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FARMER FAMILIES AT THE HEART OF THE EDUCATIONAL REVOLUTION: WHICH OCCUPATIONAL GROUP INTERITED HUMAN CAPITAL IN THE EARLY MODERN ERA?

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Farmer Families at the Heart of the Educational Revolution: Which Occupational Group Inherited Human Capital in the Early Modern Era?

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Abstract: In this paper, we assess the inheritance of human capital in the early modern period with a comprehensive dataset covering eight countries in Europe and Latin America. We focus on the within-household process of human capital formation. Gregory Clark suggested that the wealthy and 'capitalist' groups of society provided their offspring with favorable skills. We confirm this finding partially, but there is another large group that reproduces successfully: farmers. By applying age-heaping-based techniques to a dataset of more than 322,000 observations, we argue that farmers contributed significantly to the formation of human capital and, consequently, to modern economic growth.

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1. Introduction

Between the 18th and 20th century, the world fundamentally changed from a world of agriculture to a world of industrial and service sector employees. During the 20th century, the agricultural sector suffered from low income and shrinking shares of national output. Industrialization was the keyword for income growth, and economists and economic historians later started to use the "non-agricultural share" as a proxy indicator for income. In the 20th century farmers were considered as a somehow old-fashioned social group, typically with low educational standards.[1] However, does this image apply to the early modern period as well? How educated were farmers before the Industrial Revolution fundamentally changed the world?

Several authors including Schofield (1973) and Cressy (1980) showed that farmers in preindustrial England had relatively high literacy skills. However, we have to keep in mind that the country of the first Industrial Revolution was different from other countries in many aspects. Little is known about the human capital of farmers living in other early modern societies in Western and Southern Europe or other parts of the world. In this study, we assess the relative numeracy of farmers using the now-established method of age-heaping analysis. This method considers the share of persons who are able to report their exact age with an annual resolution, as opposed to those who report an age rounded to a multiple of five (saying, for example, "I am about 40" when they might be 39 in reality). We include a number of countries in Europe and Latin America: Austria, Germany, Denmark (Sleswick), Spain, Southern Italy, and Uruguay. We intentionally include one of the new world economies to which Europeans emigrated in substantial numbers, because emigration was one option

[1] The word "farmer" typically indicates someone who practices under a "market economy", whereas "peasants" describes those who mainly live by subsistence (Crone 1989, p. 21). Here, "farmers" is used to describe the large group of people that includes both the subsistent and the more market-integrated farmers or peasants. Hence, a "farmer" in our dataset can be a person who had his own farm or was at least a subsistence farmer. We refer to individuals who controlled land temporary or permanent (the land can be rented or owned). Persons, for whom the information was provided that they did not control land, were not included in the farmer category.

Europeans did have in this period. Considering only those who stayed in Europe could be seen as a biased sample. To assess the education of farmers with an additional human capital indicator, we also compare literacy evidence from Switzerland and the United Kingdom. We find that numeracy and literacy values of farmers were actually relatively high in all of these countries.

In a second step, we study the reproductive in-family success of farmers and find that it was substantial.[2] Farmers had the largest number of children compared to other occupational groups. Hence, if the properties that led to the long-run human capital formation that (after some lag) enabled modern economic growth are partially inherited, it is possible that the behavior of farmer families played the core role. This section of the study adds new insights to the debate concerning Gregory Clark's theory about the inheritance of the capitalistic spirit (Clark and Hamilton 2006, Clark 2007). Clark suggested that the wealthiest and most 'capitalist' groups of society, such as merchants, provided their offspring with favorable skills.While Clark analyzes the reproductive success between groups of different wealth, we focus on occupational groups.[3] Focusing on the large group of farmers as the decisive group is a core issue to this debate because the numerical size of the social groups plays an important role. The merchants' and professionals' occupational classes were not large enough to play a numerically substantial role (see also Boberg-Fazlic, Sharp and Weisdorf 2011).

Finally, we add a new theoretical notion to this debate: the nutritional component was an undervalued issue in this debate. Farmer families had direct access to good nutrition. Malnutrition on the other hand limits cognitive abilities and increases child mortality (Baten, Crayen and Voth 2007). This theoretical notion implies that effects between one generation

[2] The "in-family" reproductive success refers to the observable number of children in the household.
[3] Nevertheless, Clark also provides literacy evidence by occupational groups in his papers. Furthermore, occupational groups are frequently used in the literature to approximate wealth (see for example Boberg-Fazlic et al. (2011)).

and the next are more important than previously thought.

2. Literature Review

If farmers had a relatively favorable human capital, we would expect that their income was also high if the markets operated sufficiently well. The relative income of farmers has always been difficult to quantify because they had strong incentives to hide their production from the feudal lords or other taxation authorities. Grain production was easy to tax for the feudal lords or the church because they could observe the harvest directly and remove a certain share of the production. The dozens of side products and other items of agriculture were more difficult to observe because they could be hidden. The farmers could also claim that they had been destroyed by adverse circumstances.

Several studies on the agricultural versus industrial productivity for the 19th century have been performed for individual countries. Van Zanden (2002) found that in the agricultural sector of the early 19th-century Netherlands, per capita income was actually higher than industrial income. Broadberry et al. (2011) recently argued that the income from cattle farming has been severely underestimated for medieval and early modern England.

One strategy to assess the relative well-being of farmers has been the anthropometric history method. Most scholars who were able to differentiate between occupations in their studies, especially those that could determine the parental occupations, found that farmers and farmers' sons were significantly taller (for example, see Floud, Wachter and Gregory 1990, Komlos 1989, Humphries and Leunig 2007, Baten 1999, 2000). However, because the authors typically make the assumption that the income of farmers was low (motivated by 20th century evidence), anthropometric historians searched for an explanation in the non-market-sphere. Komlos (1989) suggested a model in which a non-market-integrated farmer had a very favorable and protein-rich consumption basket. During the process of market integration, farming families lost this initial nutritional advantage and gained additional consumption possibilities among industrial goods. Our aim is to extend this model. We argue that the nutritional proximity advantages of farmers allowed their offspring to develop significant cognitive abilities and hence numerical advantages that were not recognized by previous research. But were numeracy and education at all desirable in the agrarian economy? Would education not be a burden if a farmer was required to perform dull and manual tasks in the field? We would argue that although a high share of manual labor is clearly characteristic for farmer work, numeracy could raise productivity. A productive farmer was a person who would consider numerous weather indicators, for example. A wrong decision about the specific day when the hay cutting or the grain harvest should begin could cause large income or welfare losses for the farming family. In addition, the treatment of cattle diseases and the protection of crops against insects and parasitic plants were more efficient if a farmer was more educated and numerate (on fertilizer use, see Huffman 1974). The more educated farming families might have also obtained informal knowledge about infant child diseases and nutrition.

Moreover, the farmers who were able to count could negotiate the prices for their goods with intermediaries or directly with consumers on the market. While this is rather an advantage for larger market integrated farmers, smaller subsistence farmers also had incentives to be numerate: Zuijderduijn and De Moor (2012) show that smallholders in the Netherlands who lived in a market town and possessed at least a house or a small piece of land participated actively in asset markets in the Middle Ages. Consequently, the poor did not become rich, but they managed to repay their debts over time or to put away some savings. Being able to count presumably increased their chances of participating in such activities.

Further evidence for farmers to be educated is analyzed by Lorenzen-Schmidt (2002) who mentions the existence of bills of loans between peasants in Northern Germany from at least the 16th century onwards. Furthermore, peasants represented their village community until around 1700 towards the feudal power and they consequently had to be able to read and write to manage the communication. Stoklund (2002) describes the existence of 'Weather-books' in Denmark that contained guidelines for weather forecasting, but also practical advice for farming, written by peasants and first published in the 16th century. A better understanding of the environmental conditions to maximize the outcome is a strong motive for farmers to acquire basic skills.

Clearly, for a laborer counting skills would also have been of advantage. However, it required a substantial amount of parental numeracy to pass on this aspect of education to the offspring. Moreover, we assume that only farmers could provide a degree of nutritional quality to their children sufficient to obtain the required cognitive preconditions.

Our argument that parents passed on their skills to children is well-documented in a large number of studies on the intergenerational transmission of human capital. In these studies on the 20th century, the authors usually measure the relationship between the years of schooling of the parents and the years of schooling of their children, controlling for a number of other potential determinants. Haveman and Wolfe (1995) conclude that in the studies in which "years of schooling attended" is implemented, the effect of this variable is always positive and significant, independently of how it is defined.[4]

The transmission of human capital affected the numeracy skills of the next generation in a positive way. But, whereas this effect applied to the whole population, including farmers, there was another effect influencing only the numeracy of the farmers: as they were able to provide a more protein-rich food in times of crises, their children did not suffer as much from malnutrition-related diseases as other groups of society. Given this nutritional advantage, the

[4] Behrman and Rosenzweig (2002) test their hypothesis of a strong positive influence of parents' education on the education of their children by using identical twins as parents. By comparing the education of the twins' children, they measure the different outcomes of education, while guaranteeing the same family background and abilities of the parents. The authors conclude that, when comparing male twins, one more year of schooling leads to significantly more schooling of their children. Pronzato (2012) also conducts a study on twins in which she finds out that both the education of the father and the education of the mother has an influence on the children. Hence, there is strong evidence that parents are able to pass on their basic educational skills, the ability to count, to their offspring. This was clearly also the case for parents of the early modern age.

farmers were able to increase their skills and pass them on to the next generation.

Some of the farmers' children possibly had to face downward mobility. Consequently, those children may not have been able to provide their descendants with a nutritional advantage, but they could still transfer their acquired skills to their children. This focus on one or two generations is an important modification of the theory of the selection processes during the early modern period – Galor and Moav (2002) argued that these effects worked through natural selection (which would include multi-generation effects). But even with the restriction to one or two generations, due to their large number of children, farmers contributed significantly to the numeracy revolution that Europe achieved between the late Middle Ages and the early 19th century.

During this Human Capital Revolution, European numeracy rates grew from around 50 percent to around 95 percent (Figure 1). This is a real revolution because the magnitude of almost 50 percent is comparable to the difference between the poorest and the richest economies of the early 20th century (Crayen and Baten 2010: South Asia had a numeracy of 52 percent in the 1940s, whereas the richest countries had reached full numeracy). Hence, Europe had turned from a half numerate into a mostly numerate continent during this revolution. Interesting are also the differences between the European regions: Southern Europe evolved the fastest in the late Middle Ages, but the well-known overtaking of Northwestern Europe is also visible in the numeracy record.

In summary, we argue that farmers developed a favorable numeracy that was reproduced by two mechanisms: one was the transmission of human capital that caused the transfer of skills to the next generation. A second mechanism influenced the numeracy of the farmer family offspring in particular: As they were able to provide a more protein-rich food in times of crises, their children did not suffer as much from malnutrition-related diseases as other groups of society.

3. The Data

The dataset we use for the age-heaping analysis contains data from six countries in Europe and Latin America: Austria, Germany, Denmark (Sleswick), Spain, (Southern) Italy and Uruguay. Additionally, we use data from Switzerland and the UK to complement the numeracy analysis with evidence on literacy.

With a total number of 322,316 observations (Table 1) and more than 42,000 family heads with children, this comprehensive dataset provides us with the possibility to study the relationship between the number of children and the socioeconomic background in the early modern era.[5] Because the process of numeracy formation within farming families is a core issue of our study, a sufficient number of farming families is important. With a total number of more than 9,800 farming families with children this analysis is feasible on a broad and representative basis.[6]

The datasets of the different countries stem from surveys in which information about families and households is reported (Table 2). Our sources originate from governmental censuses on the one hand and from church censuses ("Libri Status Animarum": soul registers) on the other hand. The only difference between those two types of sources is that the governmental surveys include (parts of) the whole population while the church censuses include only members of a certain confession. Nonetheless, this difference is negligible because the territories under study were religiously quite homogenous (except England). Germany had both Protestants and Catholics, but the territories in which the censuses were taken were relatively homogenous. While the datasets from Spain, Italy and Uruguay are based on governmental census data, a significant part of the Austrian and Swiss datasets as

[5] For further information about the family heads with children see our Internet Appendix A.
[6] The total number of farmers in the dataset aged between 23 and 62 years is 14,982 (Table 3).

well as a smaller fraction of the German datasets consist of church census data.[7] The English evidence on literacy stems partially from wills that Clark investigated (Clark 2007), and the remaining evidence is based on marriage registers (Schofield 1973).

What all of the surveys have in common is that each person reported detailed information about their age (or literacy), their occupation (at least for the head of the household), their sex and the number of children living in their household. Furthermore, the number of other persons living in the household, e.g., servants, employees and further family members (parents, aunts, cousins, etc.), can be obtained from these lists.

The countries in our dataset are represented by a substantial number of observations, even if the availability of sources generates a stronger focus on certain regions in some countries (Figure 2). Italy and Denmark are represented by the countries' southern regions, whereas more evidence from the northern region of Germany is available. For Switzerland, we have evidence for the center of the country, and for Spain, we have evidence for the center and the southern regions. To emphasize the representativity of our data, we include a map of the numeracy levels in the 1840s in which we differentiate between the rural and urban parts of the samples (Figure 2). It is visible that urban and rural places are quite randomly scattered over the educational types of regions within countries. If there were only data from a single urban place available (Italy, Denmark), it was located in the center of the rural regions. However, because we are mainly interested in the occupational differences, those regional composition issues should be less crucial.

The classification we use to organize the occupational groups is based on the Armstrong scheme (1972). Thus, we consider six different occupational categories in this study. The professionals, who are mainly people with a higher education, are represented by the first

[7] A significant amount of the German and Danish datasets was created by the so-called "Volkszahl-Register" project, which is composed of different censuses. The Danish area belongs today partially to Germany (Sleswick).

group in which the most prominent examples would be merchants, doctors and lawyers. Additionally, the remaining members of the upper strata of society were included here (mayors, nobility). For the second group, we classify semi-professional (or intermediate) people as administrators and clerks, for example. The third group contains skilled persons who typically completed several years of apprenticeship, including blacksmiths, craftsmen and people of similar professions. In the following section, we categorize the partly skilled people, such as herdsmen (who do not own animals), rope makers, and carriage drivers in the fourth group. Unskilled people without any education, such as servants and day laborers, are classified into the fifth group.

Finally, the farmers are allocated to their own category, the sixth group, whereas large landowners are classified into the first group. The differentiation whether a person is a farmer or a large landowner, is made by the term used in the respective language. Typically, a large landowner was indicated by another term than a farmer. If we consider the Spanish census, a farmer, as we define the term in this study, was always indicated by the word "labrador" while a large landowner was indicated by the word "hacendado". In contrast, persons indicated as "agricultural laborers" who may also have had a small garden at their disposal, not large enough to provide subsistence, were classified into the unskilled group, following the term "laborer" or "worker".[8] Furthermore, the farmers were able to nourish themselves and their children, even during times with higher food prices, while people of lower social classes suffered from malnourishment during such periods (Appleby 1975).

