Intergenerational mobility in Norway, 1865-2011

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Abstract

Using a novel data set of 835,990 linked census records, this paper documents a large increase in intergenerational occupational mobility in Norway between 1865 and 2011. Long-run changes in mobility are found to be most pronounced outside farming; in this way Norway is different from the United States. The changes did contribute to equalization of the distribution of economic welfare across families; however, in this respect, changes in the income distribution appear to be quantitatively more important than changes in occupational mobility. There are no indications of major contributions from convergence between Norwegian regions to the increase in mobility.

No long-run estimates of social mobility have so far been available for any European country outside Great Britain, and the present study is the first to show massive increases in social mobility in a data set covering the entire transition from a predominantly agricultural society to a modern economy. The high occupational persistence documented for nineteenth-century Norway shows that high mobility need not be present at the beginning of a development path leading to a modern welfare state.

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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. Economic inequality and growth does not, however, fully capture the welfare development of individual families. If social mobility is low, meaning that individuals' positions are to a large extent determined by that of their parents, not all members of society will be able to participate in the increased opportunities made available by industrialization. Economists often conceptualize this as a "dynasty utility function", where individuals have preferences not only over their own welfare, but also that of their descendants. Hence, the distribution of economic utility depends on intergenerational mobility. The extent of such mobility is changing over time, as documented by Long & Ferrie (2013): since the late nineteenth century, intergenerational mobility has decreased in the United States and remained relatively stable in the United Kingdom. This paper documents increasing social mobility over time in Norway.

In studies of economic growth and inequality, Scandinavian countries have attracted interest, as these countries today exhibit high levels of GDP with comprehensive public services and social insurance systems. Norway, in particular, has gone from being a relatively poor, agricultural country in the mid-nineteenth century to now being reported with the highest "human development index" by UNDP (2014). Comprehensive register data has made possible several studies of recent developments in inequality and economic mobility, both within Scandinavian countries and comparing these countries with other areas. Typically, social mobility is found to be moderate to high in the late twentieth and early twenty-first century. However, not much is known about social mobility in Norway prior to the 1970s. Norwegian historians typically present a narrative of nineteenth-century Norway as a "civil servant state" with low mobility at the top (Seip, 1997), as well as increasingly marginal farms being developed and a limited set of employment opportunities for the sons of marginalized cottagers. Overseas emigration from Norway was extremely high between 1866 and 1929, reflecting limited opportunities at home for a large part of the population.

This paper bridges the gap between narrative histories of mobility in the nineteenth century and register-based studies of the twentieth and twenty-first centuries. Using digitized census data from 1865 onward that is remarkably similar in structure to modern registries, comparable occupation categories are constructed to measure intergenerational occupational mobility in Norway from 1865 to 2011. The national coverage of the census data makes it possible to examine mobility for the country as a whole rather than relying on regional samples (as done in some studies on other countries). Moreover, by using the regional variation in economic development, new insights can be gathered on the local drivers of social mobility.

The analysis does confirm the picture of nineteenth-century Norway as a socially stagnant society, with high rates of persistence. Mobility increased over time, with a substantial decrease in the impact of father's occupation on son's occupation. An exception to this trend is the impact of farmer fathers on farmer sons, where persistence has increased over time.

Existing work on long-run social mobility

Long & Ferrie (2013) demonstrate that intergenerational occupational mobility increased in the United States between the nineteenth and twenieth century, using comparable sets of census or survey data for both periods. For England and Wales, however, mobility was lower than in the US in the nineteenth century and remains at about the same level today. Boberg-Fazlic & Sharp (2013) find moderate differences between the North and South of England in pre-1850 intergenerational mobility. Clark & Cummins (2014) 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.

Social mobility in Norway between 1800 and 1950 has earlier been discussed by Semmingsen (1954). Reviewing legal changes and the development of the cross-section income distribution, Semmingsen argues that the move towards 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 onwards, driven by industrialization and the increasing integration of Norway into the world market. Moreover, technological advances led to an increasing population growth, 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 types seen in Sweden, Denmark and elsewhere in Europe. At the same time, old social classes disappeared (some cottagers were allowed to buy their land and became farmers) and new emerged, in particular the large industrial working class and a new middle class in the cities.

The only quantitative studies of early social mobility in Norway known to this author are works on university admissions lists (Palmstrøm, 1935; Aubert *et al.*, 1960) and on the biographies of theological candidates (Mannsåker, 1954). These studies show how the expansion in the number of university students led to a steadily increasing share of students being recruited from middle-class and farmer backgrounds rather than upper-class backgrounds. Moreover, Abramitzky *et al.* (2012) studies the social selection of emigrants from Norway to the United States in the late nineteenth century and show some evidence that for urban residents, low economic status increased the probability of emigration to the United States. Outside of Norway, there are some studies on local communities in Sweden. Lindahl *et al.* (2012), studying three generational transitions in city of Malmö, find no large changes in intergenerational mobility in earnings. Dribe *et al.* (2012), using data from five rural parishes in southern Sweden, find some evidence of increased occupational mobility over time. In both cases, it is hard to know how the results generalize to the country as a whole, as there was substantial rural-urban migration in the period studied.

Moving toward the latter half of the twentieth century, there are several studies on social mobility in Norway based on large administrative data sets. Bratberg *et al.* (2005) find a stable relationship between parents' and children's earnings (for children born between 1950 and 1965) and find that mobility is high but does not change much over time. Jäntti *et al.* (2006) and Raaum *et al.* (2007) find intergenerational income mobility to be higher in the Scandinavian countries than in the United States and the United Kingdom. As for the relationship between parents' and children's elementary education, Black *et al.* (2005) find correlations 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) demonstrate a causal connection between parents' and children's uptake of disability benefits.

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

Occupational mobility has been extensively studied by sociologists, mainly for the modern period (1970 and onwards) and with a strong focus on comparability between countries. Breen & Luijkx (2004) find evidence of moderately increasing social mobility ("fluidity") from 1970 onwards in many Western countries, though with some exceptions (notably the United Kingdom). Ringdal (2004) confirms this picture for Norway, at least for the association betweeen father's and son's occupation; the evidence for a father-daughter association is weaker.

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

2 Data and aggregate trends

2.1 Norwegian censuses

The data used in this study comes from the Norwegian censuses of 1865, 1900, 1910, 1960, 1980 and 2011. With the exception of the 2011 census, which was compiled from administrative records by Statistics Norway, all censuses were conducted by interviews by local officials or by mail-in forms. The 1865-1910 censuses were digitized and occupations coded by a cooperation between the Norwegian National Archives, the University of Tromsø and the University of Minnesota (2008). The 1960 to 1980 censuses were consistently coded in 1984, see Vassenden (1987). In addition, data on occupation mean incomes and municipality mean incomes are obtained from tax statistics; these will be discussed in Section 2.4 below.

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

2.2 Following families over time

To study intergenerational mobility, it is necessary both to link individuals over time and to establish the family relationships between individuals. The Norwegian Central Population Register, with unique identification numbers for all individuals living in Norway, was established in 1964 based on the 1960 census. For this reason, linking individuals after 1960 is straightforward and link rates for the 1960-1980 period and the 1980-2011 period are close to 100 per cent.

Before 1960, there was no national identification system in Norway. For this reason, linking of individuals are done based on names, birth dates and birth places. The links are based on the full-count historical census microdata samples; at the time of the writing of this paper, such data was available for 1801, 1865, 1900, and 1910. The 1801 data is not used here because of the long time period until the next observation. 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.

Because of differences in the spelling of names, name similarity was 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, patronymic based on father's first name or the name of the farm of residence (or origin). Gradually, last names became to be seen as permanent and were inherited directly from the father — this practice was encoded into law in 1923 (Norwegian Department of Justice and Police, 2001, chapter 4). To take account of this variation in naming customs, last-name comparisons are done both on the last names as stated, on the last name stated compared to the farm name in the other period, and on the last name stated compared to a constructed patronymic based on the father's name. Such differences are computed between all pairs of first names and all pairs of last names, and the difference is converted into a score used for considering matches.

Potential matches are also scored based on the similarity of birthplace and of time-of-birth. For the 1865-1900 link only year of birth is available; 1910 and 1960 have complete birth dates. Until 1910 the municipality of birth is recorded, so 1865-1900 can be matched on quite detailed birth locations (there were 491 municipalities in Norway in 1865), while the 1960 census only has county of birth and hence is matched on that. Individuals are matched if they have a high score on similarity in first name, last name, birth place and birth time, and if they are unique; that is, if there are no other potential matches with similar match quality. Further information on the matching method is given in the Appendix.

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 will not be able to take over the farm until the father reaches a certain age. Moreover, historically the main source of relationship information in the census derives from the household; the father-son links are identified by the family information recorded in the census — individuals listed as a son of somebody else in the same household. For this reason, occupational information is always taken from two different censuses, by the following approach: First, an individual has an observed occupation. Second, we try to link him to a previous census. Third, in this previous census, we identify his father and record his occupation. This gives us the observation on this father-son pair of occupations. To further minimize the risk of life-cycle bias, only occupation information for an individual between 30 and 60 years of age is used.

The final data consists of occupational cross-sections for men aged 30-60 in 1865, 1900, 1910, 1960, 1970, 1980 and 2011.[1]. This study is restricted to men (fathers and sons) for two reasons. First, most women change their names at marriage in Norway, at least historically, and it is hence much harder to match women between the pre-1960 censuses than it is to match men. Second, the economic principles behind the categorization of women's employment has changed over time.

