
Age interval father	Age interval son	1865 to 1900	1865 to 1910	1910 to 1960	1960 to 1980	1980 to 2011	1970 to 2011
30-34	30-34					17.4	16.1
30-34	35-39	23.8				19.8	17.4
30-34	40-44	24.4				19.0	18.8
35-39	30-34				20.7	18.5	13.4
35-39	35-39	23.2			21.0	19.2	15.4
35-39	40-44	24.8				19.9	17.3
35-39	45-49	25.7	23.7			20.8	18.7
40-44	30-34				20.8	18.7	
40-44	35-39	25.5			22.3	18.9	21.6
40-44	40-44	26.8			20.4	19.9	18.2
40-44	45-49	25.1	24.1			20.8	17.1
40-44	50-54	25.9	26.2	19.4		19.3	18.3
45-49	35-39	21.1			22.7	17.3	
45-49	40-44	25.0			22.5	18.9	16.2
45-49	45-49	25.1	22.2		22.1	19.2	17.6
45-49	50-54	24.7	24.6	20.4		19.7	18.1
45-49	55-59	31.7	23.2	19.1		19.5	18.9
50-54	40-44	21.9			25.0	18.7	
50-54	45-49	29.5	23.2		23.1	18.0	16.2
50-54	50-54	23.3		18.3	20.9	18.9	17.5
50-54	55-59	24.9	23.8	19.5		18.7	17.7
55-59	45-49	22.5			21.9	18.0	16.2
55-59	50-54	25.0	23.4		21.4	18.0	16.5
55-59	55-59	23.7	22.4			19.1	16.5
Reference		24.1	22.9	20.4	22.3	19.1	17.7
Ref2 (0-15)		24.1	23.0	20.4	21.3	19.1	17.5

Table A11: Altham statistics and sub-components with additional age restrictions and intervals between occupation measurements

B Matching of individuals across censuses

B.1 Variables

In all sources, age, sex, occupation, and the municipality of residence are 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 (*) are obtained from the Central Population Register (as of 1964, but including those deceased 1960-64) and linked by national ID number. All data post-1960 are linked by 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.[29]

Identifying information

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

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

- First name
- Last name as stated in census

[29] In theory, one could attempt to verify the linkage procedure for post-1960 data, though the existence of a computerized registry of individuals would greatly decrease the changing of spellings (and potentially also the changing of names) between censuses.

- 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, people 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.[30]

To account for the changing last name practices, the information in the censuses is used to construct patronymics (using the first name of the father) and place-based names (using the farm names) are also used here. Last names in period 1 are 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. Instead, 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 are 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.

[30]For 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 was 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 mismeasurement 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" at 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 is calculated 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 smaller 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) match. 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; they 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 (i.e., whether reported as rural or urban) matches, to 4 if the county does not 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 using the following formula for 1865-1900, 1900-1910, and 1865-1900. To balance the impact of name changes with differences in other characteristics, name differences were multiplied by 8.

$$D = 8 \cdot D_F + 8 \cdot D_L + D_Y + D_M \tag{12}$$

and the following for 1910-1960:

$$D = 8 \cdot D_F + 8 \cdot D_L + D_D + D_C \tag{13}$$

The score D states the difference between one observation from each time period. Clearly, we want to pick the pairs of observations with low differences. 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 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 is 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, birthplace and birth time match perfectly ($D_{i,j} = 0$) and there are no other potential candidates for a 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 starts 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 A12 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 A12 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.

	Increasing			Constant		
Min. diff.	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 A12: 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.

B.5 Differences in match rates across occupation groups

Table A13 shows the father-son match rates broken down by son's occupation group.

The first panel replicates the information in Table 1. The next four panels show, for each time period, the same information broken down by son's occupation. The first row in each panel is based on the subset of sons with stated occupations. Then, for each of the four occupation categories, the sample sizes and match rates are given.

In the 1865-1900 sample, farmers are linked to a larger extent than non-farmers, and there is also a larger share of linked farmers whose fathers' identities are known. In the 1910-1960 sample, there are also differences between occupation groups, but in this case it is the white-collar sons who are better matched to their parents. It is hard to say whether this reflects changing patterns of mobility between farmers and other groups, changing geographical mobility or the difference in time span between periods. Finally, more farmers appear to be linked to their father in the 1960 registry data.