Clearly, not all 322,316 of the people in the dataset reported occupations because many of them were children and housewives. Among the adults aged between 23 and 62 years who

[8] When distinguishing between the occupational groups, we had to rely on the expressions used for the occupations in the original surveys. The groups are formed as homogeneously as possible based on the translation. In the case of Southern Italy, distinguishing between the agricultural worker and the farmer is not as simple (see Galt 1986). For all of the other countries, the difference between the term for laborer and farmer, respectively, is clear by the defition of the labels.

reported occupations, roughly 4 percent were professionals, 9 percent semi-professionals (intermediates) and 22 percent skilled as well as 20 percent farmers. Approximately 44 percent of the overall population were unskilled or semi-skilled persons (Table 3).

In the analysis below, we perform a robustness check with only those people who were family heads and had children.[9] Among the 33,232 occupational statements from family heads with children in the age-heaping dataset, we obtained the following results: about 29 percent were partly skilled and unskilled workers whereas 23 percent were skilled people (mostly craftsmen).[10] While the farmers represented the largest occupational group of the family heads with children with nearly 30 percent, the professionals and the intermediates corresponded to significantly smaller shares of about 5 and 12.5 percent, respectively.

4. Methodology

To assess our hypothesis of numerical advantages and a large number of descendants of farmers, we include various steps of analysis. First of all, we measure the human capital of the different occupational groups and countries by the age-heaping technique, which allows us to quantify numeracy. Second, we analyze literacy by occupational group to test our hypothesis using an additional human capital indicator (section 5). Finally, the number of children per occupational group and country, as reported in the surveys, is analyzed (section 6).[11]

The idea of age-heaping as a proxy for numeracy is that in less developed countries of the past, only a certain share of the population was able to report their own ages exactly when they were asked for it. The remaining population reported rounded ages, for example, 40, when they were in fact 39 or 41. The typical result is an age distribution with spikes at ages

[9] See our Internet Appendix A for further information. In the Swiss dataset children are not indicated. Hence, the analysis of families cannot be performed for Switzerland.
[10] For both the total working population and the family heads, the "farmers" capture only the people who had their own (small) farm. The total share of the people working in agriculture was much higher because persons from the partly skilled or unskilled group were often either herdsmen or laborers on farms.
[11] The number of children indicates the children who survived until the year of the survey.

ending in a five or a zero and an underrepresentation of other ages, which does not reflect the true age distribution. The ratio between the preferred ages and the others can be calculated by using several indices, one of them being the Whipple index.[12] Thus, the index measures the proportion of people who state an age ending in a five or zero, assuming that each terminal digit should appear with the same frequency in the "true" age distribution.[13]

$$(1)\ Wh = \left(\frac{(Age25 + Age30 + Age35 + ... + Age60)}{1/5 * (Age23 + Age24 + Age25 + ... + Age62)} \right) \times 100$$

For an easier interpretation, A'Hearn, Baten, and Crayen (2009) suggested another index, which we call the ABCC index.[14] It is a simple linear transformation of the Whipple index and yields an estimate of the share of individuals who report their age correctly:

$$(2)\ ABCC = \left(1 - \frac{(Wh - 100)}{400} \right) \times 100 \text{ if } Wh \geq 100\text{; else } ABCC = 100.$$

The share of persons able to report an exact age turns out to be highly correlated with other measures of human capital, such as literacy and schooling, both across countries, individuals, and over time (Bachi 1951, Myers 1954, Mokyr 1983, A'Hearn, Baten, and Crayen 2009). A'Hearn, Baten, and Crayen (2009) found that the relationship between illiteracy and age-heaping for less developed countries (LDCs) after 1950 is very close.[15] The correlation coefficient with illiteracy was as high as 0.7. The correlation with the PISA results for numerical skills was even as high as 0.85, hence the Whipple index is more strongly correlated with numerical skills. This has been reproduced for a large number of countries

[12] A'Hearn, Baten and Crayen (2009) found that this index is the only one that fulfils the desired properties of scale independence (a linear response to the degree of heaping), and that it ranks samples with different degrees of heaping reliably.
[13] A value of 500 means an age distribution with ages ending only on multiples of five, whereas 100 indicates no heaping patterns on multiples of five, that is exactly 20 percent of the population reported an age ending in a multiple of five.
[14] The name results from the initials of the authors' last names plus Gregory Clark's, who suggested this in a comment on their paper.
[15] See A'Hearn, Baten and Crayen (2009), Appendix available from the authors.

since then, and the correlation was always both statistically and economically significant.[16]

To determine the differences in the numerical skills, we create a binary variable "numerate" that assumes the value of zero if the person reported a rounded age ending in zero or five and, otherwise, a value of one for the numerate. Clearly, 20 percent of the population may have correctly reported ages ending in zero or five.[17] As independent variables, we include occupational groups, countries and birth half-century dummies to control for possible changes in numeracy over time and across space. In a similar way to the descriptive age-heaping analysis, we include only the age groups included in the 23 to 62 year range.[18] This strategy is more reliable than taking into account all of the age groups because in older groups, the so-called "survivor bias" effect could play a role.[19] Furthermore, it is more likely that the people within these age groups who reported an occupation still worked actively in this field in contrast to older people who may have already retired.

In a second step, we study the reproductive in-family success of different social groups in section 6 of this paper. Our proxy indicator is the number of children surviving until the census year and living with their parents (which are assumed to be the adults who are noted as being those in the sources).

The 'in-family' component is important, because some children might leave home early to work in another household or are put as foundlings in front of church doors if the family was very poor. The abandonment of children rose in Europe especially during the 18th century (Viazzo 2001, p.176). Only if children remained at home during early childhood, the family culture and its educational values could be provided to the child.

The number of children in a family is determined by various factors. While modern

[16] See our Internet Appendix for references.
[17] Hence, the coefficients calculated by a marginal effects regression are multiplied by 1.25 (and by 100 to obtain percentages).
[18] The age groups are arranged in 10-year steps: 23-32, 33-42, 43-52, and 53-62.
[19] This refers to possible upward biases of the age-heaping indicator because of people who survived due to their favorable numerical skills.

fertility control did not play a large role in the early modern period, infant and child mortality are clearly major components of reproductive success: If the offspring dies young, then this is obviously the opposite of success. Age at marriage and remarriage of widows might be partly endogenous components: If farmers had the subsistence means to support a family, the share of farmers able to marry was larger than among poorer contemporaries (Figure 3). In central Europe, in many if not all regions the marriage of couples was forbidden or strongly discouraged if no sufficient subsistence was given.

To analyze the reproductive success approximately, we study regressions with count data in which the number of children per individual and per head of the family, respectively, is the dependent variable. We employ occupational groups and different country dummies as independent variables. When including all individuals, we also control for marital status because it is most likely that a married person has a larger number of children than an unmarried or widowed individual. Additionally, there are two effects that could influence the number of children over time. Because we consider data from the 17th century to the early 19th century, it is possible that the number of children changes between the different time periods. To capture this potential time effect, we implement dummy variables for the census periods in which each census period covers a half of a century. Furthermore, we assume that the number of descendants increases with the individual age of a person. We control for this second time effect by including "age" as another independent variable.[20] Consequently, "age" stands for the individual age of a person and its effect on the number of children of this individual.

The number of children is a count variable taking on small values between a minimum of 0 and a maximum of 13. In the first part of the analysis, we take into account all the individuals included in the age range between 23 and 62. The type of count data we are

[20] For the regressions that contain only one census period or census year, we only test for the individual age effect.

dealing with is often considered to suffer from overdispersion, which can be ruled out by implementing a negative binomial regression model.[21]

In the second part of the regression analysis, the robustness check, we include only those individuals who are heads of families and reported at least one child in the survey. By following this strategy, we can rule out some uncertainties in the sources; i.e., if an individual stated to have “zero children”, we cannot be absolutely sure if this person really did not have any children or if there were reasons for not reporting this information. For example, a father who was surveyed could have left his family for seasonal work on foreign farms to earn money (see also Mooser 1984, p. 204). Moreover, as farmers had a very large number of children, we assume that not all of the farmers’ sons had the opportunity to become a farmer right after reaching adulthood. It is more likely that especially the younger sons left the family home to work as a paid laborer on other farms for a while before being able to establish their own household or farm (see, for example, Galt 1986). Consequently, there was a period of mobility of farmers’ sons in which they cannot be counted as belonging to the farmer group, but rather to the unskilled group of workers. Hence, the proportion of young unmarried males who are not yet heads of families is relatively high for the unskilled group and could bias the result for the regression including all individuals in the analysis of reproductive success. For that reason, we additionally perform the above mentioned robustness test in a separate regression analysis in which we include only the family heads with children.

When excluding the individuals without children, the range of the dependent variable reaches only from a minimum of 1 child to a maximum of 13 children. As we are dealing with data truncated at zero in this case, we compute a zero truncated Poisson regression (ZTP) model, which is more appropriate for this type of data. Furthermore, with a sample mean of about 2.5 and a sample variance of 2.4, the truncated data suffer from slight underdispersion

[21] Overdispersion means that the variance is larger than the mean; underdispersion stands for the opposite effect.

rather than from overdispersion.[22] To correct for this possible underdispersion, we generate a model with robust variance-covariance matrices, which results in a pseudo-maximum likelihood estimation rather than a maximum likelihood estimation and thus delivers a robust regression model (Winkelmann 2003, p. 172). We compute the marginal effects for an easier interpretation of the coefficients, which is frequently performed for nonlinear regression models.[23]

Our data originate from surveys that took place only at certain points in time; therefore, we have to consider several elements of uncertainty related to the number of children per family. For example, we cannot be sure if the family members reported all of their children or if older children had already left to start their own family. Thus, to verify the robustness of our regression analyses and to control for possible biases of these types, we perform regression analyses in which we consider only "children up to 12 years" as the dependent variable.[24]

To reassure the representativity of our analyses, we additionally perform the regression analyses with a further modification: As our data stem from many different places and regions across the countries, we use sampling weights to correct for possible biases through rural-urban composition issues. The sampling weights make sure that our regressions represent the actual urbanization rates of the countries in the respective time period (Table 4). Hence, the urban samples in our dataset in which the population may represent higher numeracy skills or

[22] Sample statistics refer to the number of children per family head. In the case of underdispersion, the standard errors tend to be overestimated (Winkelmann 2003, p. 172). On the use of zero truncated models see Cameron and Trivedi (2010, pp. 584-588).

[23] To reassure the reliability of the zero truncated regression model, we include only the family heads in the robustness checks that are not widowed or single and whose children have not been declared to stem from an earlier marriage. Thus, the children are likely to be genetic children of the mother and the father who are indicated as parents in the survey. This allows us to eliminate possible undesirable side-effects, such as a higher number of children for married or even re-married individuals compared to that of widowed people.

[24] This strategy is based on the assumption that most of the children stay at their family home at least until their 12th birthday. This is especially important for female children because marriage was often arranged after reaching physical maturity (Crone 1989, p. 111). In general, we assume that the mean number of children per social group is informative even though we do not observe the development of the children following the time of the survey.

lower numbers of children do not get more weight than they actually had.

5. Human capital: Measuring the ability to count

In this chapter, we measure the ability to count approximated by a person's ability to report his or her age correctly in a survey. Under normal conditions, we expect the occupational groups with higher income and social status to correlate with higher values of human capital compared to groups with a lower social status. This finding holds for the ABCC values of Austria, Southern Italy, Spain and Uruguay (Figures 4.1-4.7). The only exceptions are Denmark (Sleswick) and Germany, for which strong differences between the social groups are not visible in the figures (Figures 4.5-4.6). However, in Germany, there was a numerical advantage of farmers, albeit smaller than in the other countries; not so in Denmark.[25] However, we think that it is important to include the Danish data in the analysis because in this way we are able to compare reproductive behavior in countries with lower human capital values on the one hand and countries with relatively high human capital values on the other.

While previous results reflect the majority of our expectations regarding occupational differences in numeracy, there is one phenomenon that attracts special attention. In almost all of the countries in our dataset, the farmers have fairly high ABCC values. The farmers' values are similar or equal to those of the top three occupational groups. In Austria (for the early period) the human capital index of farmers is even close to the value of the professional group.

While the numeracy values of farmers in the early period in Austria are quite striking, the question might arise, why Austrian farmers and some of the other occupational groups had to take shrinking ABCC levels in the later period. First of all, we have to consider that the

[25] In Denmark, there was no difference between the farmer group and other occupational groups. The lack of diversity among the occupational groups is due to the fact that the ABCC level was already relatively high in the late 18th century in Denmark. The ABCC levels in Germany and Denmark exceed the numeracy index of 90. For Germany, there is a slight downward trend from the first to the fifth group with the exception of the partly skilled group. In Denmark, the values of all of the groups are relatively even. The only exception would be the partly skilled group, which has a lower ABCC value than the rest of the groups.

Austrian data contain the longest time period of all the countries, reaching from the mid-17th to the late 18th century. Consequently, the data cover the destructions of the Thirty Years' War (1618 - 1648) and the postwar period, which was characterized by the plague and bad harvests caused by the Little Ice Age. Between 1600 and 1650, a slow-down of numeracy development took also place in Northwestern Europe (Figure 1). As a part of the late 17th century Austrian observations stems from this period, the data include the downward trend of numeracy levels. In the Alpine parts of Central Europe, the effects of the climax of the Little Ice Age were particularly severe (Baten 2001).

To countercheck our observation of favorable farmer numeracy, we use Swiss and English data on literacy as further measures of human capital.[26] In Figures 5.1 and 5.2, the ability of Swiss people to read is displayed for the birth decades from 1560 to 1650 and from 1660 to 1730, respectively.[27] Again, as observed for the ABCC values of the other countries, we observe a difference in the reading ability of the two highest groups to the unskilled group, and again, we observe a high value for the farmers.

In England (Figures 6.1 and 6.2), the professional and intermediate (semi-professional) occupations were clearly more literate than the others, both in the Clark (2007) sample for the 16th and 17th centuries as well as in the Schofield (1973) sample for the 18th century. However, the professionals and intermediates represented a relatively small share of the total population, while the skilled groups and the farmers formed the larger group of literate Englishmen. The large group of partly skilled and unskilled people embodied primarily the illiterate lower class.

