Essays in Anthropometric History and Human Capital Development in the Muslim World

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ABBREVIATIONS

Adj. R sq.	Adjusted R-square
AR(1)	Autoregressive Model (of order 1)
BSL	Biological Standard of Living
CWR	Child-woman ratio
DHS	Demographic and Health surveys
FE	Fixed effects
GDP	Gross domestic product
GLS	Generalized Least Squares
GNP	Gross national product
HAZ	Height-for-age z-score
IFLS	Indonesian Family Life Survey
IV	Instrumental variable
Kcal	Kilokalorie
N	Number of observations
OECD	Organization for Economic Cooperation and Development
OLS	Ordinary least squares
OPEC	Organization of the Petroleum Exporting Countries
Q-Q trade-off	Quality-Quantity trade-off
RE	Random effects
SD	Standard deviation
2SLS	Two-stage least-squares generalization
WWII	Second World War
WLS	Weighted Least Square Regressions

Country abbreviations according to DIN ISO 3166

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1. General Introduction

> "Is there some action a government of India could take that would lead the Indian economy to grow like Indonesia's or Egypt's? If so, what exactly? If not, what is it about the "nature of India" that makes it so? The consequences for human welfare involved in questions like these are simply staggering: once one starts to think about them, it is hard to think about anything else."
>
> Robert Lucas (1988)

1.1 Research Questions

Major events in the Muslim world and the Middle East[1] have produced ambivalent attitudes toward the region. Substantial proportions of the populations of European countries are concerned about these developments and an overwhelming number of individuals believe that the upheaval will result in a lasting improvement in the living conditions of the population (Flash Euro barometer).

How did the standard of living develop in the Middle East over the past two centuries? When did the Western world become clearly better off in terms of income, health and education? How did the Biological Standard of Living develop in Indonesia during the colonial period? Did this standard of living increase substantially after decolonization? Did oil increase the stature of oil producing countries? How did human capital develop in Iran and Iraq in the early 20th Century? Was there a Quality-Quantity Trade-Off? These questions cannot be easily answered,

[1] Throughout this thesis, the Middle East corresponds largely to the World Bank's definition. According to the World Bank's definition, most of the region is classified as middle income countries with the exception of the small, oil rich countries of Kuwait, Qatar and the United Arab Emirates, which are classified as high income, and Yemen, which is classified as a low income country.

despite the substantially increased interest in this region in recent years. But the anthropometric histories of Islamic countries have received limited academic attention. Height studies can provide insights on socioeconomic conditions in these countries. Furthermore, comparing Islamic countries with other regions of the world highlights several sources of controversy.

My aim in this dissertation is to investigate particular aspect of human welfare for several Islamic countries, focusing on socioeconomic and anthropometric indicators. Moreover, this thesis attempts to document the long-term development – from the late eighteenth century - of nutritional status in several Islamic countries in the Middle East and in Indonesia, which has the largest Muslim population in the world. In sum, I have compiled height information and other socioeconomic indicators for this region to conduct econometric and statistical analysis. The chapters of this thesis address particular countries and reference a variety of sources. The specific data sources used in this thesis are discussed and described in their respective chapters. The data are primarily obtained from anthropometric studies, socioeconomic and demographic surveys and censuses at the regional and country levels.

However, surveying the entire Muslim world or describing all of its features is not the aim of this thesis; indeed, such endeavors would not be possible. I simply aim to highlight particular areas that are worthy of investigation.

1.2 Anthropometric history – Stature as a human welfare indicator

Anthropometric history has generated new insights on secular trends in several regions for which other economic data are widely available and for regions with limited information. Most of the studies in the literature focus on the United States and Western Europe (Steckel 2009). The long-term growth of an economy is determined by the nutritional status of the population due to the increasing ability to participate in the labor market. Measuring and tracking progress in the standard of living is an important undertaking but is difficult given the various dimensions of human well being. The average height of a population is influenced by the interactions between nutrition, disease exposure, work conditions and physical environment (Floud et al. 2011). Height information can be used to reveal important long-term aspects of human welfare, health and inequality (Baten 1999, 2006, 2009; Baten and Stegl 2009, Baten and Blum 2012, Floud et al. 2011; Komlos and Baten 1998, Komlos et al. 2003, Steckel 1995, 2009). Furthermore, several studies on developing countries have connected socioeconomic conditions such as maternal education, income, schooling and political oppression with changes in population height (Steckel 2009).

The term 'nutritional status'[2] or 'Biological Standard of Living'[3] which are at the center of this dissertation – shown by the mean heights - capture the energy intake necessary for growth, less the energy demands of bodily maintenance, resistance to disease and work (Floud et al. 2011, Komlos and Baten 1998). Therefore, the primary types of evidence for nutritional status - height and weight - are net measures and primarily reflect living conditions during adolescence. In sum, the nutritional status concept takes its place within the set of possible measures of living standard (Floud et al. 2011). In comparison, income per capita is an output measure that has frequently been criticized for failing to reflect the contributions of unpaid employment, the value of leisure time, improvements in the quality of goods and services and ultimately changes in health and mortality (Floud 2011, Steckel 1997, Baten1999, Komlos 1998). Despite these problems, presenting these two measures of living standards as being mutually exclusive is misleading as each represents a different set of characteristics. However, depending on the research question, both indicators can capture relevant aspects of the society and economy (Floud et al. 2011).

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[2] The „nutritional status" concept takes its place within the set of possible measures on living standard (Floud et al. 2011).
[3] This term was firstly used by Komlos (1985). The concept conceived to capture biologically relevant quality of live, components like nutritional status, health and longevity.

1.3 Economic development in Middle East and Islamic countries

Recent improvements in economic data availability have triggered research that is focused on geographic patterns, trends and policy questions in Middle Eastern Islamic countries (Issawi 1996, Owen and Pamuk 1998, Pamuk 2006, Bakhtiari and Meisami, 2010). An historical analysis of the very different economies that exist in the Muslim world is hampered by of the dearth of available data and because changes in the economies are difficult to discern (Pamuk 2006). For example, the gradual acceleration of changes in agriculture, transportation, finance, consumption patterns, the household decision-making processes underlying these trends and finally the political structures require separate examinations. Despite widespread research interest, a comprehensive and overlapping investigation of all of these issues is out of reach; hence, the goal of this thesis and the next section is limited to particular economic aspects of the standard of living.

In the two centuries after 1820, the GDP per capita (1990 PPP dollars) of the Middle Eastern population grew from \$ 611 in 1820 to \$ 1,023 in 1913 to \$ 5,023 in 2000. For the U.S and Western Europe, GDP per capita grew from \$ 1,246 in 1820 to \$ 4,172 in 1913 to \$ 23,680 in 2000. Comparing these regions from an economic perspective highlights the core issue: long-run growth in the Middle East was low (Pamuk 2006 Table 1)[4].

However, the Middle East experienced a substantial increase in GDP per capita from 1950 to 1970. This period of economic growth improved many social indicators over the following decades. Declining infant mortality rates and increased life expectancy are among others,

[4] The GDP per capita estimates are in 1990 Geary-Khamis purchasing power parity international dollars. Using PPPs instead of market exchange rates makes it possible to compare the output of economies in real terms, which means that differences in the price levels are controlled. The differences between the GDP per capita shown in Table 1 and Pamuk GPD are compounded by the using of the market exchange rates. (Pamuk 2006, The International Comparison Project http://siteresources.worldbank.org/ICPEXT/Resources/ICP_2011.html).

explanations for population growth in the region. The rate of population growth was greater than that of OECD countries, with annual growth estimated at 1.97 percent in 2010 (see Table 1). Thus, the Middle East had the highest fertility rate in the world until the 1970s (Yousef 2004). A pronounced decline in fertility in several Muslim countries was observable in the late 1980s. Improvements in education and health, rising unemployment and high cost of marriage[5] seem to have caused the reduction in fertility (Yousef 2004, Singerman and Ibrahim 2001).

Education is a major driver of social changes. Despite impressive economic growth in the decades following World War II, full enrolment in elementary schools was only achieved near the end of the twentieth century in many Islamic countries. For example, Iran's 1911 Education Law made elementary education compulsory for all Iranians. However, significant improvements in enrolment rates were only achieved near the end of the twentieth century. Compulsory primary education in Iraq was enacted in 1958, but widespread implementation was not reached until 1970. Turkey passed an education law in 1924 that made significant changes to the structure of the educational system, mainly because of the shift from the Arabic to the Latin alphabet (Griffin 2006). According to the World Development Indicators, full enrolment in primary education was achieved in Turkey in 2000.

Another issue that is central to economic modernization is the distribution of land. From the 1940s to the 1970s, several Middle Eastern economies implemented agrarian land reform programs as components of their development policies. Land reform was regarded as a necessary precondition for diverse economic development in the decades after the 1950s (Najmabadi 1987). For example, to transform Iran from an agricultural to a more diversified economy, the Land reform Law of 1962 limited the size of land holdings. Land reform programs in Iran and Iraq played an important role in human capital formation (see section five). Nevertheless, the overall

[5] The main basic components of the costs are: housing furniture, dower and celebration (Singerman 2007).

effects of these social transformation programs are difficult to appraise (Yousef 2004). Hence in particular for the many Middle Eastern countries, the effect of the distribution of land should be the subject of further research.

In general, countries in the Muslim world have witnessed several cycles of growth and decay. Many economic aspects received huge attention in last years. But in sum, the heterogeneous situation in the Muslim world is still under researched.

1.4 The outline of this dissertation project

Theses projects addresses fundamental question in anthropometric history and the discussion of the economic growth and may help to enlarge our understanding of standard of living. The thesis comprises four sections that are intended for separate publication. Two of these sections are co-authored. Each of the manuscripts represents a single chapter. The ultimate product of this thesis is a series of research papers describing the long-run development of height and relating the economic implications of oil production to the changes in height. Finally, the project presents evidence on the Quality-Quantity trade-off in Iran and Iraq.

The collection began with an article published in the journal Exploration in Economic History in 2009. This article provides height trends for eight Middle Eastern countries from 1850-1910. This section highlights some of the differences in height development in the Muslim world.

The second section of the thesis examines anthropometric data for Indonesia, which has the largest Muslim population in the world. We found three distinct phases in the long-run trend in Indonesian mean heights. The first phase involved a significant decline in 1870s, the second involved a modest increase over the next three decades and the third phase involved accelerating height growth after World War II.

The third section of the thesis emphasizes particular resource related aspects. Natural resource revenues increase wealth and purchasing power; hence, an abundance of resources may be expected to raise an economy's investment, growth rates and standard of living. Much of the debate surrounding the dismal economic position of Middle Eastern countries has focused on oil production. This chapter devotes particular attention to the oil producing countries of the Middle East and their height development.

The fifth section of this thesis analyzes human capital formation in Iran and Iraq and the origins of reduced fertility. Quality-Quantity trade-off processes capture important aspects of human welfare and economic growth. Changes in demographic patterns imply that parents select a quantity of children to optimize their quality (Becker, Tamura and Murphy 1990). To illuminate the endogenous factors of child quantity and quality, an instrumental variable (IV) approach is used in this section.

Section six, the last chapter in this thesis, summarizes the main findings.

References

Bakhtiari S., Meisami ,H., (2010),"An empirical investigation of the effects of health and education on income distribution and poverty in Islamic countries", International Journal of Social Economics, 37 (4) pp. 293 – 301.

Baten, J., (1999). Ernaehrung und wirtschaftliche Entwicklung in Bayern 1730-1880. Stuttgart: Steiner.

Baten, J., (2006). Global Height Trends in Industrial and Developing Countries, 1810-1984: An Overview. Tuebingen Working Paper.

Baten, J. (2009). Protein supply and nutritional status in nineteenth century Bavaria, Prussia and France. Econ.Hum. Biol. Volume 7, (2) pp. 165–180.

Baten, J., Stegl, M. (2009). Tall and Shrinking Muslims, Short and Growing Europeans: The Long Run Welfare Development of the Middle East, 1850-1980 in Explorations in Economic History 46, pp. 132-148.

Baten, J., Blum, M. (2012) Growing Taller, but Unequal: Biological Well-Being in World Regions and Its Determinants, 1810-1989, with Matthias Blum, Economic History of Developing Regions (forthcoming 2012).

Becker G.S., Murphy K.M., Tamura R.(1990). Human capital, fertility, and economic growth - Journal of Political Economy, 98, (5): 12-37.

Floud, R., Wachter, K., Gregory, A., (1990). Height, Health and History. Cambridge University Press.

Floud, R., Fogel, Robert W., Harris, B., and Hong; S. C. (2011) 'Health, Nutrition, and Human Development in the Western World Since 1700'. (Cambridge University Press).

Griffin, R. (Ed.) (2006). Education in the Muslim World: Different Perspectives.

Symposium Books. (Cambridge University Press).

Issawi, C., 1995. The Middle East Economy: Decline and Recovery. Princeton: Markus Wiener.

Komlos, John (1985). Stature and Nutrition in the Habsburg Monarchy: The Standard of Living and Economic Development in the Eighteenth Century, *American Historical Review* 90 (5), 1149-61.

Komlos, J., Baten, J. eds. (1998). The Biological Standard of Living in Comparative Perspective. Stuttgart: Franz Steiner Verlag.

Komlos, J., Hau, M., and Bourguinat, N. (2003). The Anthropometric History of Early-Modern France. Europ. Rev. Econ. Hist. 7,2, 159-190.

Lucas R. E. (1988). On The Mechanics of Economic Development. Journal of Monetary Economics 22 (1988) 3-42.

Najmabadi, A. (1987). Land Reform and Social Change in Iran. University of Utah Press Salt Lake City.

Owen, R., Pamuk S., (1999). A history of Middle East economies in the twentieth century. Cambridge, MA: Haverd University Press.

Pamuk, S. (2006). Estimating Economic Growth in the Middle East since 1820. The Journal of Economic History, 66 No. 3 pp. 809-828.

Singerman, D. and brahim B. (2001). The Cost of Marriage in Egypt: A Hidden Variable in the New Arab Demography and Poverty Research. Special Edition on “The New Arab Family,” Nick Hopkins. ed., Cairo Papers in the Social Sciences, 24 (Spring): 80-116.

Singerman, D. (2007). The Economic Imperatives of Marriage: Emerging Practices and Identities among Youth in the Middle East. Wolfensohn Center for Development Dubai School of Government working Paper.

Steckel, R. H., (1995). Stature and the Standard of Living, Journal of Economic Literature, 33 (4), pp. 1903-1940

Steckel, R. H., (2009). Height and human welfare: Recent development and new directions. Explorations in Economic History 46 (1), pp. 1-23.