From the seven census observations, the father-son observations with time differences approximating a generation length is 1865 to 1900, 1910 to 1960, 1960 to 1980 and 1980 to 2011. The first four lines of Table 1 gives the match rates for these samples. Let t_0 denote the first census of

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

t_0-t_1	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	246,373	37.7%	71.9%	66,790	91.4%	98.1%	59,896
1910-1960	246,911	45.4%	77.8%	87,188	88.8%	89.6%	69,356
1960-1980	717,678	100.0%	40.3%	289,040	82.3%	84.6%	201,297
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	159,850	38.1%	82.9%	50,490	92.5%	98.1%	45,835
1910-1960	246,911	45.4%	77.8%	87,188	88.8%	89.6%	69,356
1960-1980	154,901	100.0%	80.3%	124,437	97.5%	86.0%	104,401
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		$\approx 5\%$		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

the match, where fathers are observed, and t_1 denote the second census, where sons are observed. The first column states the matchable population — that is, t_1 census records of men between 30 and 60 years of age, born in Norway, who are old enough to have been observed in the t_0 census. The second column gives the share of these individual census records that can actually be matched to the t_0 census using the procedures outlined above. The match rate is 37.7% for the first set of observations and 45.4% in the second. Non-matches occur due to combinations of names and other characteristics being too common, so potential matches cannot be distinguished from each other, from name changes obstructing matches, and from misreporting or misspellings of names above the threshold used in the matching algorithms.[2] From 1960 onwards, with the establishment of national identification numbers, individuals are fully matched between censuses.

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

[2] Ref Appendix on matching gradients here

The fourth column of the table gives the matched population that can potentially be used for analysis. However, once we restrict the father's age to be between 30 and 60 at the time of observation (column five) and both father and son actually reporting an occupation and being in the labor force (column six) gives the final analysis sample ranging from 59,896 for 1865-1900 to 505,441 for 1980-2011.

The matched population can be compared to other studies utilizing individual match rates, namely the study by Long & Ferrie (2013) and Abramitzky *et al.* (2012). As methodologies and the way of reporting percentages (counting from t_0 or t_1) differ across studies, not all the columns can be replicated for these studies. Backward match rates in the Long and Ferrie paper are slightly above 20%; as the data is sampled, they cannot rely on uniqueness for matches with substantial deviations, and the regional dimension in their data is coarser.[3] 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%.

2.3 Changes in the occupation distribution

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

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

First, we separate farmers from non-farmers. Farming has historically been the most important occupation in nearly all societies, and still employed a large part of the population in the mid-nineteenth century. While there was considerable heterogeneity within this group, this is often not reflected in the census records, and the nomenclature varied across countries or even regions within countries. Both owner-occupier farmers and tenants are included in this group, while farm workers are not. Second, we separate non-farm work into "white-collar" and "blue-collar" groups. These correspond roughly to a non-manual / manual divide of tasks. The manual occupations are further split into a skilled/semiskilled group that requires education or specialized training, and an unskilled group that depends mainly on pure physical work. These four categories (White collar, Farmers, Manual skilled, Manual unskilled) then provide the framework for the occupation analysis.

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

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

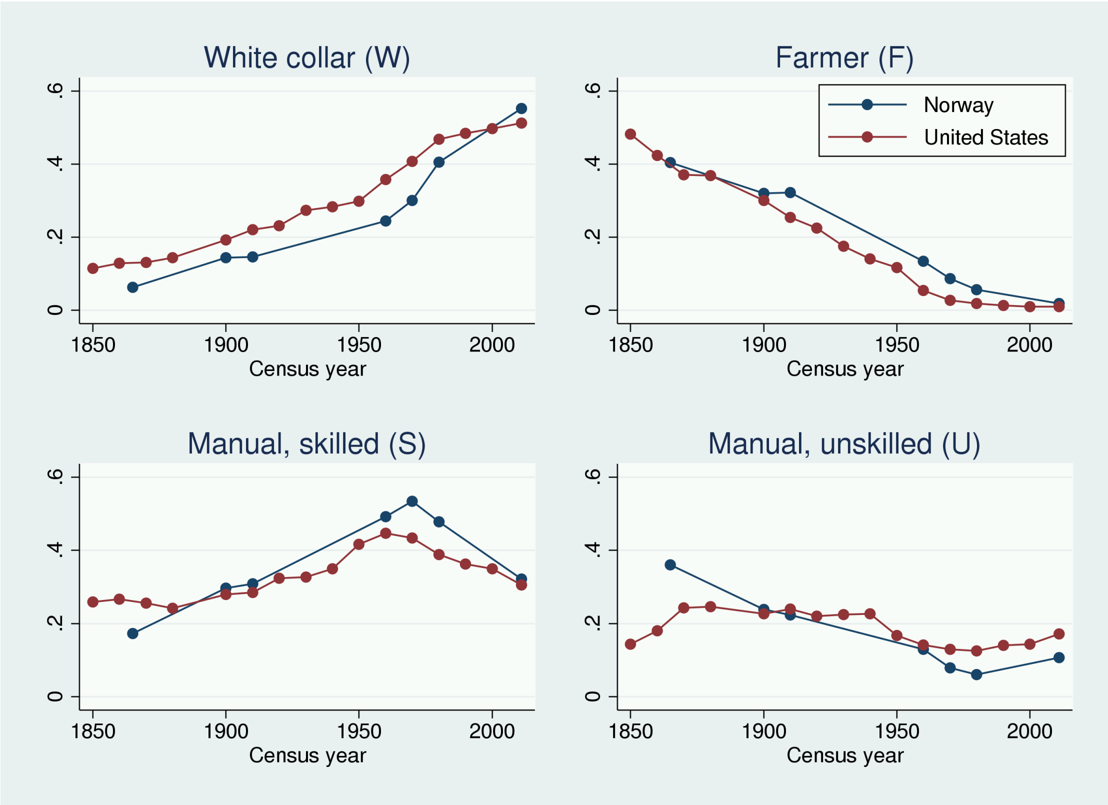


Figure 1: Occupational distributions, share of men age 30-60, Norway and United States. Sources: Norway: see text, US: author's calculation from USA IPUMS

It should be noted that the share of farmers in both Norway and the United States in the mid-nineteenth century was much higher than in the "core" European countries. As an example, using a comparable occupation classification on data for Great Britain in 1851 and 1881 gives a share of farmers of seven and five per cent, respectively, while the share of skilled or semiskilled manual workers is nearly sixty per cent in 1881. A similar exercise of Sweden for 1890 and 1900 gives a farmer share of 28 and 24 per cent, lower than the US and Norway but much higher than Great Britain.

2.4 Mean incomes

The set of occupations presented above captures important transitons between tasks and industries. However, for some analyses, it is desirable to also have income data. While this is not available on an individual level, mean incomes per occupation category can be constructed.

Mean wages by occupation category for men aged 30-60 for 1980 and 2011 are constructed 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) as an estimate of mean wages by occupation in 1960. For 1910, information on incomes by occupation is taken from published tables of mean wage by occupation, gender and age (Statistics Norway, 1915). The 1865 data is taken from income categories for 1868 reported in Norwegian Department of Justice (1871).[4]

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

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

3 Social mobility

3.1 Transition matrices and probabilities

The central unit of analysis for the study of intergenerational mobility is the 4x4 matrix of father's and son's occupation choices.[5] Visual examination of the matrix gives some information of the extent of occupational change between generations. For example, in the 1865-1900 period, 46 per cent of sons belonged to a different occupation group than their father, increasing to 50.4 per cent from 1910 to 1960, 51.5 per cent from 1960 to 1980 and decreasing slightly to 49.5 per cent for the 1980-2011 period.

[4]Unlike the other years, the age restriction for the 1865 income data is all men age 25 and above. Moreover, mean incomes for the intervals have to be imputed. [explain]. There is no data available for 1900, so the 1910 data is used also for this year. For this reason, the first interval must be interpreted with caution.

[5]The matrices for the four transition periods are presented in Table A1.

We can further analyze the occupational choice of sons (indexed by j) given the occupational choice of fathers (indexed by i). Denoting the raw counts in Table A1 by X_{ij}, the probability of a son obtaining occupation j given father's occupation i is

$$p_{ij} = X_{ij} / \sum_{j=1}^{4} X_{ij} \tag{1}$$

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

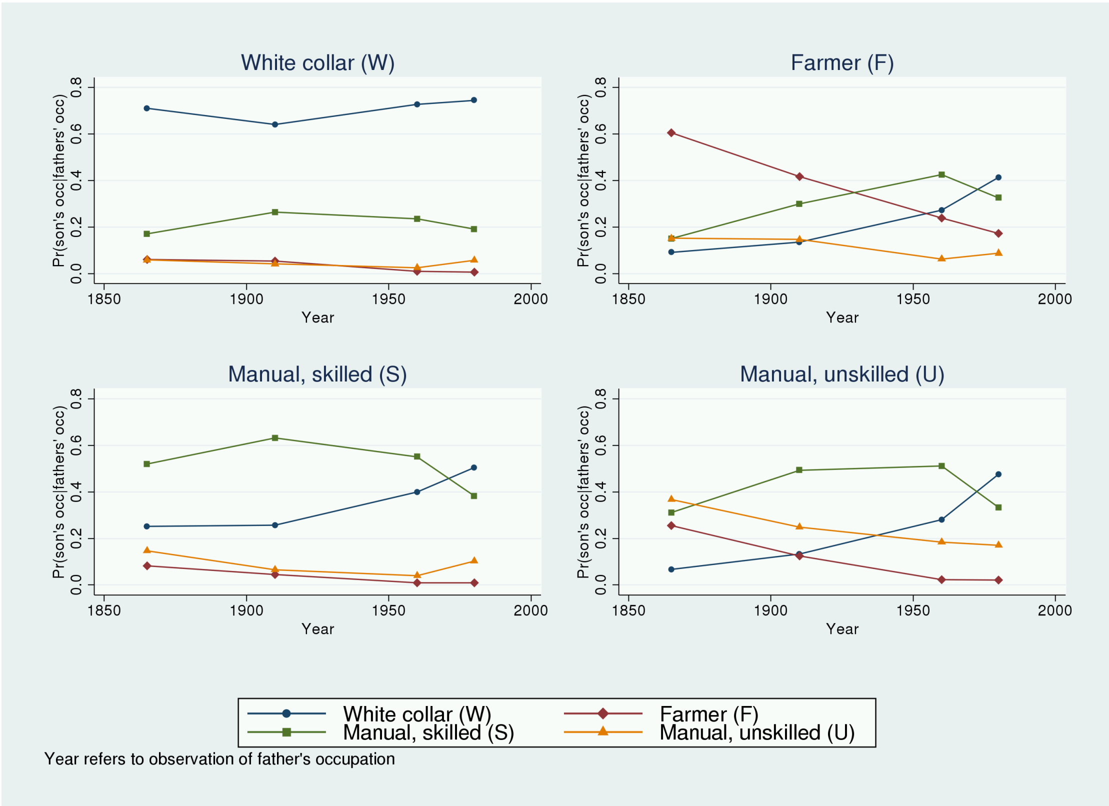


Figure 2: Transition probabilities: Probability of son's occupation, given father's occupation