The odds ratios used in the calculation of Figure 3 and the Altham statistic and sub-components are not directly affected by such differential match rates. Formally, if we let match rates z vary by son's occupation, denote "true" transition probabilities as q and observed probabilities as p, we can write the odds ratios in Equation (3) as

$$\Theta_{ijlm} = \log\left(\frac{p_{ij}/p_{im}}{p_{lj}/p_{lm}}\right) = \log\left(\frac{(z_j q_{ij})/(z_m q_{im})}{(z_j q_{lj})/(z_m q_{lm})}\right) = \log\left(\frac{q_{ij}/q_{im}}{q_{lj}/q_{lm}}\right) \quad (14)$$

There could be unobserved differences between the matched individuals that we do not pick up here; that is, z could vary with both father's and son's occupation. However, the changes in mobility shown in Table 2 are sufficiently large that they are likely to be robust to such second-order effects. This is supported by the results shown in Table A12 above, where adjustments to the matching algorithm hardly change the estimated mobility coefficients at all, despite substantial differences in the sample size obtained.

t_0-t_1	Son's occ.	Match-able 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
1865-1900	Any	242,878	36.9%	71.7%	64,329	91.4%	99.4%	58,459
1865-1900	W	27,522	36.0%	70.6%	7,000	91.8%	99.4%	6,387
1865-1900	F	88,356	41.4%	75.6%	27,673	91.6%	99.7%	25,270
1865-1900	S	63,894	33.3%	69.6%	14,800	91.2%	99.4%	13,421
1865-1900	U	56,315	34.4%	67.5%	13,070	90.7%	99.1%	11,755
1910-1960	Any	199,370	51.2%	78.4%	80,051	88.6%	99.1%	70,339
1910-1960	W	25,513	54.3%	81.4%	11,282	90.1%	98.7%	10,030
1910-1960	F	38,515	51.6%	75.6%	15,039	92.4%	99.6%	13,844
1910-1960	S	89,476	50.6%	79.0%	35,800	86.3%	99.0%	30,607
1910-1960	U	26,502	47.3%	75.5%	9,459	88.7%	99.5%	8,348
1960-1980	Any	630,133	100.0%	41.1%	259,033	83.4%	93.2%	201,298
1960-1980	W	181,004	100.0%	40.6%	73,524	88.7%	95.5%	62,292
1960-1980	F	37,145	100.0%	50.7%	18,843	64.1%	97.5%	11,780
1960-1980	S	300,886	100.0%	40.0%	120,415	83.2%	90.8%	91,029
1960-1980	U	38,366	100.0%	43.2%	16,557	76.1%	92.9%	11,699
1980-2011	Any	724,335	100.0%	94.1%	681,479	81.0%	91.6%	505,441
1980-2011	W	273,319	100.0%	94.4%	257,896	82.3%	93.4%	198,175
1980-2011	F	15,034	100.0%	94.4%	14,187	78.9%	91.8%	10,274
1980-2011	S	224,024	100.0%	93.8%	210,126	80.2%	89.7%	151,218
1980-2011	U	67,525	100.0%	92.9%	62,739	79.3%	88.6%	44,101
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
1865-1900	Any	158,112	37.0%	82.8%	48,442	92.5%	99.4%	44,525
1865-1900	W	18,822	35.5%	82.0%	5,476	92.8%	99.4%	5,052
1865-1900	F	53,450	41.8%	86.0%	19,183	93.3%	99.6%	17,833
1865-1900	S	44,733	33.2%	81.3%	12,087	91.8%	99.4%	11,028
1865-1900	U	36,240	35.4%	79.7%	10,221	91.4%	99.1%	9,259
1910-1960	Any	199,370	51.2%	78.4%	80,051	88.6%	99.1%	70,339
1910-1960	W	25,513	54.3%	81.4%	11,282	90.1%	98.7%	10,030
1910-1960	F	38,515	51.6%	75.6%	15,039	92.4%	99.6%	13,844
1910-1960	S	89,476	50.6%	79.0%	35,800	86.3%	99.0%	30,607
1910-1960	U	26,502	47.3%	75.5%	9,459	88.7%	99.5%	8,348
1960-1980	Any	141,796	100.0%	80.5%	114,096	97.6%	93.8%	104,402
1960-1980	W	44,884	100.0%	82.5%	37,036	97.7%	95.7%	34,651
1960-1980	F	4,824	100.0%	87.8%	4,235	95.5%	98.0%	3,965
1960-1980	S	66,897	100.0%	78.8%	52,733	97.6%	91.8%	47,213
1960-1980	U	7,377	100.0%	80.2%	5,920	97.1%	93.6%	5,382
1980-2011	Any	381,804	100.0%	97.7%	372,857	81.2%	93.4%	282,613
1980-2011	W	136,634	100.0%	97.9%	133,714	84.4%	94.7%	106,883
1980-2011	F	5,578	100.0%	98.2%	5,480	87.2%	93.8%	4,483
1980-2011	S	119,516	100.0%	97.6%	116,591	79.1%	91.9%	84,759
1980-2011	U	34,941	100.0%	97.1%	33,940	78.1%	91.1%	24,154

Table A13: Detailed match rates