Yousef, T. M., (2004. Development, Growth and Policy Reform in the Middle East and North Africa since 950. Journal of Economic Perpective. 18 (3), pp. 91-116.

Tables

Table 1: World Development Indicators

Country Name	Indicator Name	1960	1970	1980	1990	2000	2010
Middle East & North Africa (all income levels)	Adjusted net enrollment rate, primary (% of primary school age children)		60	73	82	86	94
Middle East & North Africa (all income levels)	School enrollment, primary (% gross)		72	86	94	98	104
Middle East & North Africa (all income levels)	GDP per capita, PPP (constant 2005 international $)			7217	6362	7605	9491
Middle East & North Africa (all income levels)	Life expectancy at birth, total (years)	46	53	58	65	70	72
Middle East & North Africa (all income levels)	Mortality rate, infant (per 1,000 live births)	171	129	84	51	36	25
Middle East & North Africa (all income levels)	Fertility rate, total (births per woman)	7	7	6	5	3	3
OECD members	Adjusted net enrollment rate, primary (% of primary school age children)		89	95	97	98	98
OECD members	School enrollment, primary (% gross)		100	105	105	103	105
OECD members	GDP per capita, PPP (constant 2005 international $)			18012	22660	27421	30036
OECD members	Life expectancy at birth, total (years)	67	69	72	75	77	79
OECD members	Mortality rate, infant (per 1,000 live births)	56	40	27	17	11	7
OECD members	Fertility rate, total (births per woman)	3	3	2	2	2	2
High income: OECD	Adjusted net enrollment rate, primary (% of primary school age children)		91	95	97	98	98
High income: OECD	School enrollment, primary (% gross)		100	102	103	102	103
High income: OECD	GDP per capita, PPP (constant 2005 international $)			19411	24920	30428	33448
High income: OECD	Life expectancy at birth, total (years)	69	71	73	76	78	80
High income: OECD	Mortality rate, infant (per 1,000 live births)	36	22	13	8	6	5
High income: OECD	Fertility rate, total (births per woman)	3	2	2	2	2	2

Source: World Development Indicators, 2011

2. Tall and Shrinking Muslims, Short and Growing Europeans: The Long-Run Welfare Development of the Middle East, 1850-1980

Abstract

In this study we examine anthropometric data for eight countries in the Middle East for the period 1850-1910, and we follow those countries until the 1980s.The Middle East had a relatively good position during the mid-19th century, if human stature or real wages are considered, but much less so in terms of GDP per capita. Initially low population densities allowed better anthropometric outcomes. The height advantage was due, among other factors, to easier access to animal products. All indicators suggest that the Middle East lost ground after the 1870s relative to the industrializing Countries.

This chapter is based on a paper written jointly with Joerg Baten (University of Tuebingen). It is published by Explorations in Economic History 46 (1) pp. 132-148. The concept of the paper was developed jointly, analyzes and writing equally shared.

2.1 Introduction

Anthropometric history is a well established method to measure biological aspects of the standard of living. Human stature is determined by the quality of nutrition, minus claims for disease environment and workload during childhood, and those were the major determinants of health and life expectancy in the poor economies of the past. Countries in many continents have been studied with anthropometric methods, including, for example, India, China, Argentina, the United States and certainly many European countries (see also Komlos 1985, Steckel 1995, Steckel and Floud 1997). However, one world region not studied by modern anthropometric historians is the Middle East. A key reason might be that heights were typically not measured by the Ottoman army or in prisons. However, a number of anthropologists measured heights in the Middle East after the late nineteenth century, and although those sources of anthropometric information provide a number of methodological challenges, we use them in the following to reconstruct human stature levels in the Middle East 1850-1910. With those height records, we can study the countries of Turkey, Iraq, Iran, Egypt, Syria, Lebanon, Palestine/Israel, and Yemen[6].

Was the nutritional situation different in the Middle East, compared to, say, Europe? Would we expect a different level or other developments than in Europe? One difference was certainly the much lower population density in the eight Middle Eastern countries (Table 1)[7]. Previous anthropometric research found that populations in sparsely populated countries often enjoyed "advantages of proximity" to animal husbandry, as a substantial proportion lived in regions specialized in this agricultural activity. Those people were taller than other populations in a situation in which some protein-rich, but less highly valued products of animal farming (offal

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[6] We will refer to these countries when we write "Middle East" in the following (please note that the Arabian Peninsula is not covered, except for Yemen).

[7] In the Table, population per arable land refers to the number of people relative to land which can be used for agriculture, i.e. excluding deserts, mountains, and other wasteland.

and milk, for example) could not be shipped at sufficiently low cost (Komlos 1996, Baten and Murray 2000). Based on those previous results, we would expect initially taller heights in the Middle Eastern countries, compared to Europe, because those Europeans who lived in industrial cities sometimes had higher purchasing power of tradable goods, but did not have these proximity advantages. Moreover, the Western urban populations still suffered from "urban penalties" of bad disease environment and hygiene in this period (see, for example, Szreter and Mooney 1998). In the Middle East in contrast, substantial parts of the population lived as Bedouins, who might have initially benefited from those proximity advantages. Low population densities also allowed a benign disease environment in the Middle East of the mid-nineteenth century.

The increase in heights in Europe from the late nineteenth century was so impressive as to suggest a possible reversal of the earlier Middle Eastern height advantage. European urban industrial populations could increasingly buy cheap proteins and benefited from improving disease environments during the twentieth century. Based on this comparison, the present study also increases our understanding of European welfare development. We will assess in the following when the Western industrializing countries started to overtake the Middle Eastern populations, which were lacking sufficient growth and development (Pamuk 2006, Issawi 1995). In particular, we will test the hypothesis that some Middle Eastern populations were taller than Europeans in the mid-nineteenth century, using British, German, Czech, and Italian samples for comparison, and whether this difference disappeared after the late nineteenth century.

In the final part of this study, we contrast heights and purchasing-power oriented welfare measures. How do our height estimates differ conceptually from estimates of real wages and GDP? The strength of GDP per capita is, of course, its comprehensive account of purchasing power and its comparability over time if given in standardized monetary units (such as the 1990

Geary-Khamis dollars). One of the disadvantages of GDP as a welfare measure is its bias against subsistence farming and production within the household. In general, non-traded goods and goods produced and consumed within households are often underreported. Moreover, other forms of informal markets, such as black markets, can often not be captured. Finally, the data requirements for GDP estimates are very large. In contrast, real wages have a better reputation in terms of data quality for long-run studies, as nominal wages and prices were recorded by contemporaries (whereas GDP relies on estimates produced by later generations). From studying real wages, however, we cannot learn about the return to land, capital, or perhaps the return to the exploitative activities of the rulers. Moreover, typical pre-modern subsistence goods or less standardized goods such as housing are again difficult to include in the consumer basket, as those who created the written sources of the past did generally not provide sufficiently detailed information. Finally, both GDP and real wages concentrate on purchasing power and do not include other "biological" living standard components such as health, longevity, and the quality of nutrition, which is the strength of anthropometric techniques (Margo and Steckel 1983). Height studies have the additional advantage of covering many groups of society.

In the next section, we will discuss the main data sources. In section 3, we report regional differences of height in countries on which we have sufficient information, and present a map for Turkey (Figure 1). Section 4 gives an overview of height levels in the Middle East and the economic background, while section 5 discusses differences between the Middle East and the industrializing countries between the 1850s and 1910s. Subsequently, we compare GDP per capita, real wages, and height estimates in section 6. Section 7 concludes the paper.

2.2 Data and Representativeness

Samples from military and prison samples have allowed scholars to study the anthropometric history of numerous countries in the world. Unfortunately, for the Middle East, military records are not available. Our research in the Ottoman Archive in Istanbul showed that anthropometric measurements in the Ottoman army were only reported as "tall", "middle", and "short", without clear definition of those categories. Another frequently used source of height records are prison measurements, but those were only exceptionally recorded for the Middle East by Western anthropologists. If available, we included those in our sample. But overall, most of our height information on the Middle East stems from anthropological studies. During the late nineteenth and early twentieth century many European and American anthropologists went to the Middle East in order to study the physical characteristics of the local population. We could find some of the resulting measurements of height as individual height data, for example in the archives of the British Anthropological Collection. Sometimes anthropologists also published their individual data (for example, Chantre 1895 and Field 1956, see Table 2). However, this (ideal) individual data accounted only for 1,476 observations in total. Another way presenting data in the anthropological studies was to organize height data aggregated by 10-year age groups. This information can also be analyzed without major methodological problems, as long as the samples were drawn representatively for the underlying population, like Inan (1939) did for 28,992 Turkish heights. Finally, the third type is height averages for which we can only reconstruct the birth decade in which most individuals were born. We will explain in section 4 below how we incorporated this type of data.

In the following, we will discuss in detail those cases where we can compare the height development based on individual cases on the one side, and grouped cases on the other, for example for Egypt and Turkey. Including the grouped data, the total number of underlying cases was 47,797, after discarding height and age extremes (in the following, we will only use ages 20-

50, with the one exception of Turkey where we also used the 50-59 year-olds, as this age range was reported in one aggregated group, see below)[8]. We concentrate on male heights only in this study, as the aim will be to compare them to heights in the industrializing countries in the nineteenth century, which are almost exclusively male (due to the predominant data generating institutions being the military, prisons, and so forth).

To what degree is our data set representative? Are the economic sectors represented by similar shares in our samples as in the overall population? The Inan (1939) dataset, which accounts for 28,992 underlying observations (or some 60 percent of our data), was representatively drawn from the Turkish population, also with respect to occupation (Inan 1939, p. 62). Inan (1939, p. 56-58) describes in great detail how he in cooperation with the Turkish Statistical Office made sure that adequate numbers of measurements were performed in each individual district. Without the direct support of Atatürk and his influence with the Turkish authorities, these large-scale measurement activites could not have been realized. Hence, for this part of our dataset, we do not expect strong selectivity biases. For our individual samples, we have occupations recorded for a smaller subset, namely 445 out of our 1,476 individual observations, of which 71 percent were engaged in the agricultural sector. For those we can compare the occupational composition with the overall population. Given Issawi's (1982, p.118) estimate that about four fifths of the Middle Eastern population were engaged in occupations related to agriculture, our best guess is that our sample might include a slightly lower share of rural people relative to the overall population. The rural population might have enjoyed a better nutritional status because of easier access to food and lacking market integration, and might thus

[8] We excluded extreme heights above 185 and below 140. When the measurement year was not reported, we assumed it to be the publication date of the survey minus three years. This increases the measurement errors – but concerns only 0.75 percent of our sample. Our robustness tests suggested that the impact is marginal and that the broad trends are unaffected. We also tested different criteria for the exclusion of outliers and found the results consistent with our findings.

have been relatively tall on average, but the difference between "four fifths" and 71 percent is not a very large difference.

Were there unrepresentative subgroups or regional biases in the dataset? Among the grouped samples, most of them were drawn randomly for a certain region of a country, hence we will need to control for regional composition in the following. Sometimes the anthropologists were particularly interested in desert tribes or in the Jewish part of the population. That is why we need to look out for those characteristics. All of the height measurements were taken within the country of origin. We excluded all migrants, with the one exception of 23 Yemenite Jews, who were measured in Israel. We included those 23 cases to fill the gap in the 1880s[9]. Those will deserve special attention in the following and will be controlled for using a dummy variable, even if they account only for a negligible 0.05% of our sample. Another group with potential social bias is prisoners. For Egypt, Craig (1911) collected height data of criminals in Cairo in 1905[10]. He argued that the anthropometric information is representative for the underlying Egyptian population because of the relatively broad social spectrum of Egyptian prisoners. He argued that the elite groups within the Egyptian society, the wealthy merchant strata of Alexandria and similar cities, were not represented in this prison sample, but given that most had foreign origins, he did not consider them a part of the Egyptian people anyway. We have some doubts about his arguments. It might well be that the sample was slightly biased towards the lower income groups of Egypt, compared with the samples taken by anthropologists, who aimed at representative data collection. However, in the following paragraph we will find that the Egyptian samples were probably not downward biased in terms of numeracy, which would support Craig's hypothesis.

[9] Otherwise the 1880s would have been dropped for not reaching the minimum inclusion number of 30 height observations.
[10] Our Egyptian data stem from five different sources: Ammar (1944), Chantre (1904), Craig (1911), Field (1952a).

Apart from those social groups, no other special subgroups were recorded in our data. But we certainly need to control for regional composition, religion, age, and migrant status below.

One strategy to assess the representativeness of historical samples is to compare the age heaping behaviour in the sample and in the underlying Mid-Eastern population. The idea of an age heaping analysis is that people who are not able or willing to state their exact age often report an age rounded to multiples of five, and those persons are typically less educated than people who report their age exactly (Baten et al. 2008). Age heaping indices such as the "Whipple Index" tend to be strongly negatively correlated with other human capital indicators such as literacy, and even stronger – in modern times – with measures of mathematical skills (as reported in the PISA survey, see A'Hearn et al. 2006). Normally those indices require large individual samples of 500 or more persons reporting their age, which we do not have for each birth cohort and country (Table 3). Nevertheless, on average the Whipple index of 309 for our individual samples is quite similar to corresponding census values of 281. The total number of our individuals with age statements is almost 600; hence this overall value is quite informative.[11] Even if sample sizes are probably too small, we also compared individual countries and birth cohorts with at least 30 observations for which matching census data could be obtained. In some cases, the Whipple index is slightly higher for our samples (such as Iraq and Iran), and the samples of Turkey and Egypt in 1850 and 1870 have lower index values than apparent in the representative census data. But on average the difference is quite modest, especially when compared to the large differences of Whipple indices in the world, reported on the bottom of the table. We should note the possibility that assuming a negative correlation between Whipple indices and heights, our Iraq and Iran estimates might be slightly overestimated, and the Egyptian

[11] We cannot use all our individual observations, as not for all countries and birth decades corresponding census data is available

and Turkish estimates slightly underestimated, although the individual country differences might also be influenced by small sample size. We conclude that the average Middle Eastern level seems quite representative for the underlying population.

To sum up, we find that the dataset is broadly representative for the underlying population.[12] The large share of the agricultural population is reflected in the dataset. While a small number of special subgroups is contained in our sample, these can be controlled for with dummy variables. Last but not least, the age heaping analysis suggests that our samples were overall quite representative in terms of human capital.

Which of the countries have larger numbers of cases overall, and for individual and grouped height figures? With 687 observations Iraq has the largest number among the individual samples (Table 4). The case numbers of the individual samples are relatively small in comparison with typical military and prison samples that have been used for Western anthropometric history. Among our grouped samples with more than 10 cases, the Turkish one is by far the largest, being based on almost 29,000 observations between the 1880s and 1910s.