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

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

Those growing up with fathers who hold skilled manual occupations overwhelmingly choose similar occupations, though the share is steadily declining in the late twentieth century and gradually replaced with white-collar occupations. For sons of unskilled fathers there is also a large propensity to enter into skilled occupations; after 1900 less than one third of sons of unskilled enter unskilled occupations.

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

3.2 Assessing relative mobility

To better understand how intergenerational occupational mobility has changed over time, it is necessary to correct for the change in the marginal occupation distributions. To this purpose, standard two-way odds ratios provide a useful tool. For a father's occupation i, the "advantage" his son has in obtaining the same occupation i compared to any other occupation can be expressed as a ratio of probabilities $p_{i,i}/(1-p_{i,i})$. The availability of occupations change over time, and we can hence expect this ratio to be affected by the availability of i occupations compared to other occupations. To account for this change, we compare the probability ratio for sons of i-fathers to similar ratios for non-i fathers, indexed by $\neg i$: $p_{\neg i,i}/(1-p_{\neg i,i})$. These odds ratios, composed from 2×2 tables of fathers' and sons' occupations collapsed from the 4×4 tables shown above, are denoted $\Theta_{2,i}$.

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

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

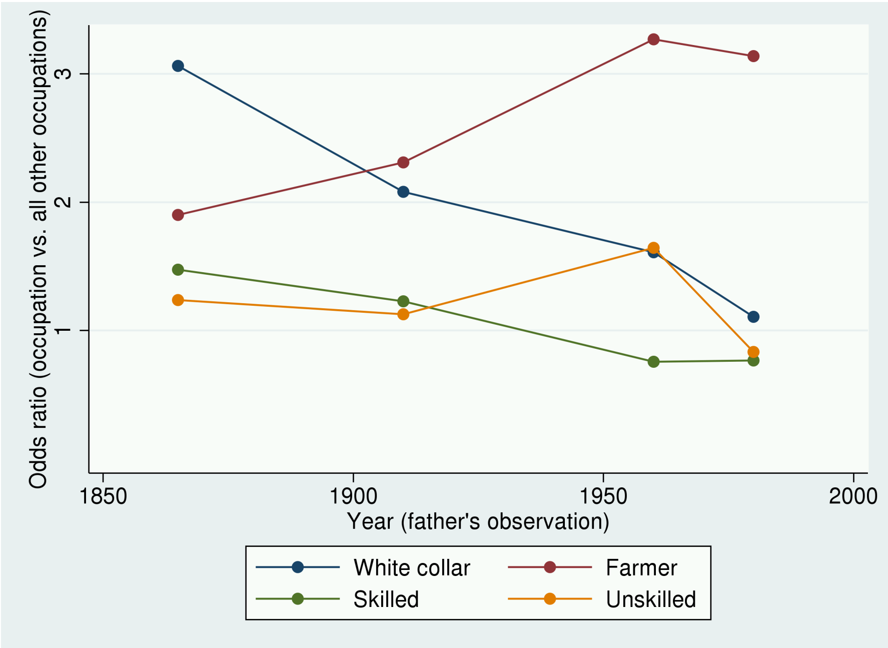


Figure 3: Two-way odds ratios: for each occupation X, $\log\left((p_{X,X}/p_{X,\neg X})/(p_{\neg X,X}/p_{\neg X,\neg X})\right)$

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

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

3.3 Outside the diagonal: the full set of odds ratios

Some changes in social mobility concern movements outside the diagonal of the mobility table. For example, from 1980 to 2011 the probability of obtaining a white-collar occupation increased faster for a son of a father in the “manual, unskilled” category than a son of a father in the “manual, skilled” category. There is 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 one considers the example where i and j are white-collar occupations and l and m are farming occupations, the nominator of the odds ratio compares the probability that the son of a white-collar father obtains a white-collar occupation to the probability that he obtains a farmer occupation. In 1865, these probabilities were 0.71 and 0.17, respectively. The denominator gives the corresponding ratio for sons of farmers, which is 0.25/0.52. The log odds ratio Θ_{WWFF} is then the ratio of these two ratios, $\log(8.60) = 2.15$.

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

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

To assess the degree of mobility in a society, we again follow Long & Ferrie (2013) and compare the mobility matrix in question (P) to a hypothetical matrix J of full mobility, where sons' occupational choice is independent of fathers' occupations. For J, all components of Θ are zero.

$$d(P,J) = \left(\sum_{i=1}^{N}\sum_{j=1}^{N}\sum_{l=1}^{N}\sum_{m=1}^{N}\left[\Theta^{P}_{ijlm}\right]^2\right)^{1/2} \tag{5}$$

The metric $d(P,J)$ (d henceforth) summarizes the distances of odds ratios from zero: if there are large differences in the transition probabilities of sons of fathers with different occupations, a society is said to exhibit low degrees of intergenerational occupational mobility.[6] Zero refers to full mobility, no association between father's and son's occupations, while there is in theory no upper bound on d except for that imposed by the discreteness of the data.

The Altham statistic d for the 1865-1900 father-son pair in Norway was 24.2. This is comparable to the 1851-1881 statistic for UK (at 22.7), and much higher (indicating lower intergenerational mobility) than nineteenth-century United States which has $d = 11.9$ (for 1850-1880) and $d = 14.6$ (1880-1900). Mobility in Norway increased over time, with the Altham statistic

[6] Note that because of the multidimensional nature of the matrix comparisons, in general, $d(P,Q) \neq |d(P,J) - d(Q,J)|$.

down to 20.3 for the 1910-1960 period. However, for the 1960-1980 father-son pair, the statistic was up to 22.3, to fall again to 19.2 in 1980-2011. As shown by Long & Ferrie, there was a strong increase in the US Altham statistic from the nineteenth to the twentieth century, with the 1950s-1970s statistic at 20.8. For the UK, there was also a small increase.

It follows from these numbers that there was an increase in intergenerational occupational mobility in Norway from the nineteenth to the twentieth century, compared to a strong decrease in the United States and a moderate decrease in the United Kingdom. However, as the Altham statistic d combines information on all odds ratios of a mobility matrix in a single number, it is hard to disentagle entirely 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 as the economic role of farmers has greatly diminished.

To examiine 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 is 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.

We start with the odds ratios that do not compare farmers at all: the comparisons W vs S, W vs. U and S vs. U for both farmers and sons. Here the increasing mobility trend is evident in nearly all odds ratios. If we compare nonfarm probability ratios for sons of white-collar workers to those of sons of skilled workers, the difference is disappearing rapidly - and monotonously - in Norway between 1865 and 2011. In the US and UK, however, there is a slight increase.[7] Mobility is increasing over time also for other comparisons of nonfarm fathers and nonfarm sons. For example, the probability of obtaining a white-collar occupation over an unskilled manual occupation in the late nineteenth century was more than 60 times higher for the son of a white-collar worker than for a son of an unskilled manual worker in Norway 1865-1900, while the corresponding numbers for the UK and the US are around 20 and 7. Between 1960 and 1980, the difference was still as high as 19 in Norway, higher than both other countries, but it decreased to around 4 by the end of the time period studied.

When we move to the aggregate of comparisons of nonfarm father (WS, WU, SU) and farmer vs. nonfarmer sons (FW, FS, FU) the trend is similar to the comparisons between nonfarm fathers. There is a substantial difference between sons of farmer and white-collar fathers in the probability of obtaining a white-collar occupation. Similarly, if we compare (FW, FS, FU) fathers to (WS, WU, SU) sons, the largest odds ratios are found when comparing sons of farmers and white-collar workers' nonfarm occupations. Here, there are fundamental differences between the countries studied. In Norway and the UK, differences between sons of farmers and sons

[7] The development of these odds ratio components are illustrated in the Appendix, Figure A2.

of white-collar workers disappear gradually over time, though there are substantial differences remaining in the last period. In the United States, on the other hand, the differences are small in the first period but increase over time.

Finally, we compare the probability ratios between farming and nonfarming for sons of farmers and sons of nonfarmers. The aggregate squared difference of these odds ratios capture most of the particularly high persistence in the farming occupations. In 1865, the square of the Altham statistic $d(P, J)$ was $24.2^2 = 585$, of which 220, or around one third, was driven by these farm-farm comparisons. In the final period, more than eighty per cent (300 of 19.2^2) was driven by low mobility among farmers. This highlights the main challenge of using a nonweighted metric for mobility, as the farm group in the final period has a very low share of total population, and is an important reminder that a study of the separate odds ratios is required.