In both samples, we differentiated between “farmers” and “husbandmen”. While the husbandmen correspond to roughly 22 percent in both, the early and later period in England, the farmers represent 46.6 percent in the early period and 6.5 percent of the total samples in

[26] The Swiss occupational groups are also composed by the Armstrong taxonomy. Because there were no data available on the number of servants, the groups are based exclusively on the occupational information.
[27] On writing abilities of the Swiss, see our Internet Appendix A.

the later period. Though the size of the farming groups is rather different in both datasets, the relation between these two groups and the other occupational groups is very similar. In both time periods, the farmers were clearly more literate than the skilled artisans and the lower skilled persons, partly skilled and unskilled. In the early sample, the farmers were even more literate than the intermediate group. The husbandmen, in contrast, displayed literacy values below those of the farmers, but still exceeded the unskilled group and reached about the same levels as the partly skilled people. The differences in literacy within the two large farming groups in England, the farmers and the husbandmen, were already discussed by Schofield (1973) and Cressy (1980). This finding is also confirmed for Northern England by Houston (1982). If we have a look at East Central European countries, where land inequality was high, we find rather low literacy values for smallholders as reported by Tóth (2000) for Hungary. Cressy (1980) reports very low literacy values for peasants in Little Poland, though for an earlier period in time than we are dealing with (end of 16th century).

In sum, in all of the samples under study, the farmers represent a large group with literacy and numeracy values above the partly skilled and unskilled, although a modestly sized elite of professionals and semi-professionals is slightly better educated, and the skilled craftsmen are on a similar level as the farmers.

In the following section, we run a set of logit regressions to test whether the skill differences were significant and whether group composition effects could play a role (such as a higher share of one occupational group among later cohorts). Model L1 includes all of the countries for which age-heaping evidence was available, whereas L2 includes only the European countries (Table 5).

If we examine these two models, it becomes clear that the two upper groups as well as the skilled and the farmers had a significant advantage over the two least skilled groups of society (the reference group). Being a part of the professional class increased an individual's probability of being numerate by roughly 8.2 percent. A farmer had the second best chance for success: his probability of being able to count was about 4.3 percent higher compared to the two lowest groups (Model L1).

To find out whether the differences between the occupational groups are significant in each of the countries, we perform the logit regressions on numeracy also for the individual countries. The weighted models for the European countries in which the samples are weighted by the respective urbanization rates display very similar results (Table 6). The farmers as well as the two upper groups of society and the skilled artisans, still have a significantly higher probability for being numerate than the partly skilled and the unskilled taken together (again, Denmark is the exception).[28]

Further evidence is given by the reading and writing abilities of the Swiss (Table 6), for which we obtain very similar results. The farmers have a significantly higher probability of being able to read and write not only than the two lowest occupational groups, but also than the skilled.

6. Reproductive success of farmers and other occupational groups

Finally, we were curious about which occupational group had the largest number of children. Particularly among the more educated groups, a large reproductive success might have contributed to the educational revolution in Europe (A'Hearn et al. 2009).[29] Except in Southern Italy and Denmark (Figures 7.3, 7.6), the farmer group had the largest number of children. Whereas in Southern Italy the farmers still had more children than unskilled people,

[28] Related to the analysis of the individual countries, Denmark is the only exception, for which we do not find any significant occupational differences. As noted above, the overall variation of numeracy might have been minor already in this country. In Germany, only the farmers have a significant advantage over the reference category, while in the other countries the upper two groups as well as the skilled and the farmers perform clearly better than the lower two groups. In Austria and Spain, the size of the farmers' coefficient has about the same size as the coefficient of the skilled. In Italy, the farmer coefficient is only slightly smaller than the one of the skilled. In contrast to the farmers in the other countries, the farmer group in Southern Italy consisted mostly of smallholders. On the farmer group in Southern Italy, see the discussion in section 7.

[29] The relatively low number of children in the professional group in Spain could be due to the fact that a large part of this dataset (especially for the professionals) stems from Toledo, an important center for trade and production in early modern Spain. As Livi-Bacci (1986) argues, some populations of larger cities were "social group forerunners" in limiting fertility.

the Danish farmers had the second largest number of children, only exceeded by the professionals. In the early period in Austria, farmers had almost four children surviving up to the year of the survey, while the partly skilled and unskilled people had less than 2.5 children (Figure 7.1). The professional and skilled Austrians only had between 2.5 and 3 children. In the later period, the differences declined slightly but were still visible (Figure 7.2). The number of children per family in Austria was in general very high and larger than in the other European countries. This might be due to the fertility pattern identified by Woods (2000) who found that also in 19th century Austria nuptiality rates were low, while marital fertility was high.

The fact that in almost all of the countries the farmers had more children than the other occupational groups is important for the contribution to numeracy improvement in the long run. The one exceptional case is Southern Italy, where the farmers had the second lowest reproductive success in the mean number of children. A possible explanation for these results differing from the other European countries is the agricultural land tenure structure in preindustrial Southern Italy (Galt 1986): Most of the land belonged to very large landowners who lived in towns and leased their ground to smallholders ("*Bracciali*") who worked the land. The number of farmers with a medium-sized or large plot of land was small.

To determine whether the differences in the number of offspring are statistically significant, we implement the "number of children" as the dependent variable in a number of regressions. The results of the negative binomial regressions including all individuals are shown in Table 7. In the regressions that contain all of the observations, we again differentiate between models including all of the countries and those including only the European countries. For Models M1 (all of the countries) and M3 (European countries), the unskilled and partly skilled groups are the joint reference category. Clearly, the number of children of the higher occupational groups, e.g., the professionals and the intermediates, differs significantly from the fourth and fifth group. This confirms our hypothesis of a larger number of children within higher occupational groups. Given these findings, we agree with other authors who detect a positive relationship between the number of offspring and wealth or social status for a static society such as the early modern population (Clark 2007, Clark and Cummins 2010, Hadeishi 2003).

However, the farmer coefficient not only has a significant and positive sign, but also the largest value compared to all of the other occupational groups. For a farmer, the expected number of children was 0.7 children higher than in families from the unskilled and partly skilled groups of society, which results in a difference of 70 children per one hundred families (Model M1). The difference between the farmers and the other occupational groups becomes even more significant in Models M2 (all of the countries) and M4 (European countries) in which only the two highest groups of society, the professionals and intermediates, are implemented as the reference category. Even when compared to the highest social groups, the farmers still have a significantly higher number of children (0.46 and 0.45, respectively), whereas groups three to five clearly had less offspring.

To verify whether our results hold under stronger assumptions, we perform different robustness tests. In the first step, we run a negative binomial regression in which "children up to the age of 12" is employed as the dependent variable. Models R1 to R4 in Table 7 confirm the results described above for the mean number of all of the children. When controlling for those children who almost certainly still live at the family home (aged 0-12 years), we find that farmers again have the largest number of offspring in contrast to all other occupational groups. A farming family has 0.37 children more than a partly skilled or unskilled family (Model R1) and even 0.25 children more when compared to the professional and intermediate group (Model R2), both on a statistically significant level.

In the next step, we exclude all the individuals without children and those who are not married. We thereby make sure that the results are not biased because of persons to whom no children were assigned, but in fact just lived temporarily in another place. For this modified dataset we perform a zero truncated Poisson regression. The results of these regressions confirm the findings of the previous analysis (Table 8). Again, the farmers display the highest numbers of descendants (up to 12 years) compared to the two lowest and the average of the two highest groups of society (Models R5 to R8).

We performed both the negative binomial and the zero truncated models as well for each of the countries in the dataset (Table 9). For almost all of the countries, the results are very similar in that the farmers have a significantly higher number of children than the partly skilled and unskilled people taken together. The only exception is Southern Italy, where the number of farm children is not significantly higher than that for the reference group.[30] Table 10 shows that in Austria, Spain, Germany and Denmark farmers also have a significant advantage over the highest two groups of society, the professionals and intermediates, related to their number of children.

While the previous regression analysis is one possibility to test reproductional differences between occupational groups, there is another measure related only to the reproductive success of males: the male net reproduction rate (MNRR). The female net reproduction rate may be used more commonly, but Myers (1941) argues that the reproduction rate for males can also be implemented to analyze reproductional differences. Alter and Clark (2010, p. 44) define the net reproduction rate as "the average number of daughters that would be born through their lifetime by the average female born in each decade". If this index takes on the value one, the female population replaces itself over the period of interest. The net reproduction rate is influenced by the birth and death rates of a population.

We proceed in a similar way as Alter and Clark (2010), but instead of calculating the female net reproduction rate, we use the observed average number of sons that are born to the

[30] For Italy, we already stated that there are only small differences between all of the occupational groups.

average male in each occupational group, because fertility by occupation is not available for pre-1800 Europe.[31] We therefore call the rate "census-based male reproduction rate" (MRR). Nevertheless, the importance of the (census-based) MRR in our analysis is to study the differentials between the occupational groups which is independent of the formula used for the calculation of the index.

In almost all of the countries, the farmers are again the group with the highest share of male reproduction (Table 11). The exceptions are Southern Italy, where the farmers have the second highest share and Uruguay, where the farmers' rate is equal to that of the professionals. The male reproduction rate of farmers exceeds the value one in all of the countries.[32]

The previous results identify the farmers as the most reproductive class of society in the early modern period. But where do these large differences between the farmers and the other occupational groups come from? Certainly, there are several factors that we have to take into consideration such as differences in fertility, mortality rates of infants, and the age at marriage of women. As studies related to these differences between occupational groups are scarce for the early modern period across Europe, we refer to somewhat later periods in time. Van Bavel and Kok (2004) find that the farmers in 19th-century Holland had significantly shorter birth intervals in contrast to other occupational groups, especially the unskilled. They argue that the farmers in Holland could afford to replace the workforce of the wife by a servant when she had to take care for a newborn child.

We assume that a very similar mechanism led to the high numbers of children of

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[31] Consequently, we calculate a male net reproduction rate that is slightly adjusted to our data because we can only include the observed male children. The reproduction rate is calculated for two time periods in Austria (birth decades until 1650 and after 1650) because we are dealing with a very long time span in the Austrian data. For the other countries, we calculate the reproduction rate over the given period for the males aged between 23 and 62 years. In our dataset we observe the parents and their children who survived until the day of the survey and live in the same household, but we do not observe the total number of sons born to a male. Hence, the reproduction rate calculated for our data may be downward biased as we do not observe all of the male children born to the average male.

[32] We also performed a regression analysis with the MRR as the dependent variable. The farmer coefficient is always highly significant compared to the reference group, the partly skilled and unskilled, and has a positive sign in all of the countries. See our Internet Appendix A for further information.

farmers in our data. This might also imply that farmers with large plots of land had more children than smallholders. In our dataset, we are able to identify two main groups of farmers by their respective terms, medium-sized (and larger) farmers representing roughly 59 percent, and smallholders who correspond to about 32 percent of the whole farmer group (Table 12).[33] Moreover, the medium-sized farmers frequently reported to employ servants: While nearly 55 percent of the medium-sized farmers had at least one servant, only about 6 percent of the small farmers reported the same information. Hence, it is most likely that this large group of prosperous medium-sized farmers did not have to restrict themselves if they preferred having a high number of children.

Another decisive factor leading to differences in the number of descendants is the mortality rate of infants by occupational group. Woods (2000) finds for 19th century England and Wales that mortality rates were high (low) for infants of lower (higher) social groups. Surprisingly, the infant mortality rate of agricultural workers, who are considered the lowest group of this time in England, is even lower than that of the professionals' young children. Woods assigns this to the less dangerous environment children of agricultural workers were exposed to in contrast to those of other occupational groups, including the professionals. Closely connected to this is the finding of a higher life expectancy among higher social groups as well as the farmers. These observations are also in line with the results we find regarding the farmers' number of offspring.

Szreter (1996) analyses the relationship between fertility, age at marriage of women and the occupational group of the husband in Great Britain during the 19th and early 20th centuries. The author shows that still in times of decreasing fertility rates for higher social classes,

[33] The numbers refer to individuals aged between 23 and 62 in the farmer group. The rest of about 9 percent are "others" who live of farming, but cannot clearly be aggregated to one of the main groups of farmers. In the Spanish dataset, there is only one definition for a farmer: "*labrador*".

farmers displayed a relatively high fertility.[34] Moreover, they belonged rather to the groups that delayed marriage but nonetheless reached high fertility levels when marrying at an older age.[35]

The previously mentioned factors and possibly others contributed to the differences in the number of children between occupational groups in the early modern period. But still, we are interested in modeling the true composition of the following generation by class as accurately as possible. Hence, after giving credit to the reasons that led to the differences, we still find the hypothesis confirmed that farmers contributed strongly to long run growth because of their larger number of children compared with other groups of that time.

7. The heterogeneity of the farmer group

As we classify the farmers into one single category, one could object that farmers are a fairly heterogeneous group, with small-scale subsistence farmers on the one hand and large farms with a high number of farm hands on the other. Furthermore, the large number of children in farming families could be associated with the need for a workforce at small farms where savings or credit was not available to hire external workers. Thus, if the dataset contained only subsistence farming families, the variation in the number of offspring between farmers and other groups of society could be caused by the sheer need for more hands to work the land.

To assess these potential objections, we take a closer look at the terms used for farmers

[34] Farmers were located at position 104 out of 195 with number 195 displaying the highest fertility rate of all occupational groups (Szreter 1996, Appendix C).

[35] Farmers in this category were located at position 58 out of 195 with number 195 representing the group with the lowest proportion marrying at an older age (Szreter 1996, p. 336 and Appendix C). In line with this is also Haines (1979) who finds variation in the marriage patterns and the number of surviving children of different social groups. As the time period underlying in Haines' study is rather composed by the 19th and 20th century, the fertility decline is already ongoing. Consequently, the high status groups of society have lower fertility while the less skilled people have many births in this later period. The fertility differentials between the groups are significant. Revealing is the fact that the differentials still exist, even after they are standardized to the marriage patterns of the female population.

in the different countries of the dataset. These terms (such as 'Yeoman', 'Husbandman' and similar terms in other countries) might provide insights into the social structure of the farmer group. In some of the countries in our dataset several terms are used for farmers, while in others there is only one label indicating a farmer. Hence, to analyze the different categories of farmers adequately, we form subcategories following the relevant terms (Table 12).

In the Austrian dataset, we are dealing with two main subcategories: nearly 80 percent of the Austrian farmer group consists of those for which the term "*Bauer*" is used, which denotes medium-sized or larger farmers. In contrast, the subcategory of smallholders ("*Haeusler*") corresponds to roughly 11 percent of the whole farmer group (Table 12).[36]

We find a certain variation of labels for farmers in Germany, especially in Holstein, where a large part of the German data stems from. The most prominent terms for the farmers in Holstein differentiate between smallholders ("*Kaetner*") and medium-sized or larger farmers ("*Hufner*") (Lorenzen-Schmidt 1996).[37]

In Rhineland-Palatinate (Southwest Germany) we are able to differentiate between two terms that both designate persons with larger or medium-sized farms ("*Ackersmann*" and "*Landwirt*"). Furthermore, we are dealing with a group of medium-sized or larger farmers in Baden-Wuerttemberg and North Rhine-Westphalia ("*Bauer*" and "*Colonus*") and a group of smallholders ("*Kaetner*"/ "*Casettarius*"). There is also a mixed or unknown group, for which it is not clearly defined if the person is rather a medium-sized farmer or a smallholder (see the note on Table 12 for further information).