The second-best documented country among the grouped cases is Egypt, again for the early cohorts from the 1850s, and the 1870s birth cohort is particularly well-documented. The grouped rates for Egypt concentrate on earlier birth decades. In Iraq we have numbers for the later cohorts based on both individual and grouped cases. The other countries' (Iran, Palestine, Lebanon, Syria, Yemen) grouped samples are concentrated in the 1850s and 1860s, allowing at least a first impression of the height levels in those countries in the 19th century.

We now study the two best-documented countries separately, Turkey and Egypt, in order to assess the measurement quality of those two samples. In particular, we consider the question as

[12] This reflects the efforts of many anthropologists who studied Mid-Eastern populations and attached great importance to a representative social mix of their data (for example, Craig 1911, p. 67 states that "it may be concluded, that the statistics are representative of the Egyptian and Nubian races with their local variations.").

to whether subsets of the available heights show similar height developments.[13] It turns out that there was very little trend for the grouped Turkish sample (Figure 2). The 1880s birth cohort might be slightly underestimated due to shrinking -- perhaps by 0.98 cm, as the Sorkin et al. (1999) analysis showed. [14] On the other hand, selective mortality counteracts this bias, as taller individuals tend to be healthier and hence more likely to survive up to this age. The youngest birth cohort might contain some individuals who did not yet reach their final adult height; hence this value might be underestimated. Given that the number of cases is quite small, not too much importance should be attached to the slightly taller individual data points before the 1870s. Only the 1860s have 63 cases and might allow a substantive height estimate. Moreover, the similar values of those born in the 1850s and 1870s might improve the credibility of the 1860s height level.[15] In conclusion, the level of the small individual Turkish height samples (1870s and before) and the large aggregated samples (1880s and thereafter) was relatively similar.

Egypt is another large country in the region, which is relatively well-documented in our sample. We can, for example, compare one well-documented individual province with the overall Egyptian development. This avoids any risk that a development over time might be caused by adding different regions for different birth cohorts and then arriving at a misleading impression of development over time. We did this for best documented province in Egypt, Sharqia (see appendix Table available from the authors). We found that the trend in this province was very

[13] The grouped Turkish heights were recorded in 1937 and refer to those aged 20-24 (i.e. born 1913-17), those aged 25-29, 30-39, 40-49, and 50-59. The latter persons were mostly born in the 1880s, although a smaller share was also born in the 1870s. We assigned birth decades by taking the one during which the majority was born. Hence, one drawback that needs to be mentioned is the imprecision of birth cohorts for Turkey.
[14] Sorkin et.al. (1999) estimate the effect for North Americans in 1980 to be 0.98 cm for the age group 50-59.
[15] The individual cases reflect mostly Erzurum-Kars province (with a share of 43 percent), and five other provinces with smaller shares. The map of Turkish heights for the birth cohorts of the 1880s-1910s shows that this region (Erzurum-Kars) had about average heights (Figure 1). Hence, the height of the first Turkish birth cohorts are unlikely to have a strong regional bias.

similar to the overall trend, hence suggesting that the movement of the time series was not caused by pooling heterogeneous regions.

Now, we could continue and go through all the countries and different samples individually, but this would take too much space. Instead, we consider the average heights jointly, and turn to consider the raw heights first (Table 5). We find that those raw heights were relatively similar across Middle-Eastern countries (for example those of the birth decade of the 1850s), except Yemen that had substantially lower average anthropometric values. The trend over time of those countries with sufficient data seems relatively stable. However, during the 1880s there was apparently a temporary decline of heights in the Middle East, which is supported by data on Egypt, Iran, and Turkey. Before comparing those raw results with the results of regression analyses, we will first consider potential regional differences.

2.3 Regional height differences

Regional differences of living standards were quite substantial in other countries of the world (on the U.S., see, for example, Margo and Steckel 1983). In order to ascertain spatial variations in the levels and trends in physical stature for the Middle Eastern countries, we estimate heights at the regional level. This will also prove useful in the following trend regressions, which will include control variable for regional differences. A detailed analysis of the determinants of spatial height differences remains a subject of future research though.

2.3.1 Iraq

Reasonably good regional information is available for Iraq. The north and northeast of Iraq are mountainous and most inhabitants are Kurdish. The regions around Mosul (Ninawa) are treeless uplands and highly dependent on irrigation from smaller rivers and rivulets. The central districts of Baghdad, Babil, and Karbala are hot flatlands. Crop cultivation was only possible by using irrigation systems. At the onset of the eighteenth century, systematic cultivation was established and controlled by Ottoman garrisons, in particular around Basra, Diyala, Arbil, and Mosul. The rest of Iraq was inhabited by tribal groups (*dira*[16]) who were self-sustaining and only under limited control by the government in Istanbul. Having large areas at their disposal, the tribesmen made use of shifting cultivation and stock-breeding (Issawi 1966, p. 129f.). The cattle herding tribesmen consumed relatively large quantities of milk, meat, and offal. In contrast, the settled inhabitants in the cities and agricultural areas relied more on starches and proteins from vegetables. Moreover, they eventually suffered from insufficient rainfalls and the devastating annual flood of the Tigris and Euphrates (Issawi 1988, p.105). In Iraq, there is a height advantage for the population living in deserts (Table 6). Those desert inhabitants were on average 0.85 cm taller than the urban dwellers in large cities such as Baghdad or Basra. Desert populations had an even stronger height advantage over Iraqis from other rural regions, such as the irrigated land along the Tigris and Euphrates rivers. Hence, it will be important to pay attention to desert regions in the following regressions. In a separate WLS regression analysis of height we found that rural inhabitants not living in the desert were 1.25 cm shorter than desert inhabitants (significant at the 0.01 level, see appendix available from the authors) after controlling for birth periods and other variables, whereas urban dwellers were 0.46 cm shorter, but not statistically significant. Over time, the share of nomadic Iraqis in the total population fell considerably, as population increased, from 35 percent in 1867 to 5 percent in 1947 (Issawi 1966, p. 158). This would support the hypthesis that initially low population densities allowed better anthropometric levels, and that this height advantage was partly due to easier access to animal products.

[16] The *dira* is the area claimed by the tribe (Issawi 1995 p. 163).

2.3.2 Turkey

For Turkey, heights were reported by ten regions (Figure 1). Unfortunately, Inan (1939) also included very old Turks born in the 1850s to 1870s, for whose shrinking bias he did not adjust in his regional averages.[17] Therefore the height levels for the regions are downward biased. Hence we do not consider the regional height levels, but only the ranking between the regions, assuming that the share of old people was more or less equal across regions. The shortest populations were from the Dardanelles in the northwest of Turkey and the Aegeis, whereas the tallest Turks could be found in central Anatolia. An important part in the economic life of Turkey was livestock breeding. This was done mainly by nomads outside of the cultivated areas. Issawi (1980, p. 270) analyzed tax returns and reported that animal husbandry was prevalent primarily in the relatively dry inland while it did not figure as a common occupation in the moist coastal regions. Stock-breeding was also widespread in the European provinces of Turkey, but per capita values were not as high. Issawi (1980, p. 8) reported that the Turkish peasants of the nineteenth century ate meat very rarely, whereas milk was available in considerable quantities. While Turkey did not have as strong a desert advantage as Iraq, a similar pattern emerges for the dry inland region of central Anatolia, which had high anthropometric values, low population density, and quite a strong nomadic element.

2.3.3 Egypt

The third of the large countries for which we can document regional inequality is Egypt. Because of Egypt's aridity, most of the population lived along the Nile valley and delta. For

[17] It is an average of both adult height and the height of persons who had already started to shrink.

agriculture, irrigation is a necessary precondition. Only the northern coast has sufficient rainfall, which might have made life somewhat easier in this region – heights were greatest in the coastal regions of Egypt (Table 6). Egypt again had a height advantage for its desert population over the urban population, although the coastal population was even taller than the desert inhabitants in this case ("other rural" being equal). Some coastal and river delta inhabitants might have benefitted from the strategy that provided a substitute for drinking water during the inundation months of the Nile: In Cairo and perhaps other cities of this region, cow milk was consumed in quite large quantities, substituting unavailable water during this period (Kuhnke 1990, p. 25). In a similar WLS regression analysis as for Iraq, we included birth decade, age, religion, and regional dummy variables (see appendix available from the authors). The constant refers to the desert population. Urban dwellers were 1.04 cm shorter than desert inhabitants (significant at the 0.01 level) after controlling for birth periods and other variables.

2.4 Height development in Middle Eastern countries 1850-1910

We will incorporate our findings from the spatial pattern analysis into our national trend analysis. Controlling for age, region, migration, and religion in a regression, we pool all height data and assign dummy variables to each country and birth cohort (Table 7, Col. 1).

When studying height trends, one frequent problem regarding anthropological surveys is the paucity of the information given on birth cohorts, as many anthropologists of the late nineteenth and early twentieth century assumed no change in height over time. Hence, we had to find out when most of the measured individuals were born, and we had to accept the fact that a smaller part of the measured individuals was born before or after the most strongly represented birth decade. The time trend which results from these estimated birth cohorts resembles moving averages insofar as it smoothes the height development. For example, if there was a height decline in the 1880s but only 70 percent of the respective individuals were born in the 1880s and 30 percent in the 1870s, the decline would be smoothened. Koepke and Baten (2005, 2008) have suggested estimating these grouped and individual data jointly with Weighted Least Square Regressions (WLS). They applied this method to populations for which we otherwise do not have any way of studying their anthropometric development, given the data which are obtainable. For the Middle-Eastern, this scarcity of data is also clearly given. Hence, we will also apply WLS regression techniques for pooled individual and grouped data here as no large-scale individual height data from archival records can be expected for future research. We follow Dickens (1990) and weight each observation by the square root of its group size.

In the following regressions, we included an age dummy for those of age 20, as there might have been late adolescent growth at this age.[18] Since the human body is subject to a shrinking process at advanced ages, we restricted our sample to individuals who were not older than 50 (except for Turkey in the 1880s). We also inserted a control variable for the Jewish minority within those mostly Islamic countries. The reason for this could be different religious food consumption rules, or possibly occupational and education differences (and discrimination). Lastly, we pay attention to regional variation. The resulting time coefficients are reported in Table 7 and graphed for each country (Figure 3).

We also checked the distribution of height for normality (Figure 4); the overall height distribution appears normal, which confirms the validity of the estimation procedure. Heaping on round numbers is very mild, which might be caused by the fact that the height measurements of our sample were performed by well-qualified anthropologists. The first regression controls for age, regions, migrant and religious characteristics, the second only for migration and religion (Table 7, Col. 1 and 2). The third regression controls only for age (Col. 3). Apparently, those who

[18] Additional dummies for ages 21 and 22 were not significantly negative and hence they were excluded from the regressions.

reported age 20 were consistently shorter than older Mid-Easterners. This might be either caused by the fact that they were still growing at age 20, or that less educated persons reported a rounded age and came from lower strata families with shorter stature (or both). Among the regional dummies, the desert region variable is positive and significant, although the coefficient is not very large. Coastal and urban dwellers were not significantly different from the other rural population of the whole sample. The results for the country-decade dummies are not very sensitive to including or omitting the dummy variables for region, migrant and religion. Only the Iranian decline of the 1880s looks erroneously large if religion is ignored (many Iranian Jews were born during the decade), and the Yemenites of the 1880s would appear too tall without attention to migrant status. We graph the dummy variable coefficients of birth decade and country reported in Table 7, column 1, in Figure 3. In the Middle East, most populations tended to be fairly tall in the 1850s-1870s by 19th century standards, especially the Turkish, Iraqi, and Palestine/Israel population, whereas Yemenites were much shorter (Figure 3). This confirms the results we found by studying the raw height data. The development over time was mostly stagnant between the 1850s and 1910s.

What was the background for this stagnation of height in most countries? To take one relatively well-documented example, we will first describe the general economic history trends of Egypt, before comparing it with the anthropometric results. Under the reform policy of Muhammad Ali (1805-49) between the 1820s and the 1840s, Egypt's GDP rose (Issawi 1982, p. 104). However, we do not know whether this GDP growth was also translated into a height increase, as Ali accepted quite large costs for the population in pursuing his aims – for example, he required 12 percent of the population to serve in forced labor institutions, and 3 percent to serve terms of military conscription. Export activities and the corresponding profits were gained by a small group of foreigners (Issawi 1966, p. 359). However, Ali slightly improved the catastrophic educational situation in Egypt by creating new schools. For example, while less than 5 percent of Egyptians reported their exact age in the 1820s, this share had slightly risen to 15 percent by the 1860s – a value which was still much lower than that for Turkey with its 45 percent (Crayen and Baten 2008). He also improved the Public Health system dramatically, by introducing smallpox vaccination, for example, and by training former slaves as mid-wives (Kuhnke 1990, p.14, 123 and 132). Better perennial irrigation increased both agricultural production and cultivation area by a large amount. Yet due to the heavy burden of taxation, the situation of the peasant population did not ease; Issawi (1966, p. 377) reports that the Egyptians did not consume much meat in this period, which also might indicate a low standard of living. Nevertheless, GDP growth, Public Health progress, and marginal educational development might have prepared the ground for some welfare increase during the subsequent period of the 1860s (Figure 3). Between the 1850s and 1860s, Egyptian heights increased by 1.34 cm (Table 7). Moreover, in this period, the conscription burden declined and the Crimean war boom is reported as having had a beneficial effect even for the Egyptian peasants (Issawi 1982, p. 104). In the early 1860s, the cotton boom which resulted from a supply shortage during the American Civil war provided additional income for the Egyptian peasants, although it did not last long. Already in the late 1860s and especially in the 1870s prices for Egyptian products began to fall, and taxes rose (Issawi 1982, p. 105). Hence, it is not surprising that heights in Egypt declined in the 1870s. For Egypt, the decline during the 1880s might have been exaggerated due to small sample size, although the fact of a decline is supported by similar height decreases in the other countries (Figure 3). Iran also experienced a temporary height decline during the 1880s, whereas the decline in Turkey might partially be caused by changes of the sample and ageing effect (see section 2 above).

What might have caused the 1880s decline? At the current state of research, not much can be said about it. One potential candidate is the cattle plague, which wiped out 80-90% of the cattle in neighboring Ethiopia and Somalia (and consequently one third of the human population) during the late 1880s before it continued its way south to Africa (Barrett and Rossiter 1999). Ethiopia and Somalia are situated just to the South of Yemen, and it is likely that the cattle plague epidemic moving slowly from Central and East Asia to Africa had reduced Middle Eastern cattle stocks before coming to Africa, albeit with less severe mortality impact, as the epidemic had been around in Asia for centuries.