As there are strong similarities between the 27 odds ratios not including differences between farmers and nonfarmers both for fathers and sons, we aggregate these odds ratios to a "nonfarm" version of the Altham statistic, d^N. In the notation of Equation (5), i and j only index the nonfarm occupations W, S and U, while l and m index all occupations.

The odds ratios comparing the probability of sons of farmers to sons of nonfarm occupations in obtainng farming occupation compared to nonfarm occupations are similarly grouped as d^F. From (5), i and j are fixed at the farm index while l and m index all occupations. From the definition of the Altham statistic it follows that the Euclidean distance between 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 decomposition of the Altham statistic into two components facilitates a graphical exposition of the changes in mobility in Norway, the United States and the United Kingdom between the nineteenth and twentieth century. Figure 4 shows d^N on the vertical axis and d^F on the horizontal axis. The distance from (0,0) to the country observations the figures denotes aggregate mobility as measured by the Altham statistic.[8]

Farm and farm-nonfarm persistence d^N was extremely high in Norway compared to the United Kingdom and United States in the nineteenth century. As shown in Figure 4, d^N in 1865-1900 was 19.0, 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.

On the other hand, farm persistence in Norway increased from $d^F = 15.0$ in the first period to $d^F = 17.5$ in the final period. A much more substantial increase is seen in the United States, where nearly all the decrease in intergenerational occupational mobility from the nineteenth to the twentieth century comes from increasing persistence among farmers. Compared to Norway and the United States, the changes in the United Kingdom between the nineteenth and twentieth

[8]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.

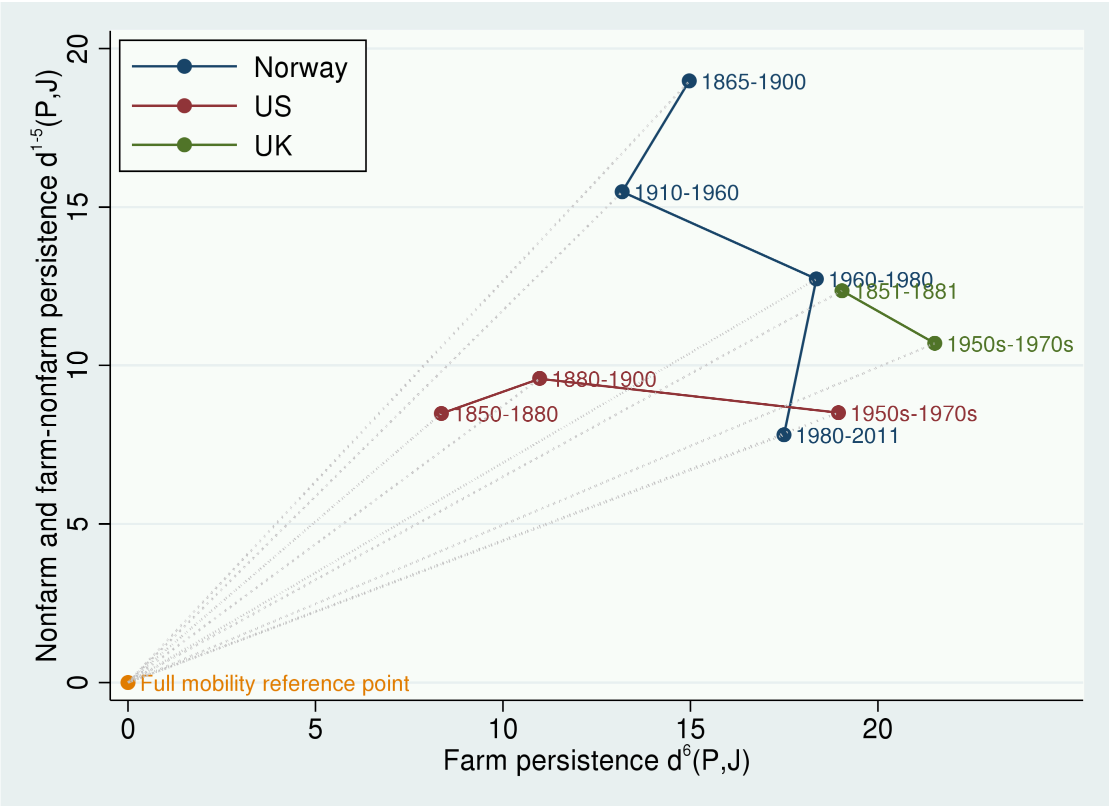


Figure 4: Two components of the Altham statistic, change over time

century are small. Figure 4 shows that mobility increased in Norway (movement towards (0,0) in the figure), decreased in the US (movement away from the origin) and was stable in the UK. However, the decrease in mobility in the US and the increase in Norway took place in separate dimensions: in the US, the major changes occurred in the farming sector of the economy, while in Norway, everywhere else.

3.4 Mobility as income jumps

So far in the analysis has not been based on any *sorting* of occupation status. Mobility as expressed by individual odds ratios or the Altham statistic can be interpreted both as vertical and horizontal changes. However, using the occupation mean incomes presented in Section 2.4 and plotted in Figure A1, one can approach the question of how changing occupation mobility has affected mobility in income. It is important, however, to note that we only have data on the mean incomes for each occupation group, meaning that we do not record economic mobility within an occupation category, or mobility driven by selection in who moves from one occupation group to another.

A natural starting point for an economic interpretation is to consider mobility due to changing positions in the income hierarchy. Let (y_q^F, y_q^S) denote the mean incomes of the occupations held by father-son pair q (observed at the census years of fathers and sons), and let $(\bar{y}^F, \bar{y}^S)$ denote the corresponding population mean incomes. The income jump Δ_q is then defined as the change in income (relative to mean income) from father to son:

$$\Delta_q = \frac{y_q^S}{\bar{y}^S} - \frac{y_q^F}{\bar{y}^F} \tag{6}$$

Scaling both incomes sets average income growth to zero and is equivalent to choosing fathers as base and re-scaling incomes of sons by the average growth rate.[9]

	Entire population			Average income difference for sons of			
	Absolute income difference $\lvert\Delta\rvert$	Share pos. $(\Delta > 0)$	Share neg. $(\Delta < 0)$	W Δ^W	F Δ^F	S Δ^S	U Δ^U
1865-1900	0.40	32 %	68 %	-0.43	-0.14	0.49	0.21
1910-1960	0.33	61 %	39 %	-0.79	0.24	-0.05	0.30
1960-1980	0.24	50 %	50 %	-0.44	0.28	0.02	0.28
1980-2011	0.18	62 %	38 %	-0.10	0.18	0.05	0.16

Table 2: Average income growth, by year and father's occupation

The average change in income is plotted in the first column of Table 2. The dispersion in income changes decreases over time; between 1865 and 1900 the mean absolute income difference

[9]Equation (6) can be expressed in terms of mean income in father's generation as $\frac{1}{\bar{y}^F}\left(\frac{1}{g}y_q^S - y_q^F\right)$ or equivalently in terms of mean income in son's generation as $\frac{1}{\bar{y}^S}\left(y_q^S - g y_q^F\right)$, where the growth rate $g = \frac{\bar{y}^S}{\bar{y}^F}$.

was forty per cent of mean income, down to eighteen per cent in 1980-2011. The distribution of the population to groups of negative and positive dispersion also changes over time. Only 32 per cent of sons of 1865 fathers observe higher mean occupation income than their fathers, while 62 per cent of sons of 1980 fathers have higher mean incomes.

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

Table 2 also shows the average income change between father and son given father's occupation. The income change is a combination of the change in income for those not changing occupation and the income jumps of those who change occupations. In the first time period, the highest "father" incomes are held by farmers and white-collar workers, giving negative mean income changes for these groups; similarly, the improvement in average wages for manual skilled workers gives positive income for sons of S fathers. While there is high mobility out of farming in all periods, farmer incomes are lowest, relatively speaking, in 1910 and 1960, giving high positive income changes for sons of farmers in these periods. From 1910 onwards, sons of skilled workers on average do not experience large income changes from their fathers. There is substantial mobility both into higher- and lower-paid occupations, and on average these sons' income changes cancel out. Sons of unskilled fathers on average always experience substantial income growth.

It is evident that the average change of income has gone down at the same time that intergenerational occupational mobility has increased. This apparent paradox is resolved in the next section, which compares the contribution of mobility and that of income change to equalization of social welfare.

3.5 The contribution of mobility to income equalization across dynasties

From the set of occupation mean wages 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.

Turning to the question of how the income of a dynasty changes over time, we can conceptualise the two-generation dynastic utility (from the father's point of view) as

$$U_{\text{dynasty}} = u(c_{\text{father}}) + \beta u(c_{\text{son}}) \tag{7}$$

where U is the total dynastic utility, u is a semiconcave period utility function, and β is the discount rate. For the time period studied here, the operationalization has to be more pragmatic: father's and son's consumption is proxied by the mean income of their occupation category at the census year. Nonetheless, by incorporating information on the relationship between fathers' and sons' occupations from the mobility matrices, we do get a metric of the utility of individual father-son pairs, measured consistently over time. To simplify the exposition, linear utility functions will be used and the discount rate set to the inverse of the aggregate of the growth rate of the economy g, giving father and son relative wages similar weights. That is, we consider the distribution of *dynastic income* Y:

$$Y = y_f + \frac{1}{g} y_s \tag{8}$$

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

The dynastic Gini coefficients are shown by the dashed line in both panels of Figure 5. Similarly to the cross-section Gini coefficients, it shows increasing inequality from the first to the second period and decreasing inequality thereafter. There is now no increase in the final time period; while the sons in the final generation experience higher cross-section inequality than the preceding generation, they are coupled with a father generation of very low inequality.