The largest part of the Danish (Sleswick) farmer group consists of the medium-sized or

[36] We did not include an individual among farmers if there was information in the dataset that the person did not control land (neither owned nor rented). In our analyses, we take farmers owning and renting the land together, because the contemporaries found the control over land to be the most decisive criterion, and this control was also given for those renting the land. Besides, 'ownership' is not a clear-cut concept in early modern times in most continental European countries.
[37] We choose the most prominent and homogenous subcategories in this section, following the terms used for farmers. There are more labels indicating farmers in the data. For further information see our Internet Appendix.

larger farmers, accounting for roughly 60 percent of all farmers in Denmark. The smallholders correspond to about 21 percent of the Danish farmer group.

In the Uruguayan data, we are able to identify a large group of medium-sized or larger farmers ("*Labrador*", 89 percent) and a minor group of smallholders ("*Chacarero*", 9.7 percent). The only term describing a farmer in Spain is "*Labrador*". He may be the owner of a larger, medium-sized or smaller farm. There was no special term for smaller farmers in Spain in the census.

In Southern Italy, the differentiation between medium-sized farmers and smallholders is more complicated, especially because of the land tenure structure in this region. On the one hand, there was a handful of very rich landowners with a large share of land. The smallholders on the other hand, were relatively poor (Galt 1986). In our dataset, we are able to identify two terms that can be classified as farmers: "*Massaro*" and "*Bracciale*". While the former rather describes a yeoman, the latter relates to a smallholder.[38] Nevertheless, the differentiation between the two terms in the census does not necessarily reflect the actual position or wealth of the person. The only clear difference is that a "*Bracciale*" did not have herd animals by definition, whereas a "*Massaro*" in most cases did (Galt 1986).[39] Though the differentiation of the two subcategories is even less clear-cut than in other countries, we assume that "*Bracciale*" stands rather for a smallholder, representing 92.7 percent of the farmers, and that a "*Massaro*" is a medium-sized farmer, corresponding to 7.3 percent of the Southern Italian farmers (Table 12).

In the first step of the analysis of different farmer categories, we examine the number of

[38] The word "*Bracciale*" can also indicate an agricultural laborer who controls some land. Nonetheless, as Galt (1986) describes, the "*Bracciale*" in 18th century Southern Italy indicates a smallholder. In the 20th century, the term only stands for a laborer.
[39] In his study, Galt (1986, p. 432) analyzes different wealth groups in an Apulian town and comes to the conclusion that "*Massari*" also exist in the poorer groups of the town. Moreover, he describes that there seemed to be a substantial social mobility between the groups. The son of a "*Massaro*" could be indicated as a "*Bracciale*" and a "*Bracciale*" could achieve the status of a "*Massaro*" (Galt 1986, p. 438). In general, artisans were less wealthy than "*Bracciali*" (Galt 1986, p. 439).

children in regression models. The results (Table 13) reveal that the smallholders clearly have a smaller number of children up to 12 years than the medium-sized or larger farmers in all of the countries for which we find different labels for farmers. In Austria, Germany and Denmark, the smallholders have a significantly smaller number of children up to 12 years than the group of the medium-sized or larger farmers. In Uruguay, the smallholders' coefficient shows also a negative sign, but not on a significant level.[40] Southern Italy is the exception because the coefficient is positive and insignificant.

For all of the countries except Southern Italy, we also find a strong relationship between the medium-sized or larger farmers and the presence of servants in the households.[41] While nearly 55 percent of all the medium-sized or larger farmers had one or more servants living in their households, only about 6 percent of the smallholders reported at least one servant on their farms. This finding strengthens the assumption that there is a correlation between the labels for the medium-sized or larger farmers and the existence of capital in their households.

Moreover, when assuming a positive relationship between the need for workforce and the number of offspring, the smallholders should be the group with high numbers of children. But, as our results show, this assumption is not fulfilled. On the contrary: we find out that the medium-sized farmers who already could afford to pay extra-familial labor were those who had significantly more children than the small farmers. We conclude from this finding that it was mainly the large group of prosperous medium-sized and larger farmers who had a significant reproductive advantage over other groups of society.

In the next step, we analyze whether there are significant differences in the numeracy levels between the farmer groups. Under normal conditions, we would expect the medium-

[40] For Uruguay we tested only the influence on the number of children in general because the number of households with children up to 12 years gets smaller than 30 in the category of the smallholders.
[41] In Southern Italy neither the medium-sized farmers nor the smallholders had servants living in their households (there are four farmer households in total that report servants).

sized or larger farmers, who tended to be rather more market-integrated, to have higher numerical skills than the small subsistence farmers. The results in Figures 8.1-8.5 reflect this assumption in most of the cases under study: In Austria, Denmark and Uruguay the smallholders have lower numeracy values than the larger farmers. The same difference is reflected by the literacy values of the two farmer categories for Switzerland and England (Figures 5.1-6.2). It is only in Germany that the smallholders have about the same level of numerical skills. In Southern Italy we find a reverse relationship: the group of smallholders has a higher numeracy value than the medium-sized farmers. But, as we stated before, the line between the smallholders and the medium-sized farmers in Southern Italy can be drawn less clearly than in other countries.

The regression analysis confirms the graphical results for Uruguay, where the smallholders have a significantly lower chance of being numerate than the medium-sized or larger farmers (Table 14). The same holds true for the writing abilities in Switzerland. In Austria, Denmark and Germany there is no significant difference between the two farmer categories.

The assumption of higher numeracy or literacy values of the medium-sized farmers holds for Uruguay and Switzerland. However, as the results do not fulfill our expectations for the other countries, we have to draw different conclusions. In Austria, Germany and Denmark, the group of farmers seems to be relatively homogeneous in terms of their numeracy, at least with respect to the hierarchy of terms used in the sources. In Southern Italy the smallholders have an even higher chance of being numerate than the medium-sized farmers.

These findings are not necessarily surprising if we consider the incentives for the farmers to acquire certain skills: Most of the smallholders also operated on their own account and thus had a high motivation to calculate their prices or the size of their acres correctly. This is confirmed by the finding of Zuijderduijn and de Moor (2012) who reveal that smallholders indeed saved or invested capital. They could only manage their assets if they had a certain level of numeracy and basic education. Moreover, as we previously argued, it is likely that factors such as nutritional advantages and permanent access to adequate nutrition could be a possible explanation for the high numerical skills of the farmers, approximated by their ability to state their age correctly. For England, Thirsk (1989, p. 735 and 2000, p. 166) outlines that milk production in the early modern period was practiced mainly by small-scale family farms. Thus, milk was included in the "poorer" farming family's diet. This finding provides further evidence for our theory because nutritional advantages in terms of milk consumption not only relate to farmers with large holdings, but especially smaller family farms.

8. Social Mobility during the early modern era

From the previous results, a number of important conclusions can be drawn. Because the variation in the number of offspring between the different occupational or social groups is fairly strong and statistically significant, we are interested in the effect of this mechanism in the later generations. If we consider a high number of descendants in farming families, it is likely that these descendants have also been able to reproduce successfully, if certain skills were passed from the parents to their children. Given a positive growth rate in each of the later generations of farmers and a negative growth rate of the partly skilled and unskilled groups, we can assume that the farmers' offspring would represent a larger part of society in more recent years.

It is apparent that not all of the farmers' sons had the opportunity to become farmers because the oldest son often inherited the family property in the impartible inheritance areas (Duplessis 1997, p. 163, p. 183, Herrigel 1996).[42] However, because not all of the siblings had

[42] We assume that the farmers' daughters often married and left their parents' home. The inheritance patterns depended on the inheritance laws and the customs of the regions. We assume here that the oldest son often inherited the family's property.

this opportunity, many adult children of farmers were forced to leave their home and search for work as an agricultural laborer. There may have been exceptional cases in which the descendants had the option to undertake an apprenticeship and become a craftsman or a higher skilled person. The situation in areas where people partitioned their inherited land was also unfavorable because a growing share of the population lived on small holdings (Herrigel 1996).

The mechanism of downward mobility in early modern society has been described for England by Clark (2007) and more recently by Boberg-Fazlic et al. (2011). Clark argues that the inheritance of "middle class values" within the wealthiest group of society, whose children moved downward, was a trigger for the Industrial Revolution. In contrast, Boberg-Fazlic et al. emphasize that the influence of the wealthiest occupational groups' descendants could not have been as significant, given that the share of the wealthier classes was relatively small compared to the size of the poorer groups they entered when moving downward. Hence, the authors suggest that some type of demonstration effect of the wealthy descendants' behavior led to the spread of "middle class values" in the poorer occupational groups to which they moved.

However, in these theories, one of the largest groups of early modern society was not considered: the farmers. Farmers represented a large share of society with one of the highest numbers of offspring among all groups and favorable human capital values (for England, see Boberg-Fazlic et al. 2011).

To identify potential mobility between the social groups in the descendants' generation, we compare the relative frequency of each of the occupational groups across two generations. Therefore, we consider the 23- to 62-year-old working men as the first generation and their male children as the second.[43] As we aim at modeling the composition of the second generation as realistically as possible, we calculate the size of the occupational groups by weighting the observations by their respective urbanization rate (Table 15). Thus we make sure that urban samples do not have a higher influence because of a higher number of observations.

The results in Table 15 reveal that the farmers are the only group with a substantial rise in their relative size from the first to the second generation. The increase in the proportion of the farmer group reaches from almost 5 percent in Spain to more than 26 percent in the second period in Austria. It is only in Southern Italy that the farmers' relative size rises only slightly by 2.1 percent, but we discussed above that the Southern Italian were mostly smallholders. While the upper two occupational groups, the professional and the intermediates, increase their relative frequency moderately in most of the countries, the skilled occupations vary in their success. The relative frequency of the partly skilled tends to decrease in most of the countries. The unskilled group, in contrast, has to take a significant loss in its percentage part from the first to the second generation, reaching from only 2.1 percent in Southern Italy to 25.6 percent in Uruguay.

In conclusion, it is apparent that the farmers who reproduced successfully and provided their offspring with beneficial numeracy and literacy skills helped to spread their human capital among the other groups of early modern society.

9. Conclusion

Clark famously argued that the well-educated, wealthier strata of society had more children in Western Europe than the poor and uneducated people and that this factor led to the Industrial

[43] Because we do not observe all of the children born to each man, but only those living in the same household, the absolute numbers may be slightly downward biased. The relative shifts in the occupational groups, though, are assumed to be constant. The male children are classified into their fathers' occupational group.

Revolution. He typically describes this group as capitalistic and mercantile; hence, most people imagine the group to consist of merchants and people of similar social strata. But what about farmers?

With a new and large dataset containing several countries and nearly 322,000 observations, we demonstrated that the number of offspring was strongly influenced by social background in early modern times. The wealthiest people who had significantly more children than poorer families were exceeded only by the large group of farmers who reproduced most successfully. Moreover, our findings suggest that a high share of farmers was able to count, and it seems likely that they taught their large offspring how to process basic numerical challenges. The favorable human capital skills of the farmers were also illustrated by their ability to read and write. One could imagine that in some countries, such as England, farmers developed particularly high human capital skills due to occupational shifts – they became a minority that produced the food for the majority of the population. But interestingly, the phenomenon of high human capital among farmers does not only apply to England and Northwest Europe in general, which were characterized by rapid occupational change. We rather find that the 'farmer effect' applies to the center as well as the periphery of Europe (including the European settlements in the New World). It is only in Southern Italy that the pattern was slightly less dominant.

The farmers had the largest number of descendants; therefore, we found that they were one of the groups of society that contributed significantly to the numeracy revolution achieved in Europe during the early modern era.

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Table 1: Total number of observations per country and region (including all individuals)

Country	**Region**	**No. of obs.**	**Percent**
Austria	Carinthia	1,458	4.7
	Lower Austria	4,935	15.7
	Upper Austria	1,824	5.8
	Salzburg	22,223	63.7
	Tirol	3,159	10.1
Denmark	Sleswick	46,502	100.0
Germany	Baden-Wuerttemberg	4,986	3.3
	Holstein	138,844	90.7
	North Rhine-Westphalia	6,540	4.3
	Rhineland-Palatinate	2,634	1.7
Italy	Brindisi	436	1.8
	Cosenza	7,712	31.8
	Napoli	1,061	4.4
	Vibo Valentia	15,007	43.8
Spain	Granada	10,214	35.2
	Guadalajara	3,497	12.1
	Malaga	1,070	3.7
	Soria	2,333	8.0
	Toledo	11,939	41.1
Uruguay	Canelones	2,179	20.3
	Maldonado	3,224	30.0
	Montevideo	5,360	49.8
Dataset Age-Heaping		297,137	
Switzerland	Canton of Zurich	25,179	100.0
Dataset Total		322,316	
England	Various Parishes	8,740	100.0

Note: There are 1,764 observations included for which the age is noted as a "missing value". More than 1,200 of these observations are children, and the other part consists of servants or slaves. These observations are kept in the dataset for calculating correct numbers of children and servants.