Nevertheless, the evidence on the causes of this temporary decline during the 1880s is not very conclusive. Cattle plague was always a relatively poorly documented epidemic, as it affected remote nomadic tribes the most and those typically left very few written records due to their illiteracy (Barrett and Rossiter 1999). The contribution of our study is rather to document that there was not an upward trend after the 1870s in the Middle East, when heights in Europe and the other industrializing countries started to grow continuously and substantially.

Iran also did not show improvements in physical stature. Gilbar (1986) argues that in Iran, the increasing cultivation of crops such as grain, opium, cotton, and fruits implied a structural development away from animal farming. However, given the similarity of stagnation tendencies in other countries, we would argue that the opium and cash crop trade might not have been the most important driving force. Moreover, Okazaki (1986) found that only a relatively small area was affected (on the opium trade, see also Hansen 2001).

Average anthropometric values were prevalent in Syria and Lebanon in the 1850s and 1860s. In general, purchasing power was relatively high in this economic core region of the Ottoman Empire (Issawi 1982, p. 106-7). Being one of the commercial centers of the Middle East, Lebanon developed a wealthy mercantile sector early on which demanded high quality food from the surrounding countryside and invested in the silk (and later fruit) exports from this region. This might have been one of the reasons for the relatively tall population in neighboring Palestine/Israel.

In contrast, the Yemenite population displayed catastrophically low anthropometric values. Since antiquity when Yemen was reportedly remarkably rich, population density was high and the economy specialized in spices, coffee, and other cash crops. One can speculate whether Yemen fell into a kind of Malthusian trap in the mid- to late nineteenth century, as conflicts did not allow the maintenance of the irrigation systems which would have been necessary for generating sufficient income for such a dense population. In the years around 1900, Yemen's territory was split into many small centers of power and its political situation was very instable due to tribal attacks against the Ottoman leadership in 1872. Those conflicts and other factors led to severe famines (Dresch 2000, p. 4).

2.5 An overall height trend of the Middle East

We now combine all country estimates into a Middle Eastern trend, weighted by population size and interpolated wherever necessary with the growth rate of height of a country with relatively robust height trend estimates (following Baten 2006). For the early half of the period, we used the Egyptian development to interpolate, and for the latter half we used the Turkish development, always using a real measurement for an individual country as a level benchmark (results in Figure 5). The levels are therefore relatively close to the true values. For the period after the 1910s, we join the trend estimates of Baten (2006) which are mainly based on the Demographic and Health surveys (DHS) for the Middle East, as well as a variety of other sources and studies on the industrializing countries (which include North America and the Asia/Pacific countries of Australia, New Zealand, and Japan). We updated this trend estimate for the Middle East with recently recorded data on Iran (Janghorbani et al. 2007), again with appropriate population weights. Finally, we used linear interpolation for the 1920s and 1930s, as most world region height estimates indicate a rather smooth upward trend for this time period. The most recent birth cohort in these series is the decade after 1980, that is, our study covers a range of individuals from those born in the 1850s to those living today.

Compared with the industrializing countries, height values in the Middle East were quite favourable until the 1870s. But was this difference actually significant? In order to test the statistical significance, we compiled anthropometric data from three different industrializing European countries and regions (see Table 8), namely Germany, Northern Italy, and the Czech lands (part of Austria-Hungary at the time), which we will compare with the United Kingdom below. We took care not to include the very extreme cases of the height distribution of industrializing countries, such as Sweden, the United States or other New World economies on the one hand (with tall heights), or Japan, Spain, and Portugal on the other hand (short heights) in this particular regression. The Middle Eastern "old world" populations were clearly shorter than the former, but taller than the latter. In contrast, we took comparable "old world" economies of Central and Southern Europe, which were closer to the average of the industrializing societies of the 19th century. We also took heights from different institutional backgrounds in order to make sure that any statistical difference was not caused by one of those institutional factors: The first sample was drawn from North Italian soldiers and deserters (Meineke 2008). A'Hearn (2003, p. 370) has shown that Northern Italians were not exceptionally short before mid-century (his sample ends with the 1840s birth cohort). The second source of information comes from Southeast German male convicts of the 1850s and 1860s. We also compared military conscripts from Southwest and Southeast Germany (districts of Frankenthal and Brueckenau, respectively, see Baten 1999). Finally, we included Czech prison height data (Hodinova 2007). All those data sets are publicly available on the IEHA data hub.[19] The Italian data were the only ones which required a truncated regression estimate, given the minimum height requirement of the Italian army at that time. In contrast, the German conscripts were measured before the minimum height requirement was applied (hence the lists included also the rejected ones). We pooled those samples with our individual Middle Eastern height data, and tested whether a Middle East dummy variable was statistically significant, regressing each birth decade separately (Table 8). It turned out that in almost all cases, the Mid-Eastern heights were significantly larger than those of European countries during the 1850s and 1860s - only the German prisoners in the 1850s were not statistically different from the Middle Eastern populations (Table 8). We can also speak of economic significance for those decades, as the height differential was always larger than one centimeter, which is a substantial amount. For example, Baten and Komlos (1998) estimated that one centimetre of height corresponds to 1.2 years of life expectancy (as already mentioned in section 2), which most people would consider to be a substantial addition to biological welfare. For the UK, Floud et al. (1990) arrive at similar height levels as the Middle Eastern populations, although there has been some debate about the absolute level of height as estimated by different truncated regression models (see Komlos 1998). Also, apart from the Minimum Height Requirement, the English Army was a volunteer army, hence it is not clear whether the army had a positive height selection compared to the civilian population.

During the 1870s and 1880s, the difference between Middle Eastern and European populations vanished and there were neither statistical nor economic differences (Table 8). The era after the 1870s was characterized by similar anthropometric values for both world regions. Only from the 1910s did the industrializing European countries overtake the Middle East (Figure 5). The Middle East was probably one of the very few world regions which had a height

[19] http://www.uni-tuebingen.de/ieha" ¶ http://www.uni-tuebingen.de/uni/wwl/dhheight.html⊥ , accessed May 2nd, 2008

advantage in comparison with Central European countries during the mid-nineteenth century (Baten 2006).

2.6 Comparison of GDP per capita, real wages, and height

How do those height trend estimates compare with existing GDP and real wage estimates? In general, both GDP per capita and heights diverged in the course of the twentieth century (Figure 5 and 7). However, the picture for the nineteenth century is fundamentally different. During the 1850s and 1860s, when the Middle Eastern countries still had a height advantage over the Western world, GDP per capita was already higher in the industrializing countries. The reason for this could be hypothesized to be distributional, as income inequality was perhaps higher in the West (Williamson 1998). Given that heights are quite sensitive to the well-being of the lower income strata, low inequality might ceteris paribus result in greater heights. The real wage of unskilled laborers relative to GDP might give a first impression. Allen (2001) calculated real wage estimates for a number of cities, including London, Amsterdam, Antwerp, Milan, and Madrid, for almost every decade of the 19th century. Comparing Allen's estimates with Özmucur and Pamuk (2002) for Istanbul, it turns out that in terms of real wages, the West was also ahead of Istanbul in the 1870s, with real wages for the Western cities being almost twice as high (Figure 7). However, this applies mainly to London and Amsterdam. If we consider the Western countries without those cities, Istanbul had in fact a real wage advantage in the early nineteenth century and wages were more or less equal in the period between the 1850s and the 1890s. If we remember that the UK and the Netherlands accounted for only 10.7 percent of Europe's population in 1890 (Maddison 2001), we might conclude that real wages in most of Europe and the Middle East were not particularly different. Could this have been a result of the fact that we considered until now only wage data for the large city of Istanbul? The answer is probably negative, as Özmucur and Pamuk (2002) showed that wages in Istanbul were in fact quite representative of Middle Eastern cities, with some cities (such as Edirne, Bursa, Damascus, and Jerusalem) having higher and other cities having lower estimated real wages.

Is the result for GDP per capita similar if we exclude the richest decile of Europe? When comparing Belgium, Italy, and Spain with the Middle East, we found no country composition effect: those three countries from the poorer part of Europe were still much richer than the Middle East (Figure 8). Assuming that both real wages and GDP estimates reflect the purchasing power of the respective social strata, we thus conclude that Western Europe must have had much stronger income inequality. The Middle East had some proximity advantages which made its population taller during the pre-1880 period. But its urban lower classes had similar purchasing power as those in the poorer four fifths of Europe. In contrast, urban merchants, factory owners, large land-owners, highly qualified engineers, other professionals, and similarly well-to-do persons who might have increased GDP per capita in Western Europe were probably substantially poorer in the Middle Eastern regions in relative terms. And what happened after 1950? The Middle East had a substantial increase of GDP per capita particularly from 1950 to 1970, but the economic development in the industrializing countries was even stronger (Figure 6).

2.7 Conclusion

This study enlarges our understanding of the Middle Eastern biological standard of living in the nineteenth and early twentieth centuries by providing anthropometric estimates for eight countries of this world region. We have to admit that the data might potentially contain more measurement errors than height studies from industrializing countries, as we had to rely partly on anthropological surveys which reported heights in an aggregated way. Unfortunately, for the Middle East, military records are not available. Our research in the Ottoman archive in Istanbul showed that heights in the Ottoman military were only recorded as “tall-middle-short” without clear definition of those categories. Heights of prisoners were only exceptionally recorded by Western anthropologists and included in our sample. Hence no large-scale individual height records from archival records can be expected from the typical sources. Here the choice is between either leaving a large blank spot on the anthropometric history world map or else undertaking a challenging exploration into these important world regions. We clearly suggest the latter strategy. Moreover, our dataset also has strengths, as for example half of the underlying data comes from a Turkish study which was drawn representatively for the whole population. Robustness tests showed that also the anthropometric estimates of the other countries might be quite reliable, at least for obtaining an idea of the general level of heights. Also, the development over time was quite similar in the main countries under study, which again suggests relatively robust estimates.

In general, Middle Eastern height values were higher than those of industrializing countries in the mid-nineteenth century. During the early stages of modern economic growth, the Middle Eastern regions enjoyed some of the well-known “advantages of proximity” to animal husbandry, as a substantial proportion lived in regions specialized in this agricultural activity. Those people were taller than other populations in a situation in which some protein-rich, but less highly valued products of animal farming (offal and milk, for example) could not be shipped at sufficiently low cost. It fits into this picture that desert inhabitants in Iraq were 1.3 cm taller than those from other rural regions. Moreover, in Egypt desert populations had a 1 cm advantage over urban dwellers, and for all eight countries the height advantage of desert people was 0.6 cm (significant at the 0.10 level). The share of nomadic people in Iraq declined from 35 percent to 5 percent, suggesting that the share of people enjoying those “advantages of proximity” declined between 1867 and 1947 (Issawi 1966, p. 158). This is important for the economies of the industrializing countries as well, because inhabitants of industrializing cities sometimes had higher purchasing power of tradable goods, but did not have these proximity advantages (Komlos 1998, Baten 1999, Baten and Murray 2000). In the Middle East, substantial parts of the population lived as Bedouins, who initially benefitted from those advantages, but after the late nineteenth century European urban industrial populations could buy cheap proteins and benefitted from improving disease environments during the twentieth century. This was the period when the Western industrializing countries overtook the Middle Eastern populations, especially so, as its urban populations could not benefit sufficiently, because industrial development and income growth took place much later (Pamuk 2006, Issawi 1995). During the late nineteenth century the industrial countries started to overtake the Middle East in terms of net nutritional status. Afterwards, a strong divergence was observable. In this study we have been able for the first time to identify the point in time when the Middle East fell back relative to industrializing countries.

References

A’Hearn, B., 2003. Anthropometric Evidence on Living Standards in Northern Italy, 1730–1860. Journal of Economic History 63, 351-381.

A’Hearn, B., Baten, J., Crayen, D., 2006. Quantifying Quantitative Literacy: Age Heaping and the History of Human Capital. UPF Working Paper 996.

Allen, R., 2001. The Great Divergence in European Wages and Prices from the Middle Age to the First World War. Explorations in Economic History 38, 411-447.

Ammar, A. M., 1944. The People of Sharqia, 2 vols. Cairo: SRGE (Société Royale de Géographie d’Egypte).

Barrett, T., Rossiter, P.B., 1999. Rinderpest: the Disease and its Impact on Humans and Animals. Advances in Virus Research 53, 89-110.

Baten, J., 1999. Ernaehrung und wirtschaftliche Entwicklung in Bayern 1730-1880. Stuttgart: Steiner.

Baten, J., 2006. Global Height Trends in Industrial and Developing Countries, 1810-1984: An Overview. Tuebingen Working Paper.

Baten, J., Crayen, D., Manzel, K., 2008. Zahlenfähigkeit und Zahlendisziplin in Nord- und Westdeutschland, 16.-18. Jahrhundert. Jahrbuch fuer Wirtschaftsgeschichte (2008, forthcoming).

Baten, J., Komlos, J., 1998. Height and the Standard of Living. Journal of Economic History 57, 866-870.

Baten, J., Murray, J., 2000. Heights of Men and Women in Nineteenth Century Bavaria: Economic, Nutritional, and Disease Influences. Explorations in Economic History 37, 351-369.

Chantre, E., 1895. Missions scientifiques en Transcaucasie, Asie mineure et Syrie 1890-1894. Recherches anthropologiques dans l'Asie occidentale, Archives du museum d'histoire naturelle de Lyon 6. Lyon: Georg.

Chantre, E., 1904. Recherches anthropologiques dans l'afrique orientale: Égypte. Lyon: Rey.

Cipriani, L., 1938. Arabi dello Yemen e dell’Hidgiaz. Archaeology Anthropology. Enthnologie 68, 115-177.

Craig, J. I., 1911. Anthropometry of Modern Egyptians. Biometrika 8, 66-78.

Crayen D., Baten J., 2008. Global Trends in Numeracy 1820-1949 and its Implications for Long-Run Growth, CESifo Working Paper 2218.

Crowfoot, J.W.,1900. Survival among the Kappadokian Kizilbash. Journal of the Anthropological Institute of Great Britain and Ireland 30, 305-320.

Dickens, W.T., 1990. Error Components in Grouped Data: Is it Ever Worth Weighting? The Review of Economics and Statistics 72, 328-333.

Dresch, P., 2000. A History of Modern Yemen. Cambridge: Cambridge University Press.

Field, H., 1929. The Field Museum – Oxford University Joint Expedition to Kish, Mesopotamia. Anthropology Leaflet no. 28. Chicago: FMNH (Field Museum of Natural History, now: Chicago Natural History Museum).

Field, H., 1931. Modern Arabs of the Kish area. Chicago: FMN 2 (Field Museum News).

Field, H., 1936. The Arabs of Iraq. American Journal of Physical Anthropology 21, 49-56.