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

The dynastic income distribution can be conceptualized as follows: for a given 4×4 mobility matrix M linking father's occupation at t_0 to son's occupation at t_1, we apply the mean occupation income in t_0 to the fathers and the mean occupation income at t_1 to the sons. The counterfactual analysis then *either* consists of replacing the occupational income distributions with counterfactuals and keeping the mobility matrix, *or* replacing the mobility matrix and keeping the marginal income distributions. In both cases the marginal distributions of individuals at t_0 and t_1 is preserved.

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

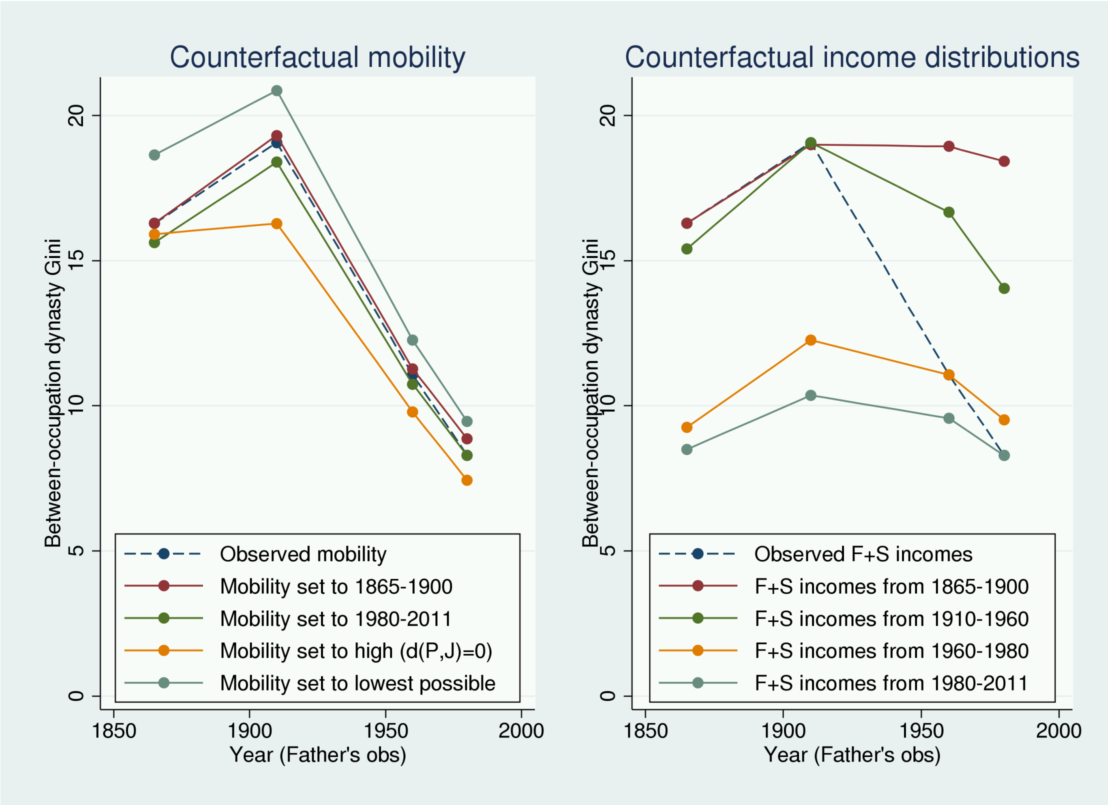


Figure 5: Counterfactual between-occupation dynasty (father+son) Gini coefficients. Left panel: using observed occupation distributions and incomes, keeping mobility constant over time. Right panel: using observed occupation distributions and mobility matrices, keeping fathers' and sons' income distributions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

The results of this procedure is presented in Figure 5. We first consider the counterfactual mobility matrices, shown in the left panel. The dotted line shows the observed dynastic income inequality, with mobility matrices being as observed in the data. If we fix mobility at any of the observed four matrices discussed in this paper, there is no large change in the level of the dynastic Gini coefficient; the two most extreme observations is shown in the figure, and it is clear that both lie quite close to the actual observed inequality. For this reason, 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 inequality given the actual marginal income distribution is 20.8 in 1910-1960.

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

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

The decomposition analysis shows that despite the massive increase in intergenerational occupational mobility in Norway, changing income distributions have had a much larger impact on the dynastic between-occupation Gini coefficient than have changes in intergenerational mobility.

4 Geographic components

The previous section has established that mobility increased in Norway from 1865 to 2011; occupational choice became less dependent on father's occupation, with the exception of farmers. The transformation trends described in the Introduction and illustrated by the changing occupation distributions in Figure 1 did not take place all across the country at the same time. Cities grew fast, with associated diversity in economic activity, while some areas remained rural and dependent on agriculture for a long time. The purpose of this section is to examine to what extent the observed changes in occupational mobility were driven by changes in the geographic makeup of economic activity in Norway.

To examine geographical determinants of intergenerational occupational mobility, the municipalities of Norway have here been grouped into 160 clusters of municipalities to obtain regional units ("regions" henceforth) that are constant over time.[10] To the regional differences can be added some covariates from published statistics, such as the mean incomes described above. On the regional level, there is often not enough individuals for all 16 cells in the mobility matrix to be

[10]There have been large changes to the municipality structure of Norway during the period studied here. For this reasons, municipalities are aggregated into units that are stable over time. The list of municipality clusters, as well as sources for the municipal covariates, is given in the Appendix.

populated, making calculation of the Altham statistic impossible. For this reason, we start the regional analysis by examining Altham statistics for larger regions, defined by various economic characteristics.

4.1 Regional differences in mobility

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

The nonfarm component of the Altham statistic d^N for these subpopulations is given in Table 3.[11] The first line of the table shows the reference total for the country as a whole, with a steadily increasing intergenerational occupational mobility, from $d^N = 19.0$ in 1865-1900 to $d^N = 7.8$ in 1980-2011.

		1865-1900	1910 -1960	1960-1980	1980-2011
Reference $d(P, J)$		19.0	15.5	12.7	7.8
Rural/Urban	Rural	17.4	15.8	13.3	7.9
	Urban	18.3	14.8	12.3	7.7
Local income growth	Below mean	19.5	15.1	12.5	7.8
	Above mean	18.3	15.0	12.5	7.8
Mover/Nonmover	Rural nonmover	18.8	16.7	14.6	8.7
	Urban nonmover	18.9	15.9	13.3	8.5
	Mover ($R \to R$)	18.3	16.0	10.9	6.0
	Mover ($R \to U$)	14.8	12.0	10.1	5.7
	Mover ($U \to R$)	15.9	11.9	9.7	5.7
	Mover ($U \to U$)	16.8	11.4	8.4	5.4
Local emigration rate	Low	18.6	15.7		
	High	19.3	14.4		
Occupation recode	Cottager $\to$ Farmer	17.0	14.8	12.7	7.8
	"Lower W" $\to$ Skilled	18.8	16.1	13.4	8.2
	"Lower W" $\to$ Unskilled	16.0	10.6	8.4	6.4

Table 3: Nonfarm and farm-nonfarm mobility d^N for subsamples of the total population

First, we consider local regions with cities/towns and completely rural areas separately. We

[11] The farm component d^F and the total is given in the Appendix.

find that there is only a very small difference in d^N between rural and urban areas, and that both rural and urban d^N 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. This can likely be explained by near-city areas (counted as urban regions here) having more established, larger farms and a larger population in nonfarm occupations, giving social classes that are more aligned with occupation categories.

Second, we group local regions by income growth, and consider high- and low-growth regions (those with income growth above and below the mean) separately. Again, we find very small differences, if any at all, in the nonfarm mobility component. However, high income-growth areas have less persistence among farmers. High income-growth areas are to a large extent rural, as the rural-urban income gap was much higher in the nineteenth century than it is today.

Farmer persistence in rural areas could also be lower because of migration patterns. The movement of people from the countryside to cities and suburban areas goes on over the entire period. Given a fixed number of farms, if this migration is drawn from all layers of society, one will observe higher mobility into farming in the sending compared to the receiving region. We can examine this more closely by moving from groupings of region of origin to a grouping of individual by their realized movement decisions. If we maintain the rural-urban distinction, we have two groups of nonmovers and four groups of movers. Mobility metrics d^N for each of the six mover groups is given in Table 3. It is clear that movers experience higher occupational mobility than nonmovers: individuals more likely to change occupation is more likely to move, and vice versa. However, mobility for those who move from one rural area to another looks more like mobility for nonmovers in the two first periods studied.

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

From the last rows of Table 3 it is evident that the difference in d^N between the high- and low-emigration regions is not very large. There is slightly lower mobility in the high-emigration regions in the 1865-1900 period, while the difference is opposite in the next period. Farm mobility d^F is always higher in the low-emigration regions. As the differences are small, however, we can draw the preliminary conclusion that emigration did not substantially affect intergenerational occupational mobility in Norway. There could, however, be effects within each occupation group that are not picked up here.