Table 2: Data sources

Country and Region	Survey Years	Survey Type	Source
Austria			
Carinthia	1757	CC	Soul Registers: Vienna Database on European Family History. Numeric data file, Version 0.1 [SPSS file]. Vienna: University of Vienna, 2003.
Lower Austria	1751, 1754, 1762, 1787		
Upper Austria	1762		
Salzburg	1647/48, 1690, 1733, 1750, 1755, 1762, 1794		
Tirol	1781		
Denmark			
Sleswick	1769, 1803	GC	Various Censuses: Arbeitskreis Volkszahl-Register (AKVZ) www.akvz.de (last accessed Feb 4th, 2012)
Germany			
Baden-Wuerttemberg	1749, 1758, 1771	CC	Soul Registers: Landeskirchliches Archiv Stuttgart (Archive of the Protestant Church in Stuttgart), Diözesanarchiv Rottenburg (Archive of the Diocese in Rottenburg)
Holstein	1769, 1803	GC	Various Censuses: AKVZ, www.akvz.de (last accessed Feb 4th, 2012)
North Rhine-Westphalia	1749, 1750	CC	Soul Registers: Bistumsarchiv Muenster (Archive of the Diocese Muenster), provided by: Westfälische Gesellschaft für Genealogie und Familienforschung http://www.genealogy.net (last accessed Feb 4th, 2012); City archive of Lippborg
Rhineland-Palatinate	1799, 1804	CC	"Census of the French": Landeshauptarchiv Koblenz (Main Archive in Koblenz), special thanks to Frank Neupert
Italy			
Brindisi	1742	GC	"Catasto Onciario": Internet: http://www.cosenzaexchange.com/comune.html (last accessed Feb 4th, 2012)
Cosenza	1742/43, 1749, 1753/54		
Napoli	1754		
Vibo Valentia	1741, 1743, 1745/46, 1754		Archivo di Stato di Napoli and Internet: http://www.cosenzaexchange.com/comune.html, http://www.archicalabria.it/Default.asp (last accessed Feb 4th, 2012)
Spain			"Catastro de la Ensenada":
Granada	1750, 1752/53	GC	Archivo Histórico Provincial de Granada
Guadalajara	1751/52		Archivo Histórico Nacional, Madrid
Malaga	1752		Archivo Histórico Provincial de Granada
Soria	1752/53		Archivo Histórico Provincial de Soria
Toledo	1752/53		Archivo Histórico Provincial de Toledo Archivo Regional de la Comunidad de Madrid
Switzerland			
Canton of Zurich	Several years between 1634-1698 and 1708-1764	CC	Soul Registers: Staatsarchiv Zuerich (National Archive of Zurich)
Uruguay			"Padrones" (Censuses):
Canelones	1826	GC	Archivo General de la Nación, Montevideo
Montevideo	1836		
Maldonado	1779/1780		Archivo General de la Nación Argentina

Note: CC stands for "Church Censuses", GC for "Governmental Censuses".

Table 3: Numbers of observations and compositional percentages by occupational group and country (individuals aged 23-62 years)

	Austria1	Austria2	Italy	Spain	Germany	Denmark	Uruguay	Switzer-land1	Switzer-land2	Total
Professional	130	282	462	537	1,145	391	150	45	40	3,127
Intermediate	184	427	143	751	3,791	1,470	121			6,942
Skilled	346	1,919	1,016	1,990	7,314	2,995	378	155	304	16,417
Partly skilled	129	430	539	955	3,160	1,582	100	323	110	7,032
Unskilled	230	2,531	310	2,312	14,428	4,380	1,071		209	25,767
Farmers	238	1,390	2,446	1,728	6,609	1,540	559	243	229	14,982
Total	1,257	6,979	4,916	8,273	36,447	12,358	2,379	766	892	74,267
	%	%	%	%	%	%	%	%	%	%
Professional	10.3	4.0	9.4	6.5	3.1	3.2	6.3	5.9	4.5	4.2
Intermediate	14.6	6.1	2.9	9.1	10.4	11.9	5.1			9.3
Skilled	27.5	27.5	20.7	24.1	20.1	24.2	15.9	20.2	34.1	22.1
Partly skilled	10.3	6.2	11.0	11.5	8.7	12.8	4.2	42.2	12.3	9.5
Unskilled	18.3	36.3	6.3	27.9	39.6	35.4	45.0		23.4	34.7
Farmers	18.9	19.9	49.8	20.9	18.1	12.5	23.5	31.7	25.7	20.2
Total	100	100	100	100	100	100	100	100	100	100

Note: Displayed are the individuals aged 23-62. These age groups are relevant for the analysis of numeracy, literacy and the number of children. Austria1 indicates the early period of Austrian data (birth decades 1580-1650), Austria2 indicates the later period (birth decades 1660-1760). Switzerland1 indicates the early period of Swiss data (birth decades 1570-1650), Switzerland2 indicates the later period (birth decades 1660-1730). Similar groups are aggregated if the number of observations in one group is N<30 (professional and intermediate; partly skilled and unskilled). Sources: see Table 2.

Table 4: Urbanization rate of the data compared to the actual urbanization rate of 1750

	Urbanization Rate Data (overall)	Actual Urbanization Rate
Austria	27.8	8.9
Italy	18.2	19.4
Spain	31.9	14.0
Denmark	8.0	5.7
Germany	6.6	10.8

Note: The places counted as "urban" in the data are Salzburg (Austria), Monteleone (Southern Italy), Toledo and Granada (Spain), Kiel and Ludwigsburg (Germany) and Husum (Denmark/ Sleswick). The "correct" urbanization rates are based on estimates for urban centers with 5,000 or more inhabitants in 1750 (Malanima 2010, p. 262). For Denmark, we use the Scandinavian urbanization rate approximately. For Uruguay, there is no urbanization rate available for the respective time period. Our data for Switzerland contain only rural areas and therefore are not weighted by urban shares. For the UK, we do not know the urban shares of Clark's and Schofield's data. Sources: see Table 2 on the data and Malanima (2010) on the actual urbanization rates as well as Bairoch et al. (1988) for Austria.

Table 5: (Weighted) logit regressions on numeracy, all available countries

All countries **Logit, marginal effects** **Dependent variable:**	**L1**	**L2**
	Numerate	
Included countries:	All	European (weighted)
Professional	8.16***	7.78***
	(0.00)	(0.00)
Intermediate	3.91***	3.08***
	(0.00)	(0.00)
Skilled	3.69***	2.93***
	(0.00)	(0.00)
Partly skilled	ref	ref
Unskilled	ref	ref
Farmers	4.28***	4.14***
	(0.00)	(0.00)
Austria	-11.43***	-12.95***
	(0.00)	(0.00)
Italy	-27.2***	-26.14***
	(0.00)	(0.00)
Spain	-16.76***	-16.28***
	(0.00)	(0.00)
Germany	ref	ref
Denmark	0.76	0.93
	(0.23)	(0.15)
Uruguay	-35.24***	-
	(0.00)	
Age	-0.33***	-0.29***
	(0.00)	(0.00)
Time dummies included?	yes	yes
Chi^2	0.00	0.00
Pseudo R^2	0.029	0.025
Observations	72,609	70,230

Note: Robust p-values in parentheses. ***, **, * indicate significance on the 1%, 5% and 10% level. "ref" indicates the reference category. Time dummy variables are birth half centuries. Control group=a person from Germany, born in birth half century 1700, aged 48 years (occupational group indicated by "ref"). Sampling weights are the corresponding urbanization rates of the countries. Urbanization rates were not available for Uruguay. Marginal effects are reported. Coefficients are multiplied by 125 to correct for the missing 20 % of the population that reported an age ending on 0 or 5 correctly. See Internet Appendix B for further information. Sources: see Table 2.

Table 6: (Weighted) logit regressions on numeracy (literacy) by country

Logit Marginal effects	**L1a**	**L1b**	**L1c**	**L1d**	**L1e**	**L1f**	**L1g**	**L1h**
Dep. variable:			**Numerate**				**Reading**	**Writing**
Included country	**Austria**	**Italy**	**Spain**	**Germany**	**Denmark**	**Uruguay**	**Switzerland**	
Weighted	yes	yes	yes	yes	yes	no	no	no
Professional	19.80***	23.95***	18.14***	3.60*	1.65	17.94***	0.51***	0.54***
	(0.00)	(0.00)	(0.00)	(0.08)	(0.56)	(0.00)	(0.00)	(0.00)
Intermediate	12.99**	12.58**	13.36***	1.04	0.30	18.25***	0.56***	0.75***
	(0.02)	(0.02)	(0.00)	(0.40)	(0.85)	(0.00)	(0.00)	(0.00)
Skilled	11.28***	11.89***	9.68***	0.94	0.24	16.46***	0.40***	0.29***
	(0.00)	(0.00)	(0.00)	(0.32)	(0.85)	(0.00)	(0.00)	(0.00)
Partly skilled	ref	ref	ref	ref	ref	ref	ref	ref
Unskilled	ref	ref	ref	ref	ref	ref	ref	ref
Farmers	9.48***	9.05***	9.01***	3.35***	0.04	13.08***	0.46***	0.37***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.98)	(0.00)	(0.00)	(0.00)
Age included?	yes	yes	yes	yes	yes	yes	yes	yes
Time dummies included?	yes	yes	yes	yes	yes	yes	yes	yes
Province dummies included?	yes	yes	yes	yes	-	yes	-	-
Chi²	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00
Pseudo R^2	0.028	0.034	0.025	0.012	0.001	0.043	0.273	0.176
Observations	8,236	4,916	8,273	36,447	12,358	2,379	1,650	1,260

Note: Robust p-values in parentheses. ***, **, * indicate significance on the 1%, 5% and 10% level. "ref" indicates the reference category. Time dummy variables are birth half centuries. Control group=a person aged 48 years (occupational group indicated by "ref"). Sampling weights are the corresponding urbanization rates of the countries. Urbanization rates were not available for Uruguay. The Swiss dataset contains only rural observations and is therefore not weighted. Marginal effects are reported. Coefficients are multiplied by 125 to correct for the missing 20 % of the population that reported an age ending on 0 or 5 correctly (in the numeracy regressions). See Internet Appendix B for further information. Sources: see Table 2.

Table 7: (Weighted) negative binomial regressions on the number of children and robustness tests (all available countries, all individuals included)

Neg. Bin. Marginal effects Dep. variable:	**M1**	**M2**	**M3**	**M4**	**R1**	**R2**	**R3**	**R4**
	No. of children				**Children up to 12 years**			
Included countries:	All		European (weighted)		All		European (weighted)	
Professional	0.42***	ref	0.44***	ref	0.25***	ref	0.26***	ref
	(0.00)		(0.00)		(0.00)		(0.00)	
Intermediate	0.17***	ref	0.16***	ref	0.08***	ref	0.05**	ref
	(0.00)		(0.00)		(0.00)		(0.04)	
Skilled	0.23***	-0.01	0.23***	-0.01	0.09***	-0.04	0.07***	-0.04
	(0.00)	(0.76)	(0.00)	(0.86)	(0.00)	(0.14)	(0.00)	(0.11)
Partly skilled	ref	-0.19***	ref	-0.19***	ref	-0.13***	ref	-0.12***
		(0.00)		(0.00)		(0.00)		(0.00)
Unskilled	ref	-0.26***	ref	-0.26***	ref	-0.12***	ref	-0.10***
		(0.00)		(0.00)		(0.00)		(0.00)
Farmers	0.70***	0.46***	0.68***	0.45***	0.37***	0.25***	0.34***	0.24***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Married	ref	ref	ref	ref	ref	ref	ref	ref
Single	-1.91***	-2.15***	-2.03***	-2.27***	-1.53***	-1.66***	-1.60***	-1.71***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Widowed	-0.50***	-0.56***	-0.53***	-0.59***	-0.63***	-0.68***	-0.65***	-0.70***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Austria	-0.02	-0.02	0.00	0.00	0.02	0.02	0.05	0.05
	(0.71)	(0.76)	(0.96)	(1.00)	(0.71)	(0.67)	(0.27)	(0.29)
Italy	0.16***	0.18***	0.14***	0.15***	-0.03	-0.02	-0.04	-0.03
	(0.00)	(0.00)	(0.01)	(0.01)	(0.51)	(0.62)	(0.35)	(0.45)
Spain	-0.09**	-0.10**	-0.11**	-0.12**	-0.19***	-0.20***	-0.20***	-0.22***
	(0.02)	(0.02)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)
Germany	ref	ref	ref	ref	ref	ref	ref	ref
Denmark	-0.10***	-0.12***	-0.10***	-0.12***	-0.09***	-0.10***	-0.09***	-0.09***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Uruguay	0.29***	0.35***	-	-	0.19***	0.22***	-	-
	(0.00)	(0.00)			(0.00)	(0.00)		
Age included?	yes	yes	yes	yes	yes	yes	yes	yes
Time dummies included?	yes	yes	yes	yes	yes	yes	yes	yes
Chi²	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudo R^2	0.224	0.224	0.227	0.227	0.244	0.244	0.247	0.247
Observations	62,273	62,273	60,934	60,934	55,533	55,533	54,359	54,359

Note: Robust p-values in parentheses. ***, **, * indicate significance on the 1%, 5% and 10% level. "ref" indicates the reference category. Time dummy variables are census periods (half centuries). Included are all of the individuals aged 23-62, for whom the marital and occupational status is available. Excluded are the married and widowed individuals who are not heads of households, e.g. wives, to make sure that the children of a household are not counted twice. Excluded are also the families with identifiable children of former marriages because we cannot control if the children are genetic children of the mother or father. Control group=person from Germany, surveyed in census period 1750, aged 48 years. Sampling weights are the corresponding urbanization rates of the countries. Urbanization rates were not available for Uruguay. Marginal effects are reported. Sources: see Table 2.

Table 8: Robustness test: (Weighted) zero truncated Poisson regression on the number of children up to 12 years (all available countries, only family heads with children included)

ZTP, Marginal effects **Dep. variable:**	**R5**	**R6** **Children up to 12 years**	**R7**	**R8**
Included countries:	All		European (weighted)	
Professional	0.43***	ref	0.49***	ref
	(0.00)		(0.00)	
Intermediate	0.19***	ref	0.18***	ref
	(0.00)		(0.00)	
Skilled	0.11***	-0.15***	0.10***	-0.16***
	(0.00)	(0.00)	(0.00)	(0.00)
Partly skilled	ref	-0.22***	ref	-0.22***
		(0.00)		(0.00)
Unskilled	ref	-0.27***	ref	-0.28***
		(0.00)		(0.00)
Farmers	0.36***	0.10***	0.34***	0.08**
	(0.00)	(0.00)	(0.00)	(0.02)
Austria	0.24***	0.28***	0.24***	0.27***
	(0.00)	(0.00)	(0.00)	(0.00)
Italy	-0.07	-0.07	-0.09*	-0.10*
	(0.15)	(0.19)	(0.07)	(0.09)
Spain	-0.00	0.01	0.00	0.01
	(1.00)	(0.88)	(0.95)	(0.85)
Germany	ref	ref	ref	ref
Denmark	-0.08***	-0.09***	-0.07***	-0.09***
	(0.00)	(0.00)	(0.00)	(0.00)
Uruguay	0.72***	0.86***	-	-
	(0.00)	(0.00)		
Age included?	yes	yes	yes	yes
Time dummies included?	yes	yes	yes	yes
Chi²	0.00	0.00	0.00	0.00
Pseudo R^2	0.023	0.023	-	-
Observations (households)	25,142	25,142	24,624	24,624

Note: Robust p-values in parentheses. ***, **, * indicate significance on the 1%, 5% and 10% level. "ref" indicates the reference category. Time dummy variables are census periods (half centuries). Included are all the heads of households aged 23-62. Excluded are the families with identifiable children of former marriages because we cannot control if the children are genetic children of the mother or father. Control group=family head from Germany, surveyed in census period 1750, aged 48 years (occupational group indicated by "ref"). The Pseudo R^2 is not displayed for weighted zero truncated Poisson regressions. Sampling weights are the corresponding urbanization rates of the countries. Marginal effects are reported. Sources: see Table 2.