Field, H., 1939. Contributions to the Anthropology of Iran. Chicago: FMNH (Field Museum of Natural History, now: Chicago Natural History Museum), Anthropological Series 29.

Field, H., 1940. The Anthropology of Iraq, Part 1-1. Chicago: Field Museum of Natural History. Anthropological Series 30.

Field, H., 1951. The Anthropology of Iraq, Part 2-1, The Northern Jazira. Cambridge: Papers of the Peabody Museum of American Archaeology and Ethnology, Harvard University.

Field, H., 1952a. The Anthropology of Iraq, Part 2-2, Kurdistan. Cambridge: Papers of the Peabody Museum of American Archaeology and Ethnology, Harvard University.

Field, H., 1952b. Contribution to the Anthropology of Fayun, Sinai, Sudan, Kenya. Berkeley, Los Angeles: University of California Press.

Field, H., 1956. An Anthropological Reconnaissance in the Near East 1950. Cambridge: Harvard University Press.

Floud, R., Wachter, K., Gregory, A., 1990. Height, Health and History. Cambridge University Press.

Genna, G.E., 1938. I Samaritani. Antropologia 1. Rome: Nuove Grafiche.

Gilbar, G.G., 1986. The Opening Up of Qajar Iran: Some Economic and Social Aspects. Bulletin of the School of Oriental and African Studies 49, 76-89.

Gloor, P.A., 1950. Recherches anthropologiques en Palestine meridionale. Archives Suisses d'Anthropologie Geneva. 15, 107-142.

Hansen, B., 2001. Learning to Tax: The Political Economy of the Opium Trade in Iran 1921-1941. Journal of Economic History 61, 98-113.

Hodinova, K. 2007. Determinanten der fruehen Humankapitalbildung in ost- und mitteleuropaeischen Regionen. Working Paper and Diploma Thesis Univ. of Tuebingen.

Inan, A., 1939. L'Anatolie, le pays de la "race" turque: recherches sur les caractères anthropologiques des populations de la Turquie; enquète sur 64000 individus. Geneva: Albert Kundig.

Issawi, C., 1966. The Economic History of the Middle East 1800-1914. Chicago: University of Chicago Press.

Issawi, C., 1980. The Economic History of Turkey. Chicago: University of Chicago Press.

Issawi, C., 1982. An Economic History of the Middle East and North Africa. London: Columbia University Press.

Issawi, C., 1988. The Fertile Crescent, 1800-1914. Oxford: Oxford University Press.

Issawi, C., 1995. The Middle East Economy: Decline and Recovery. Princeton: Markus Wiener.

Janghorbani, M., Amini, M., Willet, W.C., Gouy, M.M., Delavari, A., Alikhani, S., Mahdavi, A., 2007. First Nationwide Survey of Prevalence of Overweight, Underweight, and Abdominal Obesity in Iranian Adults. Obesity 15, 2797-2808.

Koepke, N., Baten. J., 2005. The Biological Standard of Living in Europe During the Last Two Millennia. European Review of Economic History 9, 61-95.

Koepke, N., Baten. J., 2008. Agricultural Specialization and Height in Ancient and Medieval Europe. Explorations in Economic History 45, 127-146.

Komlos, J., 1985. Stature and Nutrition in the Habsburg Monarchy: The Standard of Living and Economic Development. American Historical Review 90, 1149–1161.

Komlos, J., 1996. Anomalies in Economic History: Reflections on the Antebellum Puzzle. Journal of Economic History 56, 202-214.

Komlos, J., 1998. Shrinking in a Growing Economy? The Mystery of Physical Stature during the Industrial Revolution. Journal of Economic History 58, 779-802.

Kuhnke, L., 1990. Lives at Risk – Public Health in Nineteenth-Century Egypt. Cairo: The American University in Cairo Press.

Maddison, A., 2001. The World Economy: a Millennial Perspective. Paris: OECD.

Margo, R.A., Steckel, R.H., 1983. Heights of Native-Born Whites During the Antebellum Period. Journal of Economic History 43, 167-174.

Meineke, L., 2008. Die Vereinigung Italiens und der Biologische Lebensstandard. Working Paper and Diploma Thesis, Univ. of Tuebingen.

Okazaki, S., 1986. The Great Persian Famine of 1870-71. Bulletin of the School of Oriental and African Studies 49, 183-192.

Orensteen, M.M., 1915. Correlation of Anthropometrical Measurements in Cairo-Born Natives. Biometrika 11, 67-81.

Özmucur, S., Pamuk, S., 2002. Real Wages and Standard of Living in the Ottoman Empire, 1489 – 1914. Journal of Economic History 62, 293-321.

Pardini, E., 1975. Anthropological Research in Sistan. East and West 25, 267-276.

Pamuk, S., 2006. Estimating Economic Growth in the Middle East since 1820. Journal of Economic History 66, 807-828.

Seltzer, C.C. 1936. The Racial Characteristics of Syrians and Armenians. Papers Peabody Museum of American Archeology and Ethnology. 13, Harvard University.

Seltzer, C.C., 1940. Contributions to the Racial Anthropology of the Near East. Cambridge: Peabody Museum, Harvard University.

Shanklin, W.M., 1935. The Anthropology of the Rwala Bedouins. Journal of the Royal Anthropological Institute of Great Britain and Ireland 65, 375-390.

Shanklin, W.M., 1936. Anthropology of the Akeydat and Maualy Bedouin. American Journal of Physical Anthropology 21, 217-52.

Shanklin, W.M., 1938. Anthropometry of Syrian Males. Journal of the Royal Anthropological Institute of Great Britain and Ireland 68, 379-414.

Shanklin, W.M. 1946. Anthropometry of Transjordan Bedouin with a Discussion of their Racial Affinities. American Journal of Physical Anthropology N.S. 4, 323-375.

Sorkin, J. D., Muller D.C., Andres R., 1999. Longitudinal Change in the Heights of Men and Women: Consequential Effects on Body Mass Index. Epidemiologic Reviews 21, 247-260.

Steckel, R., 1995. Stature and the Standard of Living. Journal of Economic Literature 33, 1903–1940.

Steckel, R., Floud, R., (Eds.), 1997. Health and Welfare During Industrialization. Chicago: Chicago University Press.

Szreter, S., Mooney, G., 1998. Urbanization, Mortality, and the Standard of Living Debate: New Estimates of the Expectation of Life at Birth in Nineteenth-Century British Cities. Economic History Review 51, 84-112.

Thomas, B., 1929. Among Some Unknown Tribes of South Arabia. Royal Anthrop. Inst. 59, 97-111.

Thomas, B., 1931. Some Anthropological Observation on South Arabians. Man 31. Proc. Royal Anthropological Institute. 219.

Thomas, B., 1932. Anthropological Observation in South Arabia. Journal Royal Anthrop. Inst. 62, 83-103.

Vallois, H.V., Chamla, M.C., 1964. Recherches anthropologiques sur les Alaouites (Syrie). L'Anthropology. 68, 317-362.

Wagenseil, F., 1925. Beiträge zur physischen Anthropologie der spaniolischen Juden und zur juedischen Rassenfrage. Zeitschrift für Morph. Anthropologie 23, 33-150.

Weissenberg, S., 1909. Die jemenitischen Juden. Zeitschrift für Ethnologie 41, 309-327.

Weissenberg, S., 1911. Die syrischen Juden anthropologisch betrachtet. Zeitschrift für Ethnologie 43, 80-90.

Weissenberg, S., 1913. Zur Anthropologie der persischen Juden. Zeitschrift für Ethnologie 45, 108-119.

Williamson, J.G., 1998. Real Wages and Relative Factor Prices in the Third World 1820-1940: The Mediterranean Basin. Harvard University Discussion Paper 1842.

World Bank, 1995. World Development Indicators on CDROM. Washington: World Bank Group.

Tables

Table 1: Population densities in selected European and Middle Eastern countries

	Population density			Population per arable land		
	1820	1870	2003	1820	1870	2003
Germany	70	110	231	199	314	681
Italy	67	93	192	153	212	698
United Kingdom	87	129	247	295	436	981
Czechoslovakia	97	129	199	236	314	496
Iraq	2	4	56	24	34	448
Yemen	5	5	37	205	225	1,344
Middle East (8 countries)	8	10	99	79	110	996

Note: "Middle East (8 countries)" is weighted with population size. „Arable land" refers to 1961 for 1820 and 1870, and to 2003 for 2003. Source: Maddison (2001), World Bank (1995), www.worldbank.org, accessed May 5th, 2008.

Table 2: Anthropometric data sources for the birth decades of the 1850s to 1910s

Country	Height sources
Egypt	Ammar (1944), Chantre (1904), Craig (1911), Field (1952b), Orensteen (1915)
Iran	Weissenberg (1913), Field (1939), Pardini (1975)
Iraq	Field (1929, 1931, 1936, 1940, 1951, 1952a, 1956)
Palestine/Israel	Genna (1938), Gloor (1950), Vallois (1964),
Lebanon	Seltzer (1936, 1940), Shanklin (1935,1946)
Syria	Seltzer (1940), Shanklin (1936,1938), Weissenberg (1911)
Turkey	Inan (1939), Chantre (1895), Wagenseil (1925), Crowfoot (1900), Field (1956)
Yemen	Weissenberg (1909), Cipriani (1938), Thomas (1929, 1931, 1932)

Table 3: Whipple Indices of our sample in comparison with census data

Country	Birth decade	Sample	Census	N (sample)
Iraq	1900	325	237	231
Iraq	1910	300	226	30
Iran	1890	367	228	60
Iran	1900	308	239	99
Iran	1910	228	198	46
Turkey	1850	297	361	37
Turkey	1860	315	315	54
Egypt	1870	330	451	47
Mean		309	282	
For comparison:				
United Kingdom	1850		115	
Poland	1850		149	
Dominican Rep.	1910		221	
Nigeria	1910		304	
India	1910		367	
Pakistan	1910		412	

Note: Iraq 1910 and Iran 1910 refer to age 20-49 (otherwise observations would be less than 30). Source: we thank Dorothee Crayen and Joerg Baten for friendly providing the Whipple Indices based on censuses (males). See also Table 2. Abbreviations: see Table 2.

Table 4: Number of height observations by country, birth decade, and individual versus grouped data

	1850	1860	1870	1880	1890	1900	1910	Total
Egypt	738	109	9447					10294
	22	145	28	36				231
Iraq					1733	740		2473
			20	78	165	394	30	687
Iran	119							119
			30	50	61	99	46	286
Israel/Pal.	381	640						1021
								0
Lebanon	1066	415						1481
								0
Syria	1581	282						1863
								0
Turkey				4402	5098	7014	12478	28992
	39	63	37	23	28	2		192
Yemen	38	40						78
			22	30	10	18		80
	3984	1694	9584	4619	7095	8267	12554	47797

Notes: Grouped data are grey-shaded. Sources: Table 2.

Table 5: Raw height average by country and birth decade

Country	1850	1860	1870	1880	1890	1900	1910
Egypt	166.44	167.82	166.92	163.55			
Iraq				168.55	166.52	168.85	165.73
Iran	165.34		165.82	163.44	165.44	166.83	166.08
Israel/Palestine	168.42	168.63					
Lebanon	166.58	167.23					
Syria	166.35	168.03					
Turkey	168.82	168.94	168.34	167.39	168.41	168.40	167.70
Yemen	162.45	161.30		158.80			

Note: Height averages are weighted by the number of observations. Only cases with N>30 shown.
Sources: Table 2.

Table 6: Height averages by region type and country

Country	Coast	Desert	Other rural	Urban	Desert minus urban
Egypt	167.03	166.92	166.99	165.79	1.13
Iraq		168.78	166.71	167.92	0.85
Iran			166.03	164.59	
Israel/Palestine	168.06		168.00	168.73	
Lebanon	166.76				
Syria	167.16		165.93	168.10	
Turkey	168.12		167.95		
Yemen	161.45				

Note: Height averages are weighted by the number of observations. Only cases with N>30 shown. Sources: Table 2.

Table 7: Weighted Least Square regressions of heights in the Middle East

	(1)	p-value	(2)	p-value	(3)	p-value
Coast	0.18	0.66				
Desert	0.56*	0.09				
Large urban	-0.11	0.81				
Jews	-2.56***	0.00	-2.47***	0.00		
Age 20	-0.52***	0.00	-0.52***	0.00	-0.51***	0.00
Migrant	-0.24	0.63	-0.33	0.29		0.00
Syria 1850	-1.61**	0.01	-1.61***	0.01	-1.60***	0.01
Syria 1860	0.03	0.96	0.07	0.88	0.08	0.86
Lebanon 1850	-1.50***	0.00	-1.38***	0.00	-1.37***	0.00
Lebanon 1860	-0.79**	0.03	-0.73***	0.00	-0.72***	0.00
Iran 1850	-2.62**	0.02	-2.62**	0.02	-2.61**	0.02
Iran 1870	0.31	0.81	0.33	0.80	-2.13*	0.07
Iran 1880	-2.76***	0.00	-2.84***	0.00	-4.51***	0.00
Iran 1890	-1.97**	0.01	-2.03**	0.01	-2.51***	0.00
Iran 1900	-0.48	0.54	-0.55	0.46	-1.12	0.13
Iran 1910	-0.76	0.38	-0.83	0.32	-1.63**	0.04
Iraq 1870	0.93	0.51	1.31	0.34	1.32	0.34
Iraq 1880	0.42	0.50	0.60	0.32	0.61	0.31
Iraq 1890	-1.35***	0.00	-1.30***	0.00	-1.43***	0.00
Iraq 1900	0.61	0.12	0.95***	0.01	0.96***	0.01
Iraq 1910	-1.80	0.11	-1.91*	0.07	-1.91*	0.07
Yemen 1850	-5.69***	0.00	-5.51***	0.00	-5.50***	0.00
Yemen 1860	-6.83***	0.00	-6.66***	0.00	-6.65***	0.00
Yemen 1880	-7.18***	0.00	-7.01***	0.00	-9.15***	0.00
Yemen 1890	-5.23***	0.00	-5.06***	0.00	-5.05***	0.00

Yemen 1900	-5.96***	0.00	-5.78***	0.00	-5.78***	0.00
Yemen 1850	0.71	0.41	0.86	0.29	0.87	0.28
Turkey 1860	1.11	0.14	1.22*	0.08	1.00	0.16
Turkey 1870	2.13**	0.03	2.15**	0.02	0.49	0.57
Turkey 1880	-0.56***	0.00	-0.56***	0.00	-0.56***	0.00
Turkey 1890	0.46***	0.00	0.46***	0.00	0.46***	0.00
Turkey 1900	0.45***	0.00	0.45***	0.00	0.46***	0.00
Israel/Pal. 1850	1.11***	0.00	1.08***	0.00	0.47	0.22
Israel/Pal. 1860	0.90***	0.01	0.90***	0.00	0.68***	0.00
Egypt 1850	-1.60***	0.01	-1.51**	0.01	-1.50**	0.01
Egypt 1860	-0.26	0.51	-0.14	0.73	-0.13	0.75
Egypt 1870	-1.07***	0.00	-1.04***	0.00	-1.03***	0.00
Egypt 1880	-4.96***	0.00	-4.41***	0.00	-4.40***	0.00
Constant	167.95***	0.00	167.96***	0.00	167.95***	0.00
N (Original)	47797	0.00	47797	0.00	47797	0.00
R-squared	0.32		0.31		0.30	

Notes: Robust p-values in parentheses. ***, **, * significant at the 0.01 , 0.05 level, 0.10 level respectively. Intercept represents a 20-50 year old male who was born in Turkey in 1910 (col. 1-3), in a “other” rural province (col. 1), and who was not migrant or Jewish (col. 1 and 2). N(Original) refers to the underlying, originally measured persons. The number of different height figures (counting grouped data as 1) is 1,595, 1,476 individual and 119 grouped. Sources: Table 2.