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

4.2 Neighborhood effects

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

This section introduces a way of correcting for region of origin, using the covariate-adjusted Altham statistic described in Modalsli (2014). 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 $\boldsymbol{\gamma}_k$.

$$\log\left(\frac{Pr(Occ_q = k)}{Pr(Occ_q = W)}\right) = \alpha_k + \boldsymbol{\beta_k'} \boldsymbol{D}_q + \boldsymbol{\gamma_k'} \boldsymbol{X}_q + \epsilon_{k,q} \qquad k = F, S, U \tag{9}$$

It follows from Equation (5) that the Altham statistic now can be expressed exclusively using the β coefficients:

$$d(P, J) = \left(\sum_{i=1}^{N} \sum_{j=1}^{N} \sum_{l=1}^{N} \sum_{m=1}^{N} \left[(\beta_j^i - \beta_m^i) - (\beta_j^l - \beta_m^l) \right]^2 \right)^{1/2} \tag{10}$$

If we omit the $\mathbf{X}$ covariates, the estimated odds ratios and Altham statistic are similar to those studied in Section 3.3. To examine the effect of neighborhoods, we can make use of the available data on municipal covariates: the employment shares of each of the four occupation groups (from the Census), and the mean incomes for each region. The results of each of these adjustments are presented in Table 4. The table also presents 90% 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
1865-1900	24.2	24.2	22.1	20.8	21.0
	(23.7 − 24.7)	(23.0 − 25.4)	(21.1 − 23.1)	(19.4 − 22.3)	(19.7 − 22.3)
1910-1960	20.3	20.3	18.1	17.7	17.7
	(20.0 − 20.7)	(19.2 − 21.6)	(17.5 − 18.8)	(17.0 − 18.4)	(17.0 − 18.4)
1960-1980	22.3	22.3	21.2	20.0	19.9
	(22.1 − 22.6)	(21.2 − 23.6)	(20.5 − 22.0)	(19.3 − 20.8)	(19.1 − 20.7)
1980-2011	19.2	19.2	18.1	17.1	16.9
	(18.9 − 19.4)	(18.3 − 20.1)	(17.4 − 18.9)	(16.4 − 17.8)	(16.3 − 17.6)

Table 4: Estimates of social mobility in Norway when controlling for regional background. 90% confidence intervals in parentheses, standard errors clustered on region in columns 2-5

The first column reports the baseline Altham statistic for Norway and the corresponding confidence intervals. It is evident that the intervals are relatively small. As all covariates used in this section is at the regional level, standard errors will be clustered at regions; the second column of Table 4 reports the baseline estimates with such clustering. This expands the confidence intervals somewhat, but most differences between time periods can still be clearly distinguished.

Adding one variable for the local mean income does increase the measured social mobility — the Altham statistic goes down. This reflects that some of the effects previously ascribed to father's occupation is now rather taken up by the coefficient on regional mean income. The reduction is not large — for the 1865-1900 period, the Altham statistic is reduced from 24.2 to 22.1, while for the 1980-2011 period, from 19.2 to 18.1. However, the 90%-intervals for the statistic do not overlap in any of the periods. Correcting for occupation shares by adding occupation shares for the occupation categories (with W as reference category) further increases estimated mobility. Finally, the entire regional variation can be taken out by adding a dummy variable for each region. When this is done, the Altham statistic decreases by approximately 3 in all periods. The decrease reflects that odds ratios are, on average, closer to zero within local regions than in the country as a whole; hence, the mobility statistic calculated without controls attributes some between-region variation in occupation choice as arising from father's occupation. The effect is, however, small, and does not change the time trend in intergenerational occupational mobility in Norway. The effect is similar across the sub-components d^F and d^N.

5 Concluding comments

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

Moreover, analysis using data on occupation mean incomes suggest that there has been a substantial decrease in the average change of income experienced by a given Norwegian father-son pair. Decreasing inequality in the distribution of income between families (father-son pairs) over time suggests an increase in welfare over and above the aggregate income growth. However, intergenerational mobility is not a quantitatively important element in explaining this growth.

Given the large geographic differences in intergenerational mobility that have been found in present-day United States (Chetty *et al.*, 2014), one could expect disappearing regional economic differences to be driving at least parts of the differences in intergenerational mobility over time. However, while adding controls for regional elements suggest some persistence effect of childhood region, this element is relatively constant over the entire period studied.

The Norwegian welfare state has expanded enormously in the period studied. The quality and scale of elementary education increased continously over the first 100 years, followed by high-school reforms and expansion of university and college education. Future work will attempt to map out more carefully the effect of education expansion on intergenerational mobility. Moreover, increases in old-age, disability and unemployment insurance, health care and other reforms are likely to have had substantial impacts on intergenerational mobility.

The present paper is the first to show a radical change in intergenerational mobility in a European country. This stands in contrast to the thesis by Clark (2014) that mobility is driven by fundamental processes that do not change over time. While there may be some one-off effect from particular reforms that have been enacted in the period under study, particularly with respect to education, the continous decrease in the measured odds ratios does suggest a secular trend in social 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 lead to a decrease in intergenerational mobility.

A Appendix: Tables, figures and further analysis

A.1 Transition matrices and occupation mean wages

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

	Father's occupation:				Col
Son's occupation:	W	F	S	U	sum
White collar (W)	2228	3210	1590	1055	8083
Farmer (F)	189	21118	519	4006	25832
Manual, skilled (S)	536	5237	3288	4887	13948
Manual, unskilled (U)	185	5285	932	5790	12192
Row sum	3138	34850	6329	15738	60055

(a) 1865 - 1900

	Father's occupation:				Col
Son's occupation:	W	F	S	U	sum
White collar (W)	6575	3530	5910	1371	17386
Farmer (F)	553	10872	1055	1297	13777
Manual, skilled (S)	2710	7800	14576	5111	30197
Manual, unskilled (U)	426	3817	1515	2582	8340
Row sum	10264	26019	23056	10361	69700

(b) 1910 - 1960

	Father's occupation:				Col
Son's occupation:	W	F	S	U	sum
White collar (W)	32650	11279	37545	6444	87918
Farmer (F)	478	9904	909	529	11820
Manual, skilled (S)	10583	17589	51911	11750	91833
Manual, unskilled (U)	1140	2607	3813	4239	11799
Row sum	44851	41379	94178	22962	203370

(c) 1960 - 1980

	Father's occupation:				Col
Son's occupation:	W	F	S	U	sum
White collar (W)	156392	14300	121350	13784	305826
Farmer (F)	1267	5965	2423	612	10267
Manual, skilled (S)	40184	11272	92076	9651	153183
Manual, unskilled (U)	12080	3038	24742	4953	44813
Row sum	209923	34575	240591	29000	514089

(d) 1980 - 2011

Table A1: Transition matrices

A.2 Other measures of social mobility

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

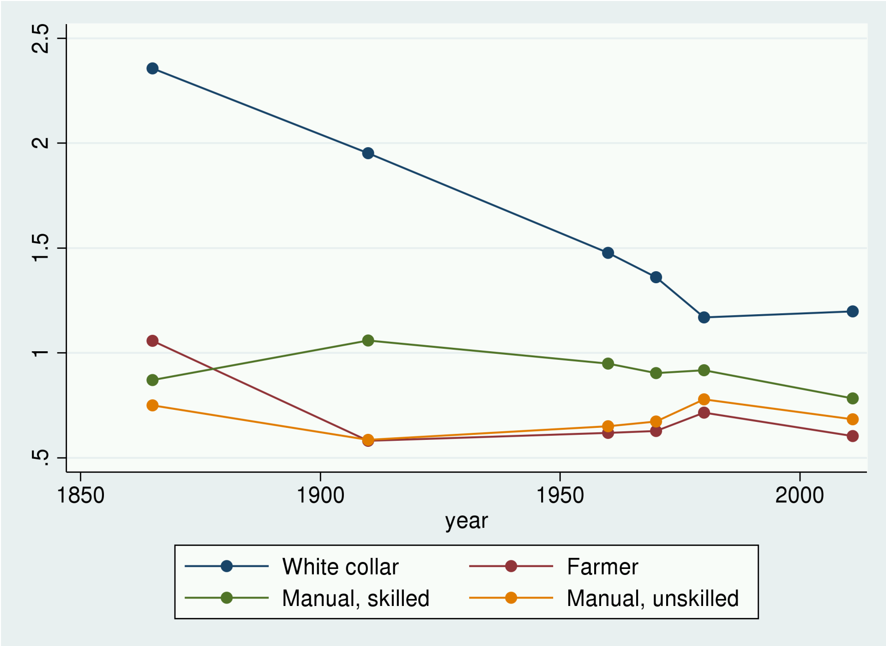


Figure A1: Mean income (men 30-60yrs), by occupation group, normalized (1865: men 25 years and above)

from their fathers, mobility can be said to be higher.

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.

The unadjusted off-diagonal share, denoted M, and three adjusted shares M' are shown in the first four columns of Table A2. While the unadjusted diagonal is increasing between 1865 to 1980, there is a slight decrease in the latter period. Fixing the marginal distributions to that of the Norwegian matrices of 1910-1960 or 1980-2011 gives increasing mobility from the first to second and the third to fourth period, with a decrease between the two middle periods. Using the nineteenth-century US marginal distributions or the Norwegian 1865-1900 distribution (not shown), gives decreasing mobility between the first two periods.

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

Country and time	Share off diagonal M	Share off diagonal M' with marg.dist. adjusted to NO10-60	NO80-11	US50-80	Over-representation at diag.	Altham statistic $d(P, J)$
1865 - 1900	0.460	0.483	0.371	0.460	1.6	24.2***
1910 - 1960	0.504	0.504	0.388	0.429	1.8	20.3***
1960 - 1980	0.515	0.488	0.362	0.442	1.5	22.3***
1980 - 2011	0.495	0.538	0.392	0.495	1.3	19.2***
US 1850 - 1880	0.454	0.573	0.454	0.555	1.3	11.9***
US 1952 - 1972	0.566	0.533	0.383	0.566	1.4	20.8***
UK 1851 - 1881	0.426	0.483	0.355	0.520	1.5	22.7***
UK 1952 - 1972	0.453	0.502	0.358	0.493	1.3	24.0***
Mob.ch. 1865-2011	+	+	+	+	+	+

Table A2: Estimates of intergenerational mobility, 1865-2011

$$s_{ij} = \frac{P(F = i \cap S = j)}{P(F = i) \cdot P(S = j)} \tag{11}$$

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

Following Eika *et al.* (2014), we can use the weighted average of s along the diagonal as a summary measure of mobility; a higher number means less mobility as the cell counts on the diagonal are further from what the independence model would predict. The average is shown in the fifth column of Table A2, 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 A2 also gives estimates for the United Kingdom and the United States in two time periods, 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 45% vs. 36%; $d(P, J)$ at 11.9 vs. 24.2); 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 towards higher mobility than any of the other two countries had in the 1950s-1970s period.