Table 9: Overview of farmer coefficients of (weighted) regressions by country (reference group: partly skilled and unskilled)

Included country	Model no.	Regression model		Dependent variable	Farmer coefficient vs. reference group: partly skilled & unskilled	Obser-vations
Austria	M1a	Weighted	Neg. Bin.	Children	1.27***	7,668
	R1a		ZTP		0.96***	2,384
	R2a		Neg. Bin.	Children up to 12	0.76***	7,172
	R3a		ZTP		0.50***	1,993
Italy	M1b	Weighted	Neg. Bin.	Children	-0.02	3,419
	R1b		ZTP		-0.10	2,576
	R2b		Neg. Bin.	Children up to 12	-0.04	3,079
	R3b		ZTP		-0.12	2,209
Spain	M1c	Weighted	Neg. Bin.	Children	0.48***	7,273
	R1c		ZTP		0.63***	5,073
	R2c		Neg. Bin.	Children up to 12	0.25***	4,613
	R3c		ZTP		0.36***	2,918
Germany	M1d	Weighted	Neg. Bin.	Children	0.90***	31,658
	R1d		ZTP		0.89***	15,578
	R2d		Neg. Bin.	Children up to 12	0.43***	29,108
	R3d		ZTP		0.41***	13,673
Denmark	M1e	Weighted	Neg. Bin.	Children	0.52***	10,916
	R1e		ZTP		0.57***	4,433
	R2e		Neg. Bin.	Children up to 12	0.27***	10,063
	R3e		ZTP		0.22***	3,831
Uruguay	M1f		Neg. Bin.	Children	1.00***	1,339
	R1f		ZTP		0.85***	668
	R2f		Neg. Bin.	Children up to 12	1.01***	1,174
	R3f		ZTP		0.95***	518

Note: ***, **, * indicate significance on the 1%, 5% and 10% level. Time dummy variables are census periods (half centuries). Control group=family head aged 48 years. Time dummy variables are not included when only one census period was available. The ZTP model contains only married family heads with children, the negative binomial models contain all individuals. Included are the same cases as in the models with all of the countries (notes on Tables 7 & 8). In all types of regression models, it is controlled for provinces. Marital status is included when calculating the negative binomial models; this reduces the number of observations compared to the logit models. Included are only individuals aged 23-62. Sampling weights are the corresponding urbanization rates for the countries. Urbanization rates were not available for Uruguay. Marginal effects are reported. Sources: see Table 2.

Table 10: Overview of farmer coefficients of (weighted) regressions by country (reference group: professional and intermediate)

Included country	**Model no.**	**Regression model**		**Dependent variable**	**Farmer coefficient vs. reference group: professional & intermediate**	**Obser-vations**
Austria	M2a	Weighted	Neg. Bin.	Children	1.07***	7,668
Italy	M2b	Weighted	Neg. Bin.	Children	-0.33**	3,419
Spain	M2c	Weighted	Neg. Bin.	Children	0.27***	7,273
Germany	M2d	Weighted	Neg. Bin.	Children	0.62***	31,658
Denmark	M2e	Weighted	Neg. Bin.	Children	0.32***	10,916
Uruguay	M2f		Neg. Bin.	Children	0.03	1,339

Note: ***, **, * indicate significance on the 1%, 5% and 10% level. Time dummy variables are census periods (half centuries). Control group=family head aged 48 years. Time dummy variables are not included when only one census period was available. Included are the same cases as in the models with all of the countries (notes on Tables 7 & 8). In all types of regression models, it is controlled for provinces. Included are only individuals aged 23-62. Sampling weights are the corresponding urbanization rates for the countries. Urbanization rates were not available for Uruguay. Marginal effects are reported. Sources: see Table 2.

Table 11: (Weighted) male reproduction rate (census-based) by country

	Austria1	Austria2	Italy	Spain	Germany	Denmark	Uruguay
Professional	0.86	0.81	0.87	0.81	0.81	0.87	1.28
Intermediate	0.79	0.77	1.03	0.86	0.91	0.82	1.12
Skilled	0.86	0.62	1.09	0.99	0.70	0.73	0.72
Partly skilled	0.42	0.63	1.16	0.57	0.71	0.34	-
Unskilled	-	0.05	0.43	0.77	0.50	0.42	0.11
Farmers	1.41	1.28	1.10	1.12	1.32	1.06	1.28

Note: The first generation of the census-based male reproduction rate is composed of the male individuals aged 23-62 who can be classified into an occupational group, except those indicated as "children". The second generation is composed of all male children who are indicated as such, classified into their fathers' occupational group. Excluded are the families with identifiable children of former marriages because we cannot control if the children are genetic children of the mother or father. The rate is only calculated if the observation number of each category is at least N=30. The European observations are weighted by their respective urbanization rates. Urbanization rates were not available for Urguay in the respective time period. Austria1 indicates the early period of Austrian data (birth decades 1580-1650), Austria2 indicates the later period (birth decades 1660-1760). Excluded are regions or places for which individual information on the children (e.g. sex or age) is not provided: Soria (Spain), Rhineland-Palatinate (Germany), Cerrillos and Maldonado & Districts (Uruguay). Excluded are also slaves in Uruguay because potential children of the slaves are not indicated. The rate may be downward biased because we can only include the observed sons of a male. Sources: see Table 2.

Table 12: Numbers of observations and compositional percentages of the farmer groups by country

		Austria	Italy	Germany	Denmark	Uruguay	Switzerland	Total
		Obs.	Obs.	Obs.	Obs.	Obs.	Obs.	Obs.
1	Medium-sized/ larger farmer	1,270	179	4,779	928	497	156	7,809
2	Smallholder	196	2,267	1,077	326	54	316	4,236
3	Other/ mixed	162	-	753	286	8	-	1,209
	Total	1,628	2,446	6,609	1,540	559	472	13,254
		%	%	%	%	%	%	%
1	Medium-sized/ larger farmer	78.0	7.3	72.3	60.3	88.9	33.1	58.9
2	Smallholder	12.0	92.7	16.3	21.2	9.7	66.9	32.0
3	Other/ mixed	10.0	-	11.4	18.6	1.4	-	9.1
	Total	100	100	100	100	100	100	100

Note: Displayed are the individuals aged 23-62. These age groups are relevant for the ABCC analysis and the number of children. The three different groups contain the following labels: Austria: 1="Bauer", 2="Hauesler", 3=Someone who lives of farming, but cannot clearly be aggregated to one of the first two groups. Italy: 1="Massaro", 2="Bracciale". Germany: 1="Hufner", "Partial Hufner", "Property with land & agriculture", "Bauer", "Colonus", "Landmann", "Landwirt", "Ackersmann", "Parcelist", 2="Kaetner", "Koetter", "Haeusler", leaseholder or owner of a small piece of land, 3=Someone who lives of farming, but cannot clearly be aggregated to one of the first two groups. Denmark: 1="Hufner", "Bohlsmann" (Farmer in Sleswick), 2="Kaetner", 3=Someone who lives of farming, but cannot clearly be aggregated to one of the first two groups. Uruguay: 1="Labrador", 2="Chacarero", 3=Someone who lives of farming, but cannot clearly be aggregated to one of the first two groups. Switzerland: 1="Bauer", 2="Haeusler", "Kaetner". Sources: see Table 2.

Table 13: Negative binomial regressions on the number of children (up to 12 years) of farmers by country

Neg. Bin. Marginal effects Dependent variable:	**F1**	**F2**	**F3**	**F4**	**F5**
	Children up to 12 years				**No. of children**
Included country	**Austria**	**Italy**	**Germany**	**Denmark**	**Uruguay**
Medium-sized/ larger farmer	ref	ref	ref	ref	ref
Smallholder	-1.21***	0.01	-0.22***	-0.23**	-0.55
	(0.00)	(0.97)	(0.00)	(0.03)	(0.14)
Province dummies included?	yes	yes	yes	-	-
Marital status included?	yes	yes	yes	yes	-
Time dummies included?	yes	yes	yes	yes	-
Age included?	yes	yes	yes	yes	yes
Chi²	0.00	-	0.00	0.00	0.00
Pseudo R^2	0.049	0.100	0.040	0.071	0.055
Observations	1,106	1,674	4,439	974	474

Note: Robust p-values in parentheses. ***, **, * indicate significance on the 1%, 5% and 10% level. "ref" indicates the reference category. Time dummy variables are census periods (half centuries). Control group=person surveyed in census period 1750 (Germany/ Austria), aged 48 years and married. It is not controlled for period in Denmark because the number of observations in some categories is N<30. The robustness check with children up to 12 years is not possible for Uruguay because in the category "smallholder", the number of observations is N<30. For Uruguay, the results of the regression with "the number of children" are displayed. The category "other" is dropped. Marginal effects are reported. Sources: see Table 2.

Table 14: Logit regressions on numeracy (literacy) of farmers by country

Logit Marginal effects Dependent variable:	**F6**	**F7**	**F8**	**F9**	**F10**	**F11**	**F12**
			Numerate			**Reading**	**Writing**
Included country	**Austria**	**Italy**	**Germany**	**Denmark**	**Uruguay**	**Switzerland**	
Medium-sized/ larger farmer	ref	ref	ref	ref	ref	ref	ref
Smallholder	-2.50	8.75*	2.50	-5.00	-12.50*	-0.03	-0.15***
	(0.55)	(0.06)	(0.16)	(0.17)	(0.10)	(0.38)	(0.00)
Province dummies included?	yes	yes	yes	-	-	-	-
Time dummies included?	yes	yes	yes	-	-	-	yes
Age included?	yes	yes	yes	yes	yes	yes	yes
Chi²	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudo R^2	0.052	0.040	0.011	0.005	0.021	0.007	0.083
Observations	1,459	2,446	5,856	1254	551	472	342

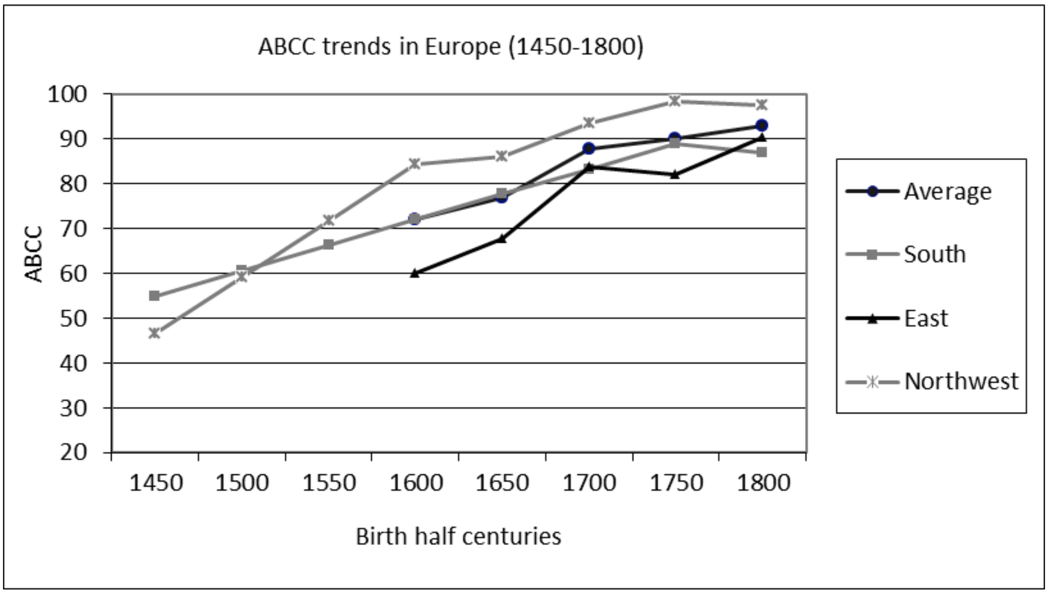
Note: Robust p-values in parentheses. ***, **, * indicate significance on the 1%, 5% and 10% level. "ref" indicates the reference category. Time dummy variables are birth half centuries. Control group=person born in half century 1700 (Germany/ Austria), 1750 (Denmark), aged 48 years. It is not controlled for provinces and periods in Uruguay and for periods in Denmark and Switzerland (reading) because the number of observations in some of the categories is N<30. The category "other" is dropped. Marginal effects are reported. Coefficients are multiplied by 125 to correct for the missing 20% of the population that reported an age ending on 0 or 5 correctly (when numeracy regressions are displayed). See Internet Appendix B for further information. Sources: see Table 2.