Table 8: Was the difference between the Middle East and various European countries statistically significant?

Comparison sample	Italy	Italy	Germany-SE (prison)	Germany-SE (prison)	Germany-SW (cons.)	Germany-SW (cons.)
Birth decade	1850s	1860s	1850s	1860s	1850s	1860s
Middle East	2.086***	3.487***	1.338	2.279***	2.742***	3.627***
	(0.81)	(0.47)	(0.89)	(0.66)	(0.91)	(0.57)
Constant	165.9***	165.2***	166.2***	166.4***	164.8***	165.1***
	(0.11)	(0.17)	(0.52)	(0.47)	(0.55)	(0.34)
Observations	4241	2157	241	369	182	556
R-squared	.	.	0.01	0.03	0.05	0.07

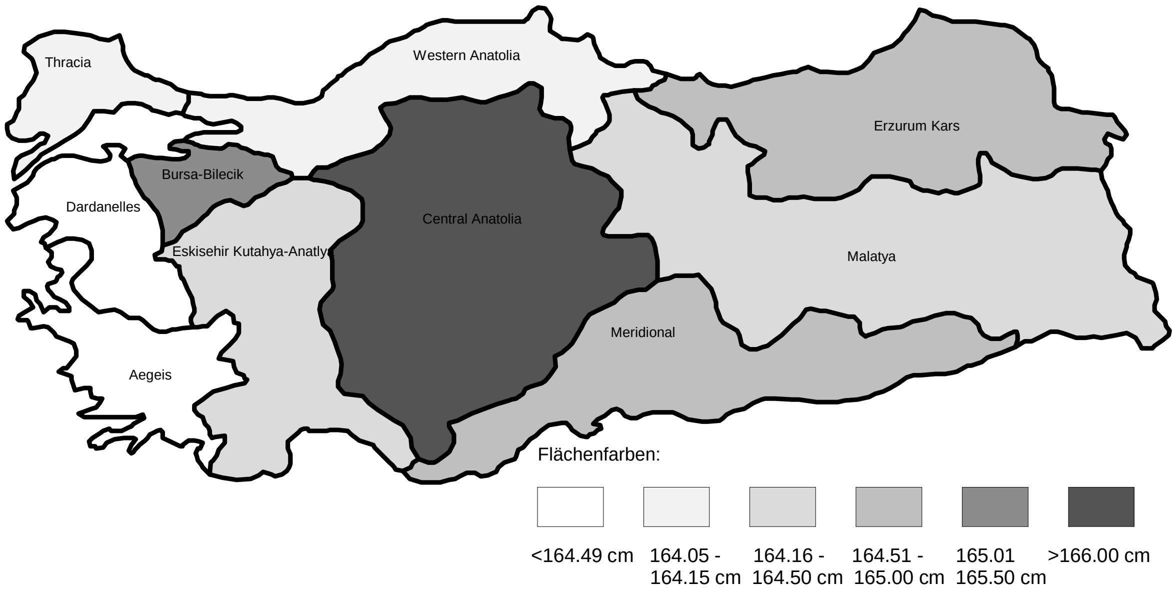
Comparison sample	Germany-SW (cons.)	Germany-SW (cons.)	Germany-SE (cons.)	Czech lands	Czech lands	Czech lands	Czech lands
Birth decade	1870s	1880s	1850s	1850s	1860s	1870s	1880s
Middle East	0.560	-0.178	1.386*	2.906**	3.217***	0.587	-0.683
	(0.58)	(0.69)	(0.80)	(1.30)	(0.80)	(0.82)	(1.06)
Constant	165.7***	165.0***	166.2***	164.7***	165.5***	165.6***	165.5***
	(0.31)	(0.55)	(0.35)	(1.08)	(0.66)	(0.66)	(0.97)
Observations	562	337	429	98	293	254	262
R-squared	0.00	0.00	0.01	0.05	0.05	0.00	0.00

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1; Notes: the standard deviations of Italy in the truncated regression model are estimated -- quite plausibly -- as 5.784 (1850) and 6.006 (1860). R-square for Italy is not reported, as this cannot be calculated for this truncation model. The number of cases refers to both Middle East and European comparison samples, for the number of cases on the Middle East, see Table 4. Abbreviation: « cons."= conscript. Reported is always the coefficient for Middle

East (ME) in pooled samples of Middle East and European samples. For sources on European heights, see "http://www.uni-tuebingen.de/uni/wwl/dhheight.html"

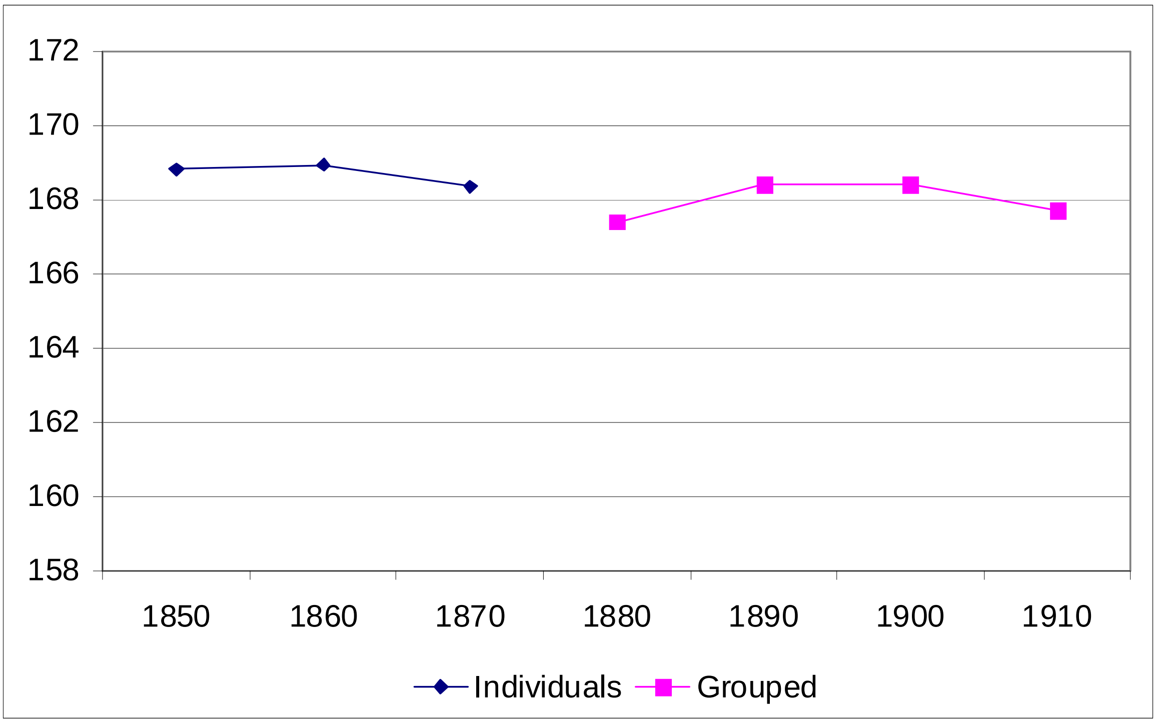
Figures

Figure 1: Regional mean stature of Turkish males, 1850-1910



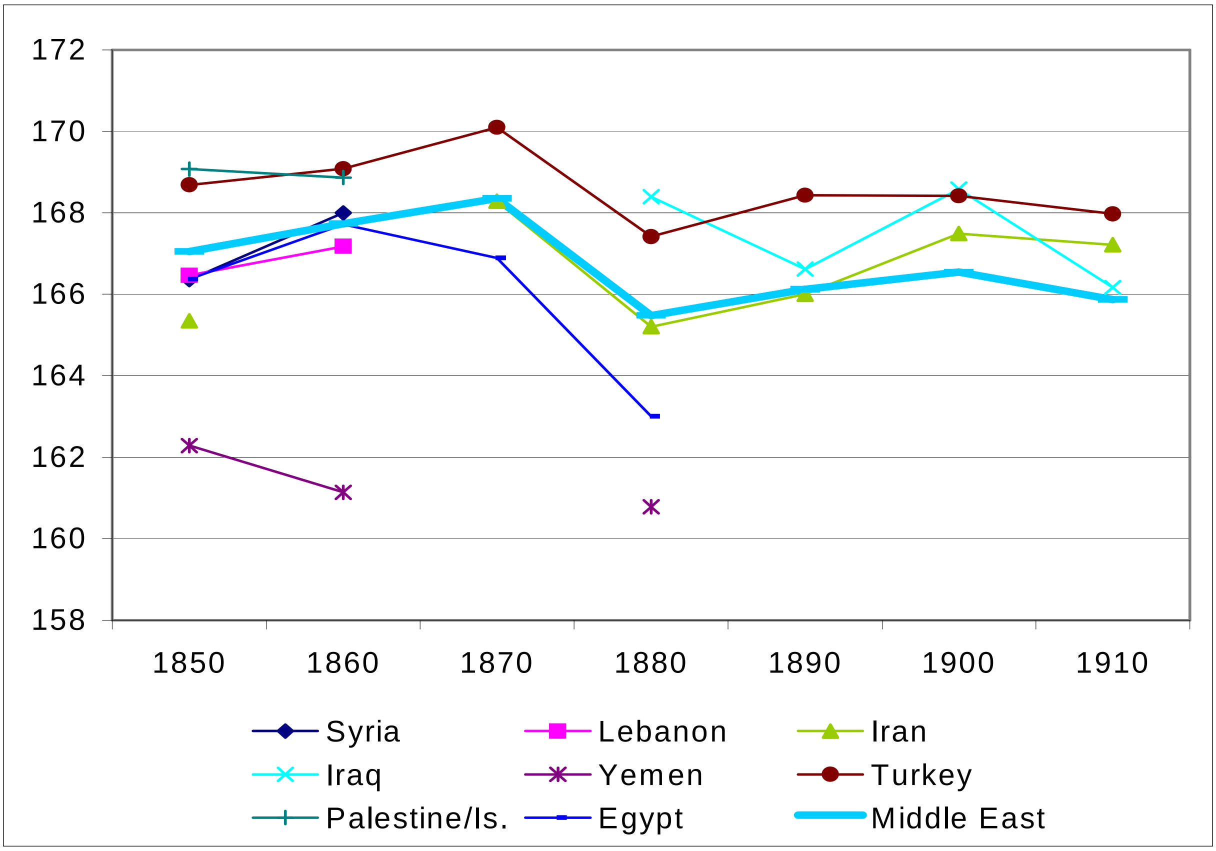
Note: due to the inclusion of elderly persons, the height levels are too low. Only the ranking between regions is informative. Source: processed from Inan (1939).

Figure 2: Individual and grouped data for Turkey



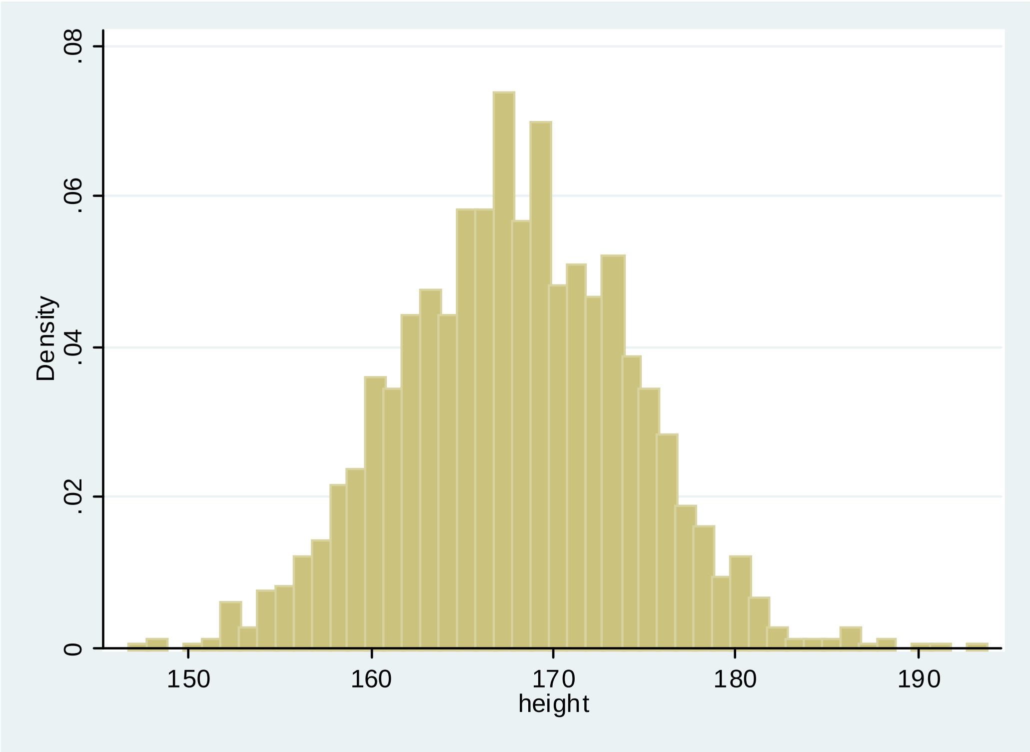
Notes: for the vertical axis, the same height interval is taken as in Figure 3. Only cases with N>30 are reported. Source and Abbreviations: Table 2.