Table A3 shows the difference between the mobility matrices of Norway, the United States

	1865 - 1900	1910 - 1960	1960 - 1980	1980 - 2011	US 1850 - 1880	US 1952 - 1972	UK 1851 - 1881	UK 1952 - 1972
1910 - 1960	6.0***							
1960 - 1980	10.3***	7.9***						
1980 - 2011	13.5***	11.7***	7.7***					
US 1850 - 1880	16.3***	11.1***	12.9***	12.7***				
US 1952 - 1972	13.2***	11.5***	7.8***	3.9***	13.6***			
UK 1851 - 1881	12.3***	10.1***	4.7**	8.8***	13.2***	9.4***		
UK 1952 - 1972	15.2***	12.7***	8.3***	9.8***	15.3***	7.9	8.9***	

Table A3: Difference between mobility matrices

and the United Kingdom. The Norwegian matrices that are closer in time are more similar to each other than those further away. The distance between the first and last Norwegian matrix is comparable to the distance between the two U.S. matrices. Nineteenth-century Norway appears qualitatively different from all the non-Norwegian samples, with differences of more than 12 in all cases. The modern Norwegian samples are similar to the US OCG sample, with a difference of only 3.9 between the 1980-2011 Norwegian sample and the 1950s-1970s U.S. sample.

A.3 Odds ratio components: a six-way categorization

To examine in more detail which occupational category cells contribute to the preferred mobility metric $d(P, J)$, we examine the 36 components, each a combination of one of six pairs of father's occupation and six pairs of son's occupations. To simplify the discussion, these components will be aggregated up into six groups, where we in each group consider the sum of the squared distance of the log odds ratios from zero as in Equation (5). The development over time in each group is shown in Figure A2.

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

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

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

A.4 Odds ratios and local economic features

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

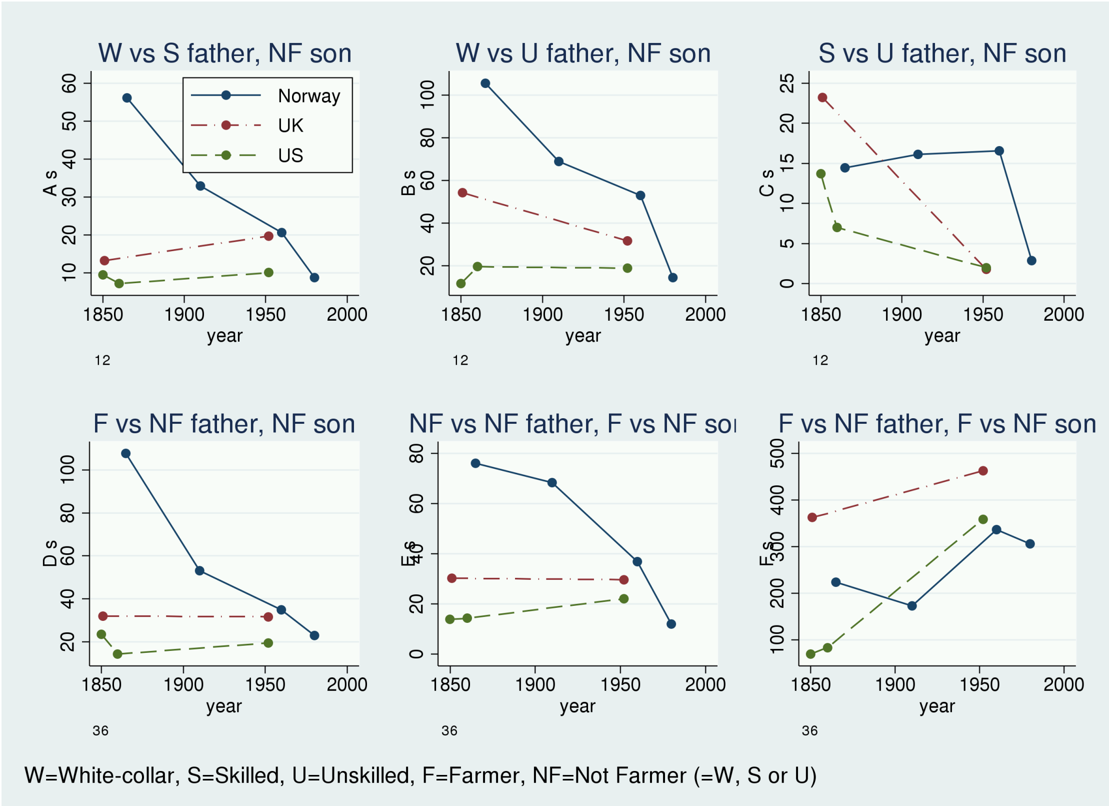
The means of local odds ratios, calculated as differences in son's opportunities given that they grow up in the same local region, are systematically lower than the odds ratios for the countries as a whole, though not by a large margin. For example, it is 19 times more likely for the son of a white-collar worker than the son of an unskilled worker to become a white-collar rather than skilled worker in the 1865-1900 period for the country as a whole ($\Theta_{WWUS} = 2.96$) while the local average is 13 ($\tilde{\Theta}_{WWUS} = 2.56$) 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:

$$\Theta_{ijlm,r} = \alpha + \beta y_r + \epsilon_r \tag{12}$$

where r identifies regions. The coefficients β are shown in Table A4.

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 0.85 percentage points (significant at the 5% level). This falls to 0.62 by the second period, and there is a negative and insignificant effect in the last two periods. The positive coefficient reported in the first two periods suggest that areas with higher mean incomes have lower social mobility. However, because of the lack of significant coefficients for nonfarm relationships it is hard to turn this into a general statement on the relationship between mean income and mobility in pre-1960 Norway.

For comparisons involving farmer fathers, however (Group 6 in Figure A2), nearly all odds ratios are significantly correlated with local mean income. Moreover, all significant coefficients are positive, meaning the excess probability of a farmer father to have a farmer son, compared to other occupations, is positive. The effects persist into the last time period studied, and is in several cases highest in this period. The log odds ratio for the son of a farmer becoming a farmer rather than a white-collar worker, compared to the son of a white-collar worker (Θ_{FFWW}) in the 1980-2011 period is 3.20, and an increase of local mean income of one percentage point increases



Group definitions:

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

Figure A2: Odds ratio components: Grouping and development over time this ratio by 1.97 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)	2.15	2.14	0.04	1.79	1.73	0.63***	1.45	1.53	-0.12	1.08	1.00	0.12
(WW/WU)/(SW/SU)	1.95	1.84	-0.19	1.38	1.27	0.28	1.07	0.88	0.23	0.97	0.90	0.18
(WS/WU)/(SS/SU)	-0.20	-0.28	0.11	-0.41	-0.41	-0.36	-0.38	-0.57	0.22	-0.11	-0.10	0.07
Group 2												
(WW/WS)/(UW/US)	2.96	2.56	0.85**	2.20	2.22	0.62**	1.73	1.72	-0.23	1.00	0.90	-0.12
(WW/WU)/(UW/UU)	4.19	3.27	-0.12	3.37	2.94	-0.21	2.94	2.33	-0.11	1.54	1.16	-0.04
(WS/WU)/(US/UU)	1.23	0.55	-0.30	1.17	0.74	-0.61*	1.21	0.66	-0.15	0.53	0.26	0.08
Group 3												
(SW/SS)/(UW/US)	0.81	0.79	0.39	0.41	0.51	-0.13	0.28	0.21	-0.28	-0.08	-0.11	-0.17
(SW/SU)/(UW/UU)	2.24	1.64	-0.24	1.99	1.66	-0.26	1.87	1.35	-0.34	0.57	0.25	-0.07
(SS/SU)/(US/UU)	1.43	0.80	-0.54**	1.58	1.19	-0.12	1.59	1.15	-0.19	0.65	0.35	0.04
Group 4												
(FW/FS)/(WW/WS)	-1.91	-1.53	-0.22	-1.68	-1.49	-0.47**	-1.57	-1.39	0.12	-1.12	-0.85	-0.10
(FW/FU)/(WW/WU)	-2.99	-2.20	-0.07	-2.81	-2.14	-0.79**	-1.89	-1.41	-0.68*	-1.01	-0.79	-0.45**
(FS/FU)/(WS/WU)	-1.07	-0.51	-0.25	-1.14	-0.66	-0.19	-0.32	-0.07	-1.03***	0.11	0.05	-0.23
(FW/FS)/(SW/SS)	0.24	0.23	0.44	0.11	0.22	0.31	-0.12	0.13	0.10	-0.04	0.16	0.02
(FW/FU)/(SW/SU)	-1.03	-0.53	0.39	-1.44	-0.85	-0.15	-0.82	-0.55	-0.18	-0.04	0.12	-0.32*
(FS/FU)/(SS/SU)	-1.27	-0.73	-0.05	-1.55	-0.95	-0.60**	-0.70	-0.67	-0.53**	-0.00	-0.05	-0.12
(FW/FS)/(UW/US)	1.04	1.10	0.38*	0.52	0.74	0.17	0.16	0.33	-0.09	-0.12	0.05	-0.17
(FW/FU)/(UW/UU)	1.20	1.20	-0.07	0.55	0.81	-0.44*	1.05	0.81	-0.43	0.53	0.35	-0.38*
(FS/FU)/(US/UU)	0.16	0.13	-0.52***	0.03	0.13	-0.62***	0.89	0.45	-0.58*	0.64	0.29	0.01
Group 5												
(WF/WW)/(SF/SW)	-1.35	-1.23	0.32	-0.75	-0.90	0.41*	-0.50	-0.05	-0.33	-0.90	-0.60	-0.25
(WF/WS)/(SF/SS)	0.80	0.92	0.08	1.04	0.84	0.88***	0.95	1.42	-0.48	0.18	0.42	-0.39*
(WF/WU)/(SF/SU)	0.61	0.54	0.27	0.62	0.46	0.92***	0.56	0.86	-0.00	0.07	0.33	-0.33
(WF/WW)/(UF/UW)	-3.80	-2.93	-0.17	-2.42	-1.96	0.41	-1.72	-1.25	-0.70	-1.70	-1.46	-0.22
(WF/WS)/(UF/US)	-0.84	-0.20	0.21	-0.22	0.31	0.62**	0.00	0.45	-1.01**	-0.70	-0.54	-0.37
(WF/WU)/(UF/UU)	0.39	0.25	-0.18	0.95	1.08	0.42	1.21	1.18	-1.27**	-0.16	-0.28	-0.42
(SF/SW)/(UF/UW)	-2.45	-1.65	-0.39	-1.67	-1.08	-0.14	-1.22	-1.17	-0.67	-0.80	-0.95	0.21
(SF/SS)/(UF/US)	-1.65	-0.79	-0.26	-1.25	-0.54	-0.23	-0.94	-0.97	-0.72*	-0.88	-1.05	-0.03
(SF/SU)/(UF/UU)	-0.22	0.05	-0.78***	0.33	0.64	-0.53*	0.65	0.21	-1.11**	-0.23	-0.71	0.32
Group 6												
(FF/FW)/(WF/WW)	4.35	3.41	0.59*	3.60	2.78	1.27***	4.09	3.00	2.46***	3.94	3.20	1.97***
(FF/FS)/(WF/WS)	2.44	1.91	0.61	1.92	1.29	0.84***	2.52	1.61	3.01***	2.82	2.36	1.94***
(FF/FU)/(WF/WU)	1.36	1.40	0.11	0.79	0.73	0.52	2.20	1.67	1.98***	2.93	2.43	1.65***
(FF/FW)/(SF/SW)	3.00	2.23	0.40	2.85	1.95	1.70***	3.59	2.90	2.15***	3.04	2.58	1.88***
(FF/FS)/(SF/SS)	3.24	2.32	0.89***	2.96	2.07	2.04***	3.47	3.00	2.36***	3.00	2.75	1.75***
(FF/FU)/(SF/SU)	1.97	1.58	0.91***	1.41	1.17	1.48***	2.77	2.30	2.42***	3.00	2.72	1.66***
(FF/FW)/(UF/UW)	0.55	0.40	0.22	1.18	0.87	1.55***	2.37	1.76	1.82***	2.24	1.65	1.80***
(FF/FS)/(UF/US)	1.59	1.49	0.50***	1.70	1.47	1.73***	2.53	2.09	1.85***	2.12	1.67	1.33***
(FF/FU)/(UF/UU)	1.75	1.61	-0.01	1.74	1.61	1.10***	3.42	2.57	1.22**	2.77	2.02	1.68***

Table A4: Local drivers of odds ratios

A.5 Subsample analysis

See Tables A5 and A6.

	1865-1900	1910 -1960	1960-1980	1980-2011
0: Reference	15.0	13.2	18.4	17.5
1: Rural	11.2	9.5	16.0	15.4
1: Urban	15.8	14.7	19.4	18.8
2: Rural nonmover	10.8	9.8	16.3	15.1
2: Urban nonmover	17.0	16.6	20.6	19.8
2: R to R	9.3	5.5	6.9	10.5
2: R to U	6.9	7.2	10.3	9.9
2: U to R	8.3	6.3	14.1	11.1
2: U to U	9.6	7.5	10.0	11.0
3: Low inc growth	14.7	15.5	18.8	18.2
3: High inc growth	15.3	9.7	18.0	16.7
4: Emig 1	14.6	11.7		
4: Emig 2	15.3	14.6		

Table A5: $d(P, J)$ farm component (d^F)

	1865-1900	1910 -1960	1960-1980	1980-2011
0: Reference	24.2	20.3	22.3	19.2
1: Rural	20.7	18.5	20.8	17.3
1: Urban	24.2	20.8	23.0	20.3
2: Rural nonmover	21.7	19.4	21.8	17.4
2: Urban nonmover	25.4	23.0	24.5	21.6
2: R to R	20.6	16.9	12.9	12.1
2: R to U	16.3	14.0	14.4	11.4
2: U to R	17.9	13.5	17.1	12.5
2: U to U	19.3	13.6	13.0	12.2
3: Low inc growth	24.4	21.7	22.6	19.8
3: High inc growth	23.9	17.9	21.9	18.4
4: Ref			22.3	19.2
4: Emig 1	23.6	19.6		
4: Emig 2	24.6	20.5		

Table A6: $d(P, J)$ all components

A.6 Robustness

Age robustness: Table A7.

[TO BE INSERTED: Tables showing how mobility metrics are stable when different selection criteria (nonimmigrants, 0-15 at t_0) and different matching algorithm parameters are used.]

	agc	agf	ags	agx
1865-1900	24.2	24.2	24.2	24.2
	(23.7 − 24.7)	(23.7 − 24.7)	(23.7 − 24.7)	(23.8 − 24.8)
1910-1960	20.3	20.3	20.3	20.4
	(20.0 − 20.7)	(20.0 − 20.7)	(20.0 − 20.7)	(20.0 − 20.7)
1960-1980	22.3	21.9	22.0	21.9
	(22.1 − 22.6)	(21.6 − 22.2)	(21.8 − 22.3)	(21.7 − 22.2)
1980-2011	19.2	18.8	19.0	19.0
	(18.9 − 19.4)	(18.6 − 19.1)	(18.8 − 19.3)	(18.7 − 19.2)

Table A7: Age robustness. agc=control, agf=age of father dummy, ags=age of son dummy, agx=both dummies

Table A8 shows results when some occupations are coded differently. In the first row, cottagers are coded as farmers rather than manual unskilled workers. In the second and third rows, "lower white collar" workers (defined as in Long and Ferrie) are coded as skilled and unskilled manual workers instead of white-collar workers. As is evident from the table, the overall results are not greatly affected by these substantial recodes.

	1865-1900	1910 - 1960	1960-1980	1980-2011
	Nonfarm component			
Reference	19.0	15.5	12.7	7.8
Recode C to F (not U)	17.0	14.8	12.7	7.8
Recode L to S (not W)	18.8	16.1	13.4	8.2
Recode L to U (not W)	16.0	10.6	8.4	6.4
	Farm component			
Reference	15.0	13.2	18.4	17.5
Recode C to F (not U)	14.2	13.2	18.4	17.5
Recode L to S (not W)	15.2	13.2	18.3	17.9
Recode L to U (not W)	15.5	14.1	19.6	19.0
	Both components ($d(P, J)$)			
Reference	24.2	20.3	22.3	19.2
Recode C to F (not U)	22.1	19.8	22.3	19.2
Recode L to S (not W)	24.1	20.8	22.6	19.7
Recode L to U (not W)	22.2	17.7	21.3	20.0

Table A8: Robustness: Occupation recode

B Appendix: Matching of individuals across censuses

B.1 Variables

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

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

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

B.2 Linkage

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

Identifying information

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

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

- First name
- Last name as stated in census
- Last name constructed as patronymic
- Last name constructed from place name
- Birth year
- Municipality of birth

Norwegians were not mandated to have a fixed family name until 1925. Before this, naming customs varied. Among the upper classes, families had used fixed last names since the 1700s. In cities, this was increasingly common also among the lower classes. In rural areas, one could use the name of the farm of birth or residence, or a patronymic (name of father + "sen"). Over the generations, these farm names or patronymics became attached to families and transmitted unchanged from fathers to children. Unlike other European countries, the custom of using occupation names (Smith etc) as family names has not been widespread in Norway.[12]

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

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

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

- First name
- Last name as stated in census
- Last name constructed as patronymic (only 1910)
- Last name constructed from place name (only 1910)

[12] 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

- Birth year, birth month, birth date
- County of birth
- Whether born in rural or urban municipality

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

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

Sample selection

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

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

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

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

Standardization and formatting

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

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

B.3 Matching algorithm: Calculating differences in identifying information

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

Strings (names)

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

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

Birth years

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

Birth dates (1910-1960 only)

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

Municipality of birth

Municipalities are aggregated to avoid mismatches due to border changes and mergers. The number of municipalities in 1865 is xxxx, in 1900 yyyy and 1910 zzzz. There is a total of zzz aggregated units ("cluster") 1865-1900, yyyy 1900-1910 and zzzz 1865-1910.

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

County and urbanity of birth (1910-1960 only)

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

B.4 Aggregating match scores

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

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

$$D = 8 \cdot D_F + 8 \cdot D_L + D_Y + D_M \tag{13}$$

and the following for 1910-1960:

$$D = 8 \cdot D_F + 8 \cdot D_L + D_D + D_C \tag{14}$$

This leaves us with a set of scores.

[TO BE COMPLETED]

Explain unique vs. sufficiently different here.

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