Table 15: Intergenerational change in the composition of occupational groups

	Austria1	Austria2	Italy	Spain	Germany	Denmark	Uruguay
	(Weighted) intergenerational change in the composition of the occupational goups in percentage points						
Professional	-0.2	0.7	-1.7	-0.4	0.2	1.2	4.6
Intermediate	-1.5	1.0	0.0	-0.1	2.3	3.6	3.4
Skilled	-1.0	-2.7	0.7	3.2	-2.2	3.2	-1.0
Partly skilled	-	-0.3	1.1	-3.0	-0.8	-6.6	-
Unskilled	-	-25.5	-2.1	-4.3	-12.1	-10.3	-25.6
Farmers	18.9	26.8	2.1	4.6	12.6	8.9	22.3

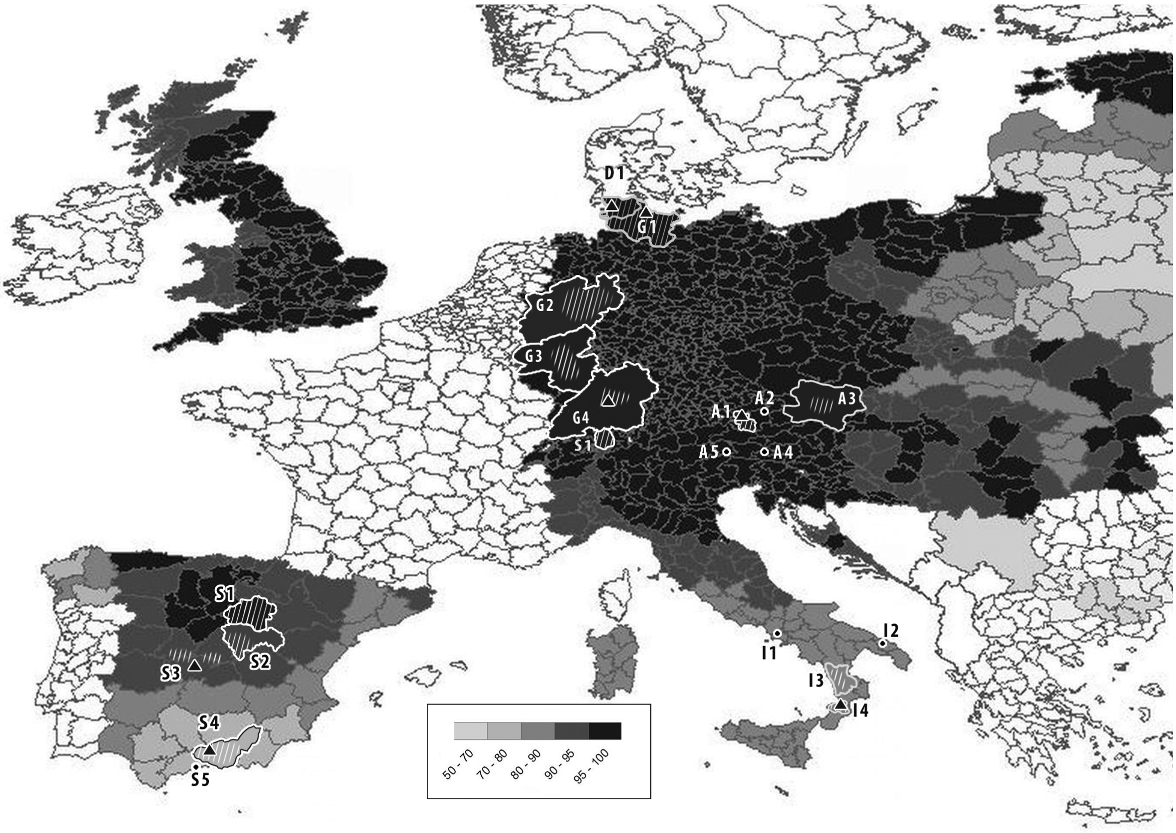
Note: The table shows the change in the occupational composition between the first and the second generation of males in the dataset. The first generation is composed of all male individuals aged 23-62 who can be classified into an occupational group, except those indicated as "children". The second generation is composed of all male children who are indicated as such, classified into their fathers' occupational group. Excluded are the families with identifiable children of former marriages because we cannot control if the children are genetic children of the mother or father. Austria1 indicates the early period of Austrian data (birth decades 1580-1650), Austria2 indicates the later period (birth decades 1660-1760). Excluded are regions or places for which individual information on the children is not provided: Soria (Spain), Rhineland-Palatinate (Germany), Cerrillos and Maldonado & Districts (Uruguay). Excluded are also slaves in Uruguay because potential children of the slaves are not indicated. The values are only displayed if the observation numbers of each category is at least N=30. The European observations are weighted by their respective urbanization rates. Urbanization rates were not available for Urguay in the respective time period. Sources: see Table 2.

Figure 1: The Human Capital Revolution in Europe



Note: Values refer to birth half centuries around the years noted. Evidence is based on A'Hearn, Baten and Crayen (2009), Table 4. We included all countries for which longer series or at least early values were available: "Northwest" is UK, Netherlands and protestant Germany, "South" is Italy (North). "East" is the average of Russia, Bohemia and Austria (from around 1600). "Average" is the average of those three regions. When values between benchmark dates were missing, they were interpolated. Weak estimates (in italic in Table 4 of A'Hearn et al.) were omitted. For UK and Netherlands before 1600, the benchmark year of UK 1600 was used, and the changes from Germany (protestant).

Figure 2: Map of European ABCCs in the 1840s and the regions of the sample



Sources: Baten and Hippe (2012, p. 278) (map), Table 2 (data of the sample).
We report the modern boundaries (not the historical ones) to allow modern readers to identify regions.

Legend

 indicates the regions for which data are available

• indicates the place of a region for which data are available (if there are not more data available from this region)

▲ indicates the urban places for which data are available:
Austria: Salzburg, Italy: Monteleone, Germany: Kiel and Ludwigsburg, Denmark: Husum, Spain: Toledo and Granada

A1 indicates the Austrian regions for which data are available:
A1: Salzburg, A2: Upper Austria (Gmunden), A3: Lower Austria, A4: Carinthia (Sirnitz), A5: Tirol (Villgraten)

I1 indicates the (Southern) Italian regions for which data are available:
I1: Napoli (Crispano), I2: Brindisi (Carovigno), I3: Cosenza, I4: Vibo Valentia

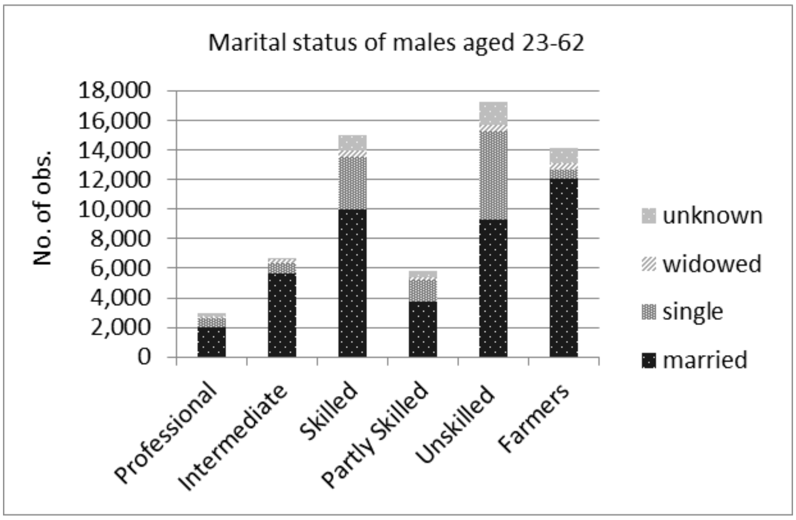
S1 indicates the Spanish regions for which data are available:
S1: Soria, S2: Guadalajara, S3: Toledo, S4: Granada, S5: Malaga (Estepona)

G1 indicates the German regions for which data are available:
G1: Holstein, G2: North Rhine-Westphalia, G3: Rhineland-Palatinate, G4: Baden-Wuerttemberg

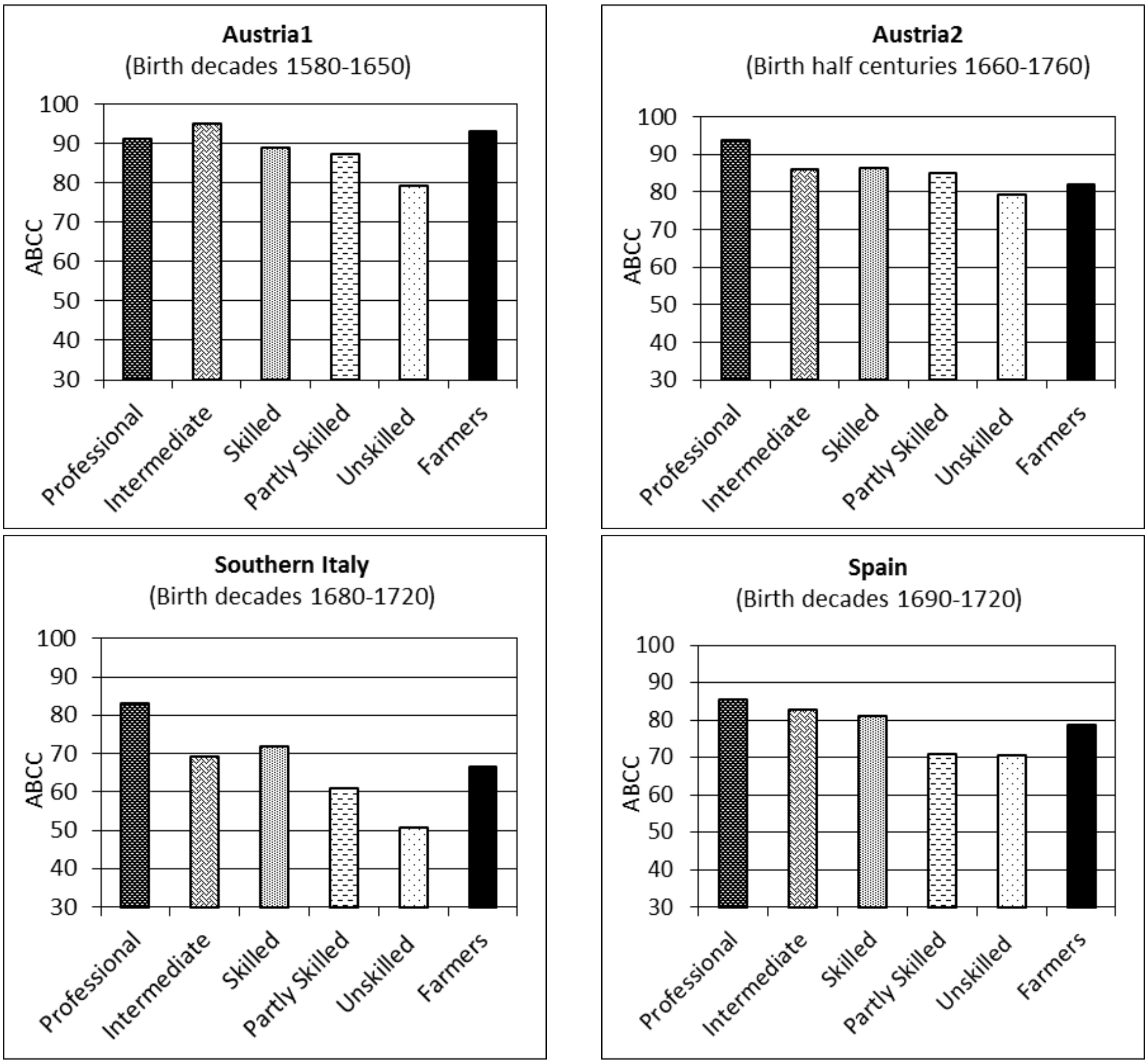
D1 indicates the Danish regions for which data are available: D1: Sleswick

S1 indicates the Swiss regions for which data are available: S1: Zurich

Figure 3: Marital status of males aged 23-62 years by occupational group[44]

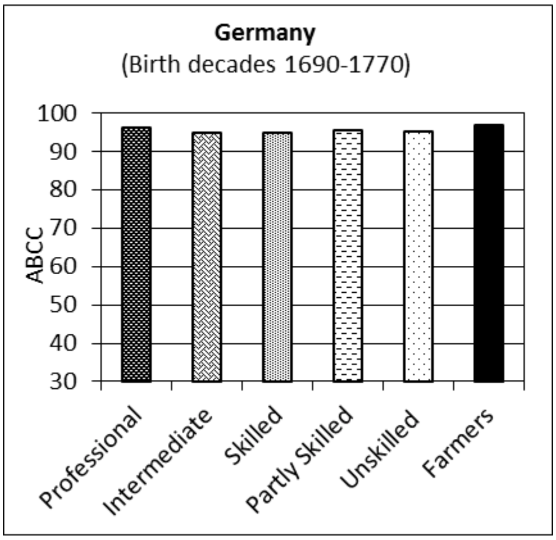


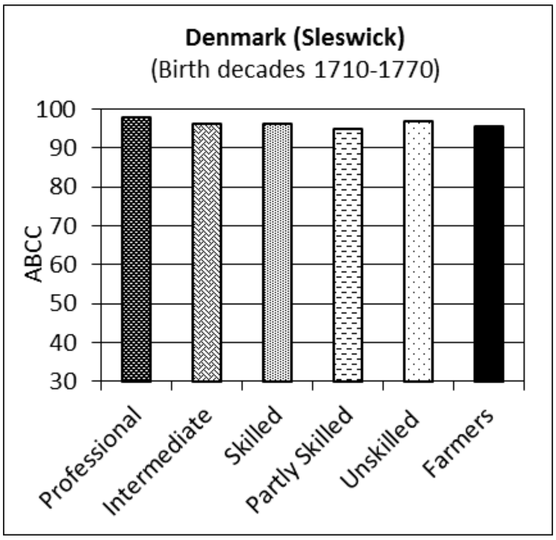
Figures 4.1-4.7: ABCC values for occupational groups and countries[45]

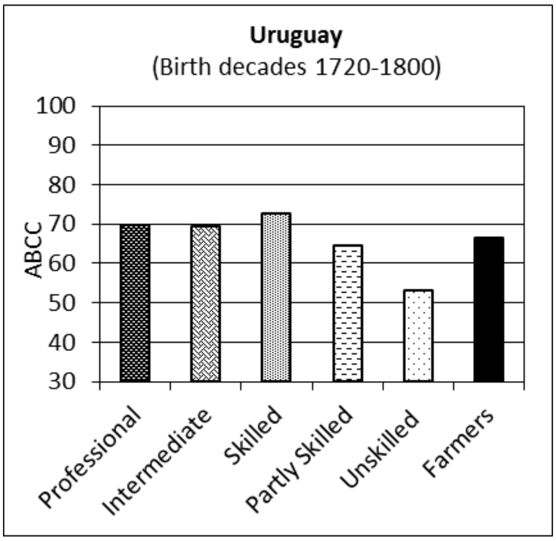


44 Sources: see Table 2.

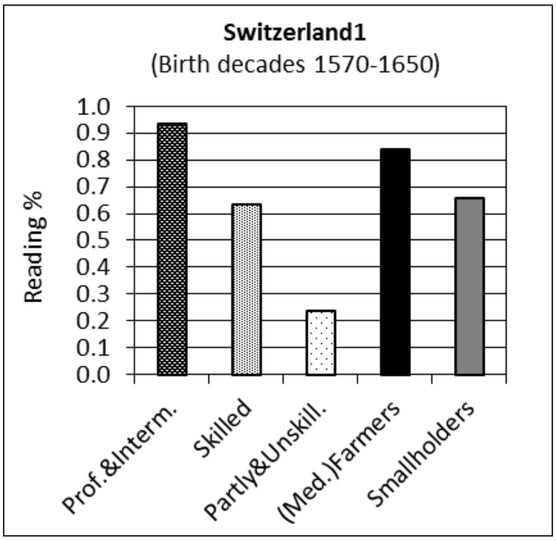
45 Sources: see Table 2. Included are individuals aged 23-62 years. For the numbers of observations see Table 3.