Figure 3: Height Development in the Middle East (regional, migratory, and religious controls included)



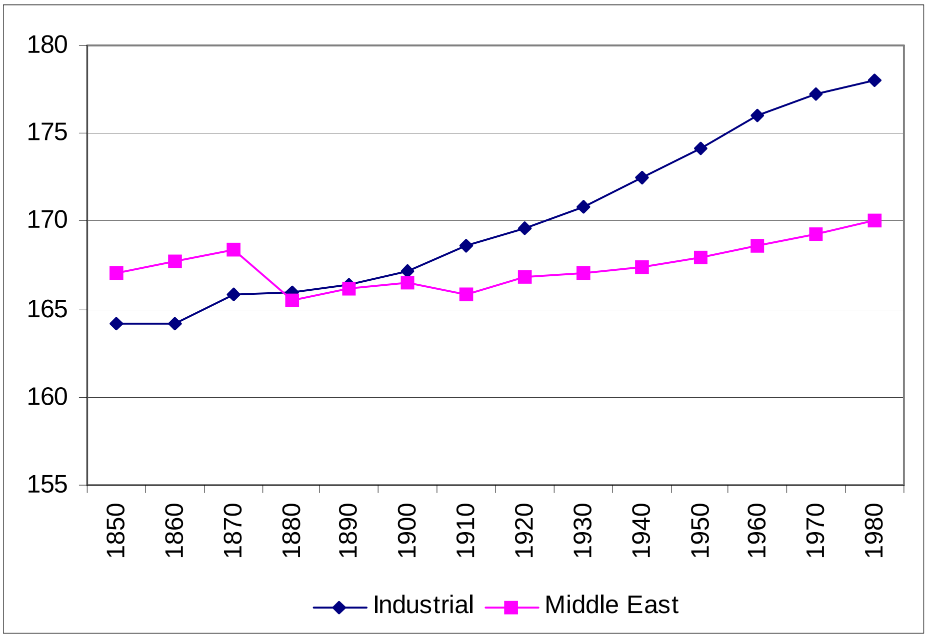
Notes: Source and Abbreviations: Table 2. Iraq 1870, Yemen 1870, 1890 and 1900 is not shown, because N is less than 30.

Figure 4: Distribution of individual height (males)



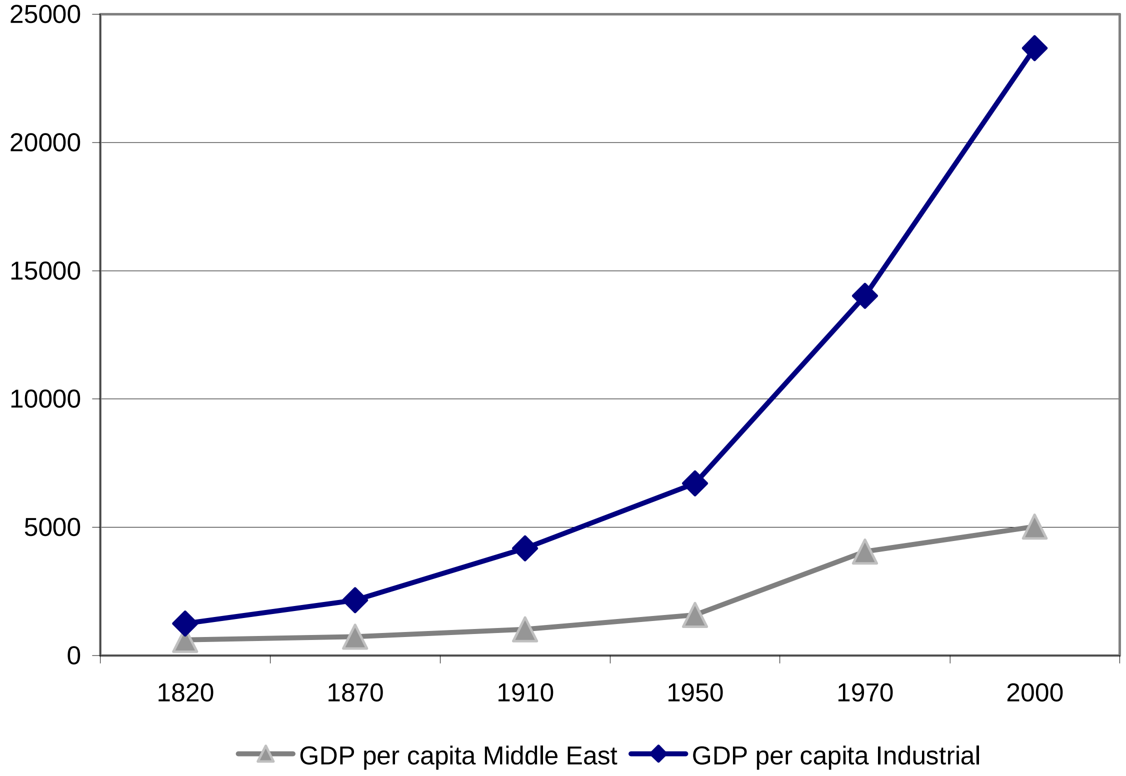
Sources: see Table 2

Figure 5: Heights trend in the Middle East and industrializing countries (weighted by population size)



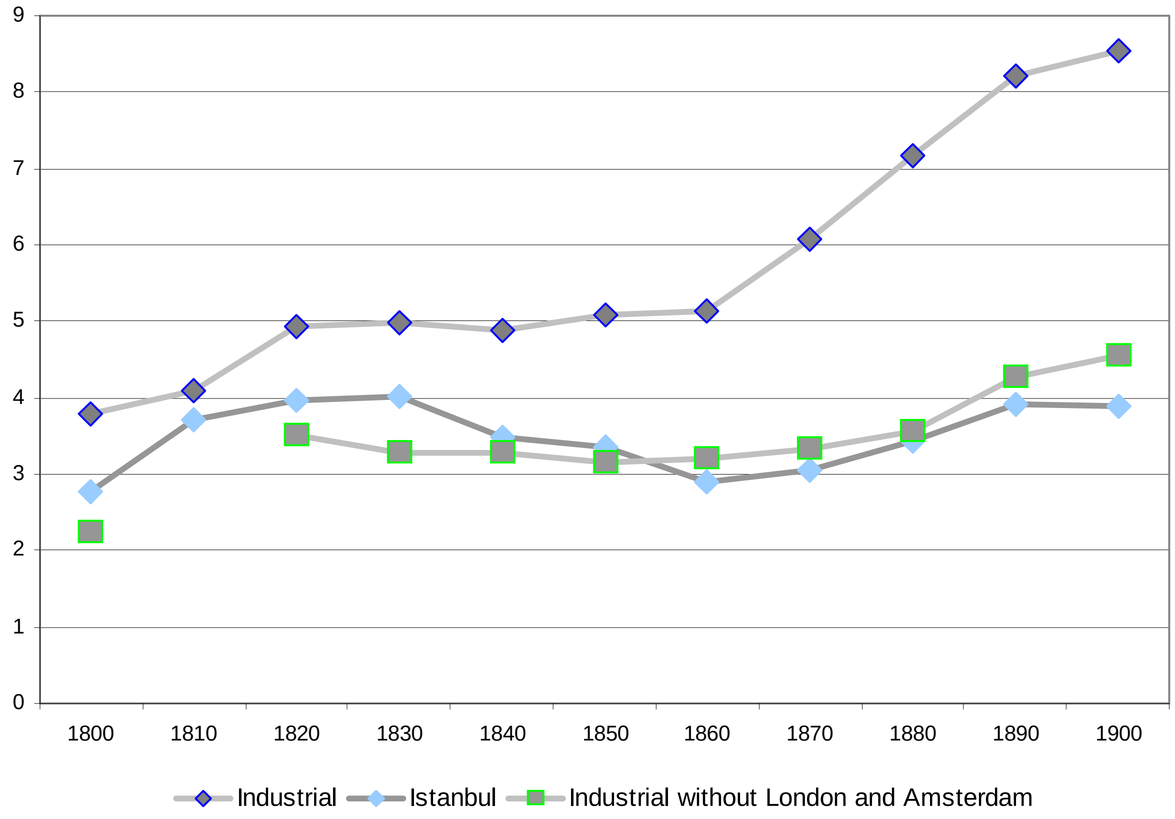
Sources: for 1850-1910: see Table 2; for 1940-1980: Baten (2006), based on Demographic and Health surveys (DHS); Janghorbani et al. (2007). The 1920s and 1930s for Middle East are interpolated.

Figure 6: GDP per capita in 1990 PPP Dollars (weighted by population size)



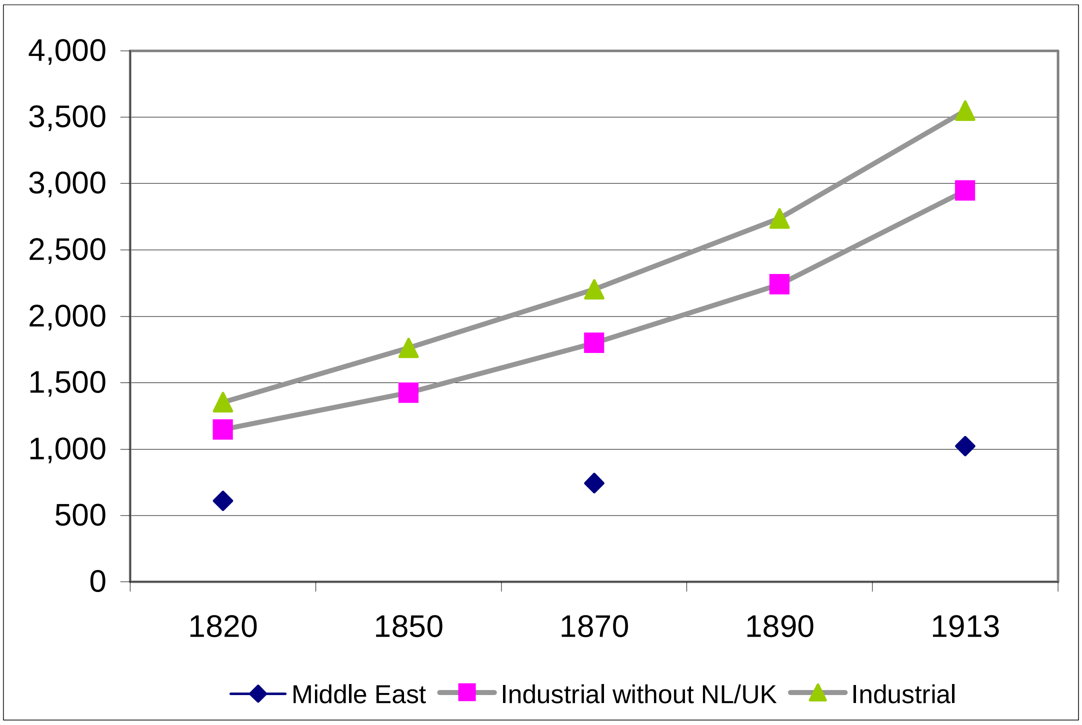
Source: S. Pamuk (2006)

Figure 7: Real wages in Istanbul and industrializing countries in grams of silver per day (weighted by population size)



Sources: Istanbul: S. Özmucur, S. Pamuk (2002), industrializing countries: Allen (2001)

Figure 8: GDP per capita (1990 International Geary-Khamis dollars)



Source: Maddison (2001); Pamuk (2006).

3. The Biological Standard of Living and Body Height in Colonial and Post-Colonial Indonesia, 1770-2000

Abstract

How did the Biological Standard of Living develop in Indonesia during colonial times? Did it increase substantially after decolonization? In our study, we use four sets of anthropometric data to construct time series of average human height since the 1770s. The paper observes a significant decline in heights in the 1870s, followed by only modest recovery during the next three decades, both of which are related to a sequence of disasters. Average heights increased from the 1900s and accelerated after World War II. The World Economic Crisis, the Japanese occupation and the war of independence in the 1930s and 1940s constituted a difficult period. Average height growth thereafter is related to improvements in food supply and the disease environment, particularly hygiene and medical care.

Keywords: biological standard of living, human heights, Indonesia, welfare, economic development
JEL codes: N35, O15, I31
This version: 7 July 2012

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3.1 Introduction

How did the Biological Standard of Living develop in Indonesia during colonial times? Did it increase substantially after decolonization? Over the past decade, the colonial legacy debate has stimulated historical research regarding the ardent question of the long-term effects of colonial expansion (Acemoglu *et al.* 2001, 2002). This debate followed a much older body of literature but developed a particular comprehensive demand for quantitative data. One core data source with great potential is anthropometric evidence on human stature, which has been developed into the widely accepted indicator of the Biological Standard of Living (BSL).[20] Indonesia is a particularly important case for this line of research because its colonial history can be divided into three different phases. During the early history, the Dutch colonial power was primarily interested in trading spices, and it interfered only modestly with the life of the population of the Indonesian islands. During the second phase, the Dutch colonial government implemented the Cultivation System in much of Java during 1830-1870. This system enhanced the cultivation of major export crops, such as coffee, sugar cane and indigo in Java. Farmers were compelled to produce such crops on farm land or to contribute their labor to the growing of crops on newly opened plantations (Van der Eng 2004). Third, the Dutch colonial government implemented a number of 'ethnical' welfare policies since the 1890s; these policies involved public agencies for hygiene and health care, agricultural extension, veterinary services, small-scale credit facilities and similar institutions (Boomgaard 1986; Cribb 1993). Some scholars argued that such policies had positive consequences for the standard of living, whereas other researchers maintained that these policies represented mere window dressing and that the *raison d'être* of Dutch colonial rule continued to be the exploitation of Indonesian resources until Indonesia finally became

[20] This term was first coined by Komlos (1985).

independent in the 1940s. In this study, we will assess whether the Cultivation System may have had a detrimental influence on the nutritional status of Indonesians, especially during the second phase. One could hypothesize that the expansion of the plantation system could have exerted pressure on the subsistence production of food. As the population was also substantially growing in size, the combination of those factors could have worsened the nutritional status of Indonesians. A second hypothesis would be that the increased international interaction during the 'First Era of Globalization' of the late 19th century could have contributed to a deterioration of the disease environment in Indonesia. The measures of the third phase, the 'ethical' welfare policy phase, could have been a reaction to health issues during the previous phase. We will assess the effects of these different phases on the BSL in Indonesia.

Two major studies discussed the long-term development of living standards in Indonesia and found it difficult to balance contrasting existing views (Booth 1998: 89-134; Dick *et al.* 2002: 133-35, 157-58).[21] Nevertheless, these studies echoed the common argument that Indonesia has experienced 'growth with equity' since the 1970s as a consequence of the 'pro-poor growth' policies that were pursued by its government and that yielded low rates of income inequality (*e.g.*, World Bank 2005: 126-127). The argument that economic growth in recent decades improved living standards equally across the board is not compatible with recent evidence of significant income inequality (Leigh and Van der Eng 2009). The purpose of this paper is to contribute to these discussions in the literature on the basis of an analysis of long-term changes in the average heights of men and women in Indonesia.