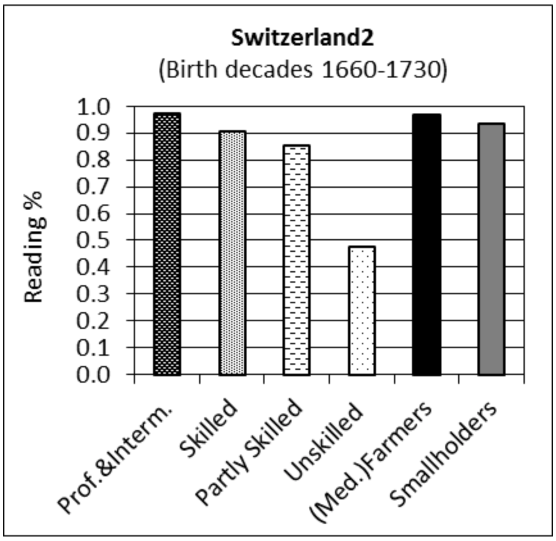






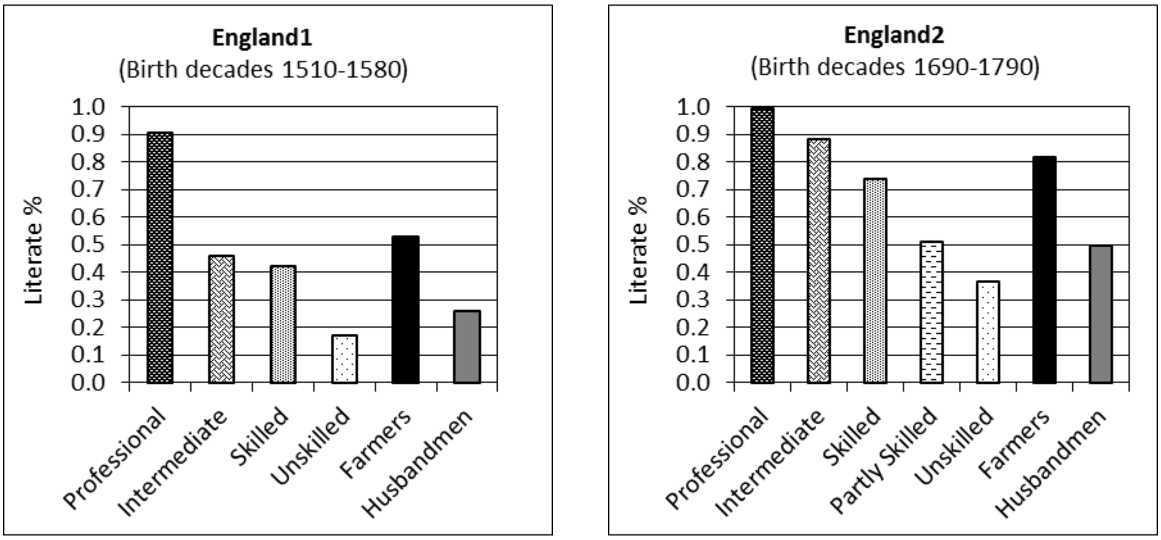
Figures 5.1-5.2: Reading abilities (in percent) for occupational groups in Switzerland[46]





[46] Similar occupational groups are aggregated if the number of observations in one group is N<30 (professional and intermediate; partly skilled and unskilled). For the numbers of observations see Table 3. Sources: see Table 2.

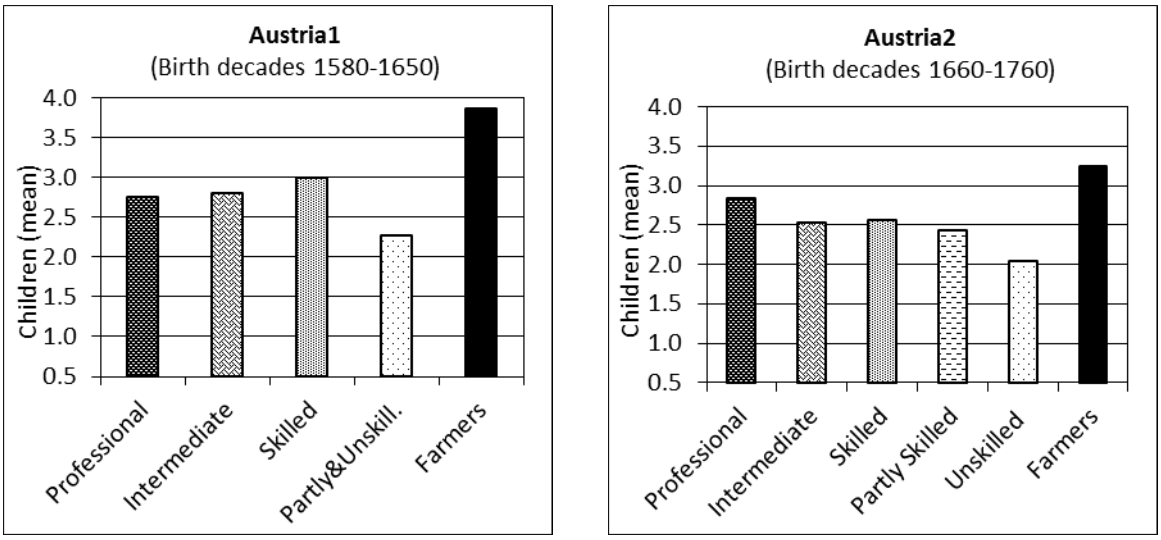
Figure 6.1-6.2: Literacy in percent for occupational groups in England[47]



Source: Clark (2007, p. 87)

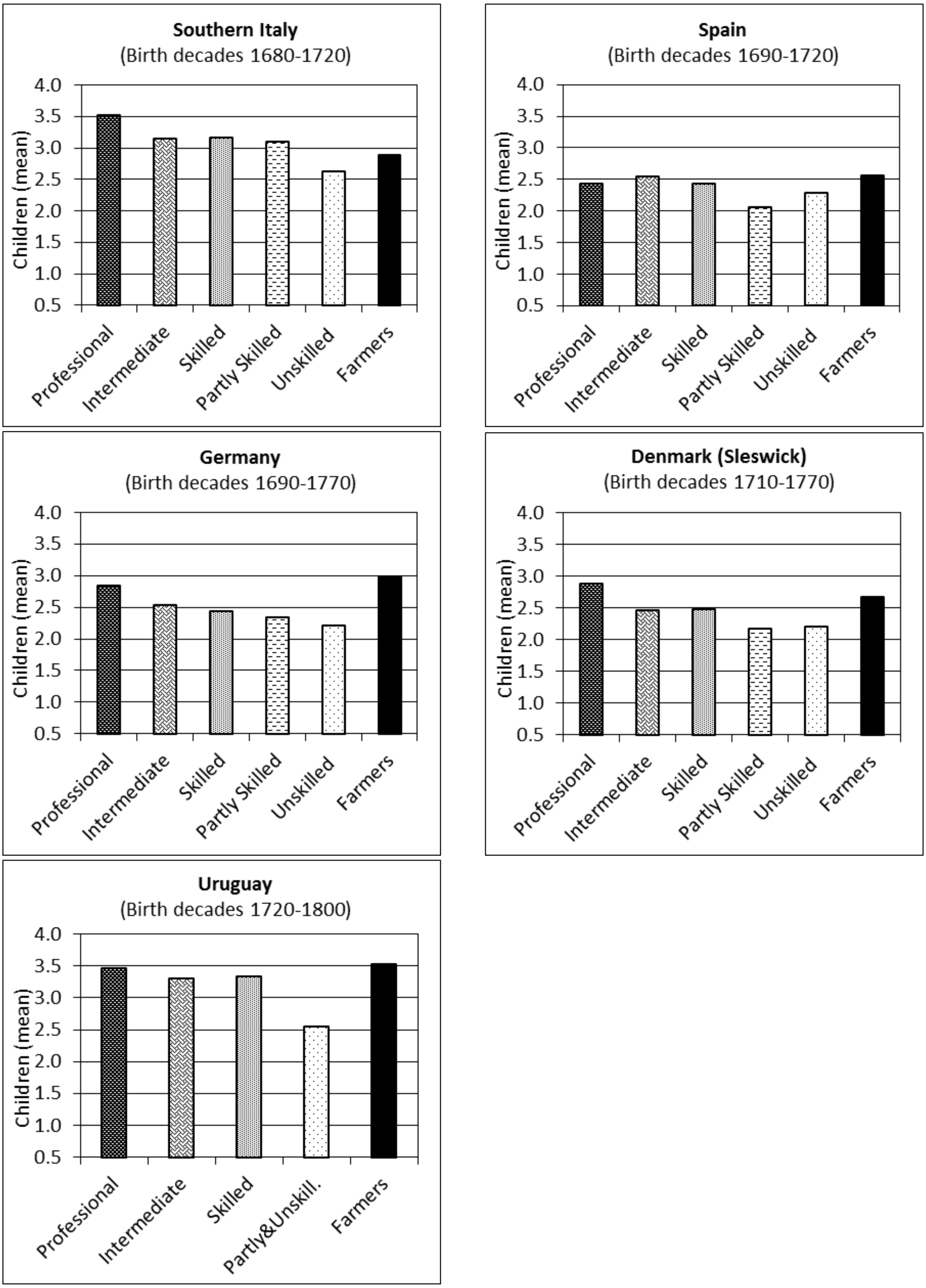
Source: Schofield (1973, p. 450)

Figures 7.1-7.7: Mean number of children for occupational groups and countries[48]

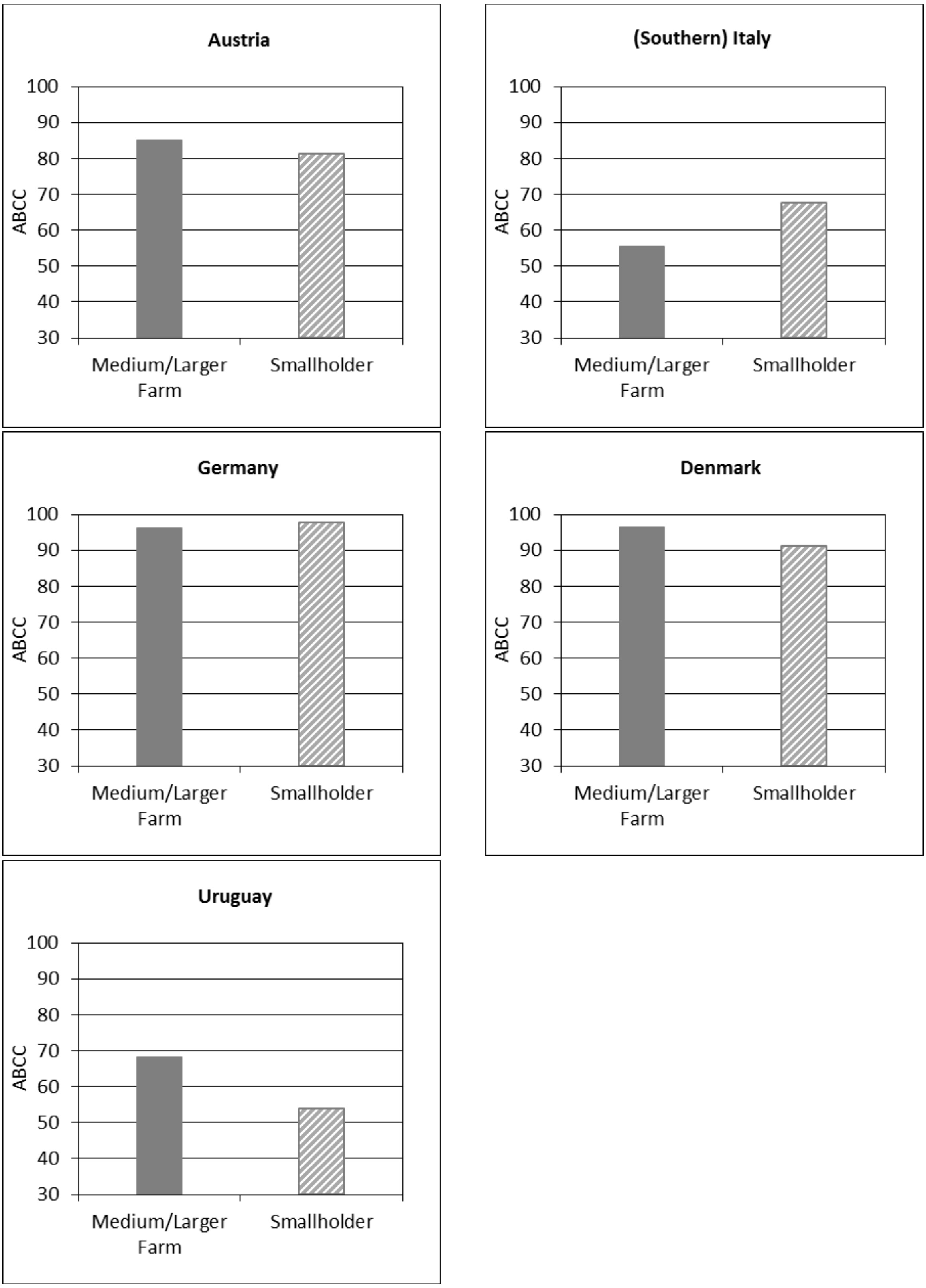


[47] Notes: Birth half centuries are calculated approximately; for Clark's data (wills), ages 50 to 70 are underlying and for Schofield's data ages 20 to 60 are underlying. Original Periods are 1585-1638 (Clark data) and 1754-1814 (Schofield data). For dividing into the Armstrong-scheme of occupations, the categories of Clark/ Schofield were summarized as follows: Clark data: Professionals = Gentry, Merchants, Professionals; Intermediate = Traders; Skilled = Craftsmen; Unskilled = Laborers; Farmers = Farmers; Husbandmen = Husbandmen. Schofield data: Professionals = Gentry, Professional; Intermediate = Estate, Officials; Skilled = Retail, Wood, Food and Drink, Textile, Metal, Leather, Miscellaneous, Transport, Clothing; Partly Skilled = Armed forces (non-officer); Unskilled = Construction and Mining, Laborers and Servants; Farmers = Yeomen, Farmers; Husbandmen. The values of all summarized groups are calculated by weighted means (weight: Observation number per original group).

[48] Similar occupational groups are aggregated if the number of observations in one group is N<30 (professional and intermediate; partly skilled and unskilled). Included are individuals aged 23-62 years. For the numbers of observations see our Internet Appendix A. Sources: see Table 2.


Southern Italy
(Birth decades 1680-1720)
Children (mean)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
Professional
Intermediate
Skilled
Partly Skilled
Unskilled
Farmers
Spain
(Birth decades 1690-1720)
Children (mean)
Professional
Intermediate
Skilled
Partly Skilled
Unskilled
Farmers
Germany
(Birth decades 1690-1770)
Children (mean)
Professional
Intermediate
Skilled
Partly Skilled
Unskilled
Farmers
Denmark (Sleswick)
(Birth decades 1710-1770)
Children (mean)
Professional
Intermediate
Skilled
Partly Skilled
Unskilled
Farmers
Uruguay
(Birth decades 1720-1800)
Children (mean)
Professional
Intermediate
Skilled
Partly&Unskill.
Farmers

Figures 8.1-8.5 ABCC values for different groups of farmers by region[49]



[49] Included are individuals aged 23-62 years. For the numbers of observations see Table 12. Sources: see Table 2.