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[21] Indonesia's national accounts data are now of reasonable quality, but at least until the methodological revisions of 1993, Indonesia's official national accounts data are of questionable reliability (Van der Eng 2002a). Hence, for the analysis of long-term changes, alternative indicators of economic growth and changes in the standard of living are required. A few other indicators of living standards, such as life expectancy, infant mortality, educational attainment or per capita food supply are available (Van der Eng 2002b), but their reliability is questionable going back in time.

Although the more recent anthropometric situation in Indonesia has been studied, the study of long-term economic change in Indonesia has hardly used anthropometrics, which have been widely used to assess changes in the BSL in less developed countries, such as in Africa (*e.g.*, Moradi 2009; Austin *et al*. 2012) and Asia (*e.g.*, Baten *et al*. 2010).[22] The lack of anthropometric studies is even more astonishing because Indonesia is the fourth largest country in the world, with a population of 238 million in 2010. The lack of readily available data prevented the analysis of anthropometric data for Indonesia for the period before 1900.[23] This paper is the first study to analyze such data based on several sources for this purpose. To analyze long-term changes in average heights, we must consider a number of determinants of height. Specifically, changes in nutritional status, the disease environment, hygiene and health care are relevant.

Multiple datasets are required to examine height development in Indonesia. These datasets are presented in following subsections. Nonetheless, the combination of such diverse datasets creates identification problems that are inherent in coupling diverse datasets because we are not fully able to isolate general patterns from selection biases, especially in the case of the early slave

[22] One exception is Földvari *et al*. (2012) for the 20th century. This study finds that regional differences between Java and the Outer Islands changed towards the end of the period: while the Outer Islands had a nutritional advantage early-on, the 1960s saw an overtaking of the capital region – Javanese were now taller than those born on Sumatra and the other islands. Unfortunately, the trend estimate in this study for the period before the 1930s is difficult to interpret, because the authors did not include military category dummies and age dummies in their regressions: The first three birth decades consisted of older soldiers mainly in their 30s and 40s of age. In most armies of the period, those age groups represented elite groups such as specially trained soldiers, grenadiers, guardsmen, and officers. In other army samples, those groups were always taller than the normal (and young) recruits. The first two birth decades represented less than 1 percent of the total dataset in the 1890s and 1900s, respectively, and the 1910s cohort is also much smaller than the young recruits in their early 20s. Hence their trend estimates are difficult to interpret. However, their regional findings seem reliable. In contrast to the dearth of studies of heights during the colonial era, there is a number of studies on the recent period. Research based on household surveys in Indonesia since the 1990s has pointed out the short run effect of crisis on the nutritional status for the fourth largest country in the world, as well as the negative effect of child labor on anthropometric values (Block *et al.* 2004; Wolff *et al.* 2008).

[23] Van der Eng (1995) focused for that reason on the 20th century.

dataset. Therefore, the causal interpretation in section 3 and the tentative conclusion (section 4) must be drawn with caution.[24]

3.2 Data section

3.2.1 Slaves in Batavia, 1770s-1810s

The first dataset that we used consists of a list of slaves in the city of Batavia (now Indonesia's capital Jakarta); this list was compiled in 1816 for the purpose of collecting tax from slaveholders. Slavery was a common institution in Southeast Asia and in Batavia under Dutch colonial rule. During a brief English interregnum from 1811 to 1816, the new government sought to undermine the institution with the purpose of abolishing it. In 1812, the government proclaimed an annual tax on the owners of slaves in Java, and slave registers were created for this purpose (Paulus *et al.* 1917-21, vol.3: 803-4). The reason to include heights in the slave register remains unclear. The government proclamation required owners to provide a description of their slaves, possibly for the purpose of identifying slaves during checks of owner households by tax officials. Many owners recorded the height of their slaves and other physical features, whereas other owners recorded only identification marks, such as facial scars.

The register recorded the name, age, height and region of origin of each slave. The original height evidence was reported in Rhenish feet; in our analysis, we use metric measures. Information pertaining to the slaves was provided by the owners. The place of origin was typically the port from which a slave had been transported to Java. Some slaves may have been unaware of their age; in these cases, their owners provided estimates of their ages. The penalty

[24] For 1770-1790 and 1810, we construct two benchmarks. From 1850 onwards, there are continuous time series until 2000.

for false registration was the emancipation of the slaves; thus, owners had an incentive to register their slaves with accurate data.

The register enables us to create (1) a subset of 600 slaves that is characterized by modest rounding and (2) a full dataset of 1,537 observations. The datasets are drawn from some pages in the source on which substantial rounding occurred and from other pages in which rounding was more modest.[25] We performed regressions with both the full dataset, which is characterized by the strong rounding pattern, and the limited sample for which rounding was less severe. For the full dataset, the rounding to 4 feet was actually much more common than rounding to 5 feet; hence, the full dataset yields lower estimates. We would argue that the limited dataset yields more reliable estimates.

Where did the slaves originate? The number of slaves from outside of the Indonesian archipelago was negligible, hence we omitted those singular cases. However, even within Indonesia, we could imagine large ethnic differences. Fortunately, the regions of origin were relatively widespread, from Aceh in the Northwest to Nusa Tenggara in the Southeast of modern Indonesia. Many of the Indonesian slaves were Buginese from Sulawesi in the Northeast. Other well-represented areas were Bali and Timor (classified under Nusa Tenggara in Table 1), and a sizeable portion was born in Batavia as descendants of slaves. East Indonesia was well represented in the data because it was customary for people in this part of the country to enter slavery through sale by local rulers, debt, punishment, capture during war, or piracy and raiding (Abeyasekere 1983: 291-3). Many slaves were born in Java, but they may have been descendants of slaves who were transported from elsewhere in the archipelago, as an early ruling of the Dutch

[25] The original dataset contained 2,479 observations with height, age and gender statement (Abeyasekere 1983: 289). Reducing the dataset to those aged 20-55 and limiting height to typical intervals (110 cm –200 cm), reduces the sample to 1,537 observations. The rounding issue is explained in detail in an Appendix, which will be made available on the internet. The register itself does not identify gender, which was established on the basis of the names of the slaves (Abeyasekere 1983: 289, 294).

East India Company – the Dutch authority prior to the establishment of colonial rule in 1796 – prohibited the enslavement of Javanese.

In Table 1, we show the results of an OLS regression analysis of height.[26] The table does not distinguish between the three birth decades, as the number of observations is prohibitively small. Among the females, Balinese slaves and those from Nusa Tenggara were the tallest, whereas among the males, only those from Sumatra (including Aceh) were significantly shorter than those from Jakarta. We also report an estimate of the overall population share of the different regions in Table 1 and compare this estimate with the sample share of slaves. Slaves from Jakarta and Bali were clearly oversampled, whereas the remaining parts of Java and Sumatra were underrepresented. To ensure that our estimates are representative of Indonesia, we calculated weighted averages of the various regions. The weighted height average of male adults who were born during the 1770s through the 1790s is 156.3 centimeter (cm), and that for females is 146.0 cm. The height of slaves is close to the lowest level that has ever been observed throughout the entire world for the 18th and 19th century.

In terms of social height selectivity, we cannot offer definite statements. The slave sample may have an upward bias, if especially tall and strong persons were enslaved through war or raiding. By contrast, a negative social height bias can be expected if poorer people were more likely to experience debt slavery. We cannot ascertain whether these potential biases might have balanced one another.[27] Eltis (1982) argued that, with regard to African slaves, the samples were

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[26] The age dummies of adolescents are heavily correlated with the birth decade dummies, and therefore do not yield robust results. They are therefore excluded. A joint dummy variable is used as a control for the 20-22 age groups as there are insufficient observations for the individual ages. The results are almost identical if this age group is excluded.

[27] On the other hand, around 1800 most of the Indonesian archipelago was still relatively sparsely populated and – with the possible exception of occasional famines caused by crop failure and epidemics – the average diet may have been sufficient for subsistence. But this assumes that the diet of slaves was sufficient as well and therefore that the cost to owners of feeding slaves was sufficiently low.

probably relatively unbiased compared with the overall population. However, he did not possess direct height evidence of other groups with which to compare. Rather, his arguments relied on the fact that samples of slaves were normally distributed, both slaves from regions with short slaves and those with tall slaves. Eltis argued that if tall slaves were preferred, then there should have been a shortfall in the lower half of the slave height distribution in ‘short’ regions. Eltis also argued that price differentials between regions of short and tall slaves were not observable. Hence, his impression was that height did not play a role in the enslavement process. Whether those arguments also apply to Indonesian enslavement processes cannot be ascertained.

All of the adolescents in the sample were born during the 1800s and 1810s. Previous studies have found that the years prior to measurement have a substantial influence on the heights of adolescents compared with the later years preceding adulthood (*e.g.*, Baten 2000). Many of the adolescent slaves may have grown up in relatively affluent households.[28] Therefore, we attempted to determine whether these adolescent slaves benefited from living in such households compared with the adult slaves in the sample. For this purpose, we estimated the adult height of the adolescents in the 1816 slave dataset.[29] For each child, we calculated the height-for-age z-score (HAZ value), which is a device to express height independently of the age of measurement. A HAZ value of 0 corresponds to an average child stature of well-nourished populations in the late 20th century. An HAZ value of -1 indicates that a child has a growth path that is one standard deviation below this modern average.[30] In this case, final height is expected to be 6.6 cm – or one

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[28] Abeyasekere’s (1983: 296) 10% sample suggests that about one-third of the slaves were in respectively European, Chinese and other (i.e. Arab, Moor, indigenous) households.

[29] For the purpose of converting HAZ values into adults height equivalents, the HAZ-values are expressed relative to mean heights in the US (in this case 176.8288 cm), and their standard deviation (6.576107 cm). It is then possible to convert for males using the equation height = 176.8288 + 6.576107 × HAZ and for females height = 163.66 + 5.989 × HAZ

[30] The reason to use a US standard, rather than standards for developing countries is that the US standard is the measure used in the overwhelming majority of relevant studies. The aim is to make this calculation not for a

standard deviation – shorter than 176 cm, which is the average US height. A child with an HAZ value of 0 would achieve an adult height of 176 cm if the environment were unchanging, and a child with an HAZ value of -1 would be correspondingly shorter. We find HAZ values of -2.36 standard deviations for male children (N = 69) after discarding extreme outliers of ± 9 standard deviations) and -2.93 for female children (N = 72). Transformed into adult height, the male children would be expected to become, on average, 161.3 cm tall later in life and females would become 146.1 cm tall if the nutrition remained as it was in the households of the slave owners. In both cases, the adult adolescents would be taller than their adult peers in 1816. Their heights are close to the highest level that was observed later in the 19th century (see below). In other words, adolescents may have benefited from growing up in slave households because their diet may have been superior to that in the villages in which their parents grew up or because the BSL in Java improved as a whole.

3.2.2 Data on migrants from Indonesia to Surinam, 1850s-1910s

Our second dataset refers to contract labourers who migrated from Indonesia to the Dutch colony of Surinam in South America.[31] The institution of contract labor has a long history in the Indonesian archipelago. For example, the first attempt by the Dutch colonial government to regulate the practice dates to 1819. After slavery was abolished in Surinam in 1863, plantation owners began to recruit contract workers in India and Indonesia. The Indonesian contract laborers were almost exclusively recruited in Java from 1888 to 1939 to work on plantations in Surinam.

subgroup of countries (such as developing nations), but to make it comparable for the whole world.

[31] Sources: Historical Database of Suriname, assembled by Maurits Hassankhan (University of Suriname) and Sandew Hira (Amrit Consultancy), based on the following original sources: National Archives of Suriname, immigration registers: 1.China 1864/1871 no. C1- C966; 2. China 1864/1871 no. C967- C1080; 3. Register China 1880 4. Register Barbados and China 1879 no 386D.

Data on these workers, including age and height, were recorded upon arrival in Surinam. Java was a preferred area for recruitment because increasing population growth and density implied that Javanese wage rates were relatively low.

Two potential biases in the migrant sample may have affected the oldest cohorts because those over the age of 45 may have begun to shrink already, although modern longitudinal studies find this effect to be relatively modest (*i.e.*, less than half of a centimeter up to the age of 50 and less than 1 cm until age 55).[32] Nevertheless, this effect could produce a downward bias among the earliest cohorts. However, those who survived to ages 50 or 55 may have been better-nourished individuals. Moreover, a small upward bias could have been generated by recruitment if the recruiting agents of the plantations were more selective in their choice of older recruits than younger individuals. Although detailed studies reported that this recruitment bias primarily concerned chest circumference (Brennan *et al.* 1994a, 1994b), the possibility that this bias also applied to height cannot be excluded.

All male observations were first included in a joint regression using age dummies for those aged 18-22. The age dummies were correlated with some of the birth decades, and the results were thus implausible. Therefore, Table 2 distinguishes between mature adults aged 23-55 and young adults aged 18-22, who were analyzed separately as a cross-check for the trends in the 23-55 age groups. Migrants from West Java were used as the reference group in the constant and the 1900s birth decade. The regression analysis in Table 2 indicates that regional differences within Java, where most contract workers were recruited, were not important. Individuals born in Jakarta were consistently taller, whereas males from Yogyakarta were sometimes shorter, but the differences were not always significant. Heights in the three regions of rural Java appear

[32] Guntupalli and Baten (2006) also arrived at low degrees of shrinkage in cross-sectional data in their study of heights in prewar India.

relatively homogenous for this group. Table 2 shows that the young adults (aged 18-22) were much shorter than the mature adults. A possible reason is that in periods of poor nutrition, young males continued to grow for an astonishingly long period, sometimes even until their mid-20s.

Compared with the male birth decade constant of the 1900s, people who were born in the 1850s and 1860s were significantly taller. The lowest values were reached in the 1910s and the 1870s/1880s. Male and female height development reveals some similarities, such as the low levels in the 1870-1880 period, as well as some differences.[33] In Figure 1, we observe that the height development of the series 'Migrants, adults' and 'Migrants, 18-22' is nearly identical. However, the levels differ substantially, as growth until age 22 (which is the constant for young males) remains substantial.

3.2.3 Anthropological and Medical Surveys Dataset, 1850s-1930s

For a similar period as in the previous sub-section, a dataset was constructed on the basis of height data for males that were reported in a range of anthropological and medical studies of people in Indonesia.[34] Despite some shortcomings, as discussed below, this dataset is a valuable resource for the purpose of cross-checking possible biases in the migrant data. This dataset also allows this study to extend the analysis of trends until the 1930s.

The primary challenge of this dataset was that some observations are in the form of grouped data. In studies of height trends, a frequent problem regarding anthropological surveys is the paucity of the information that is given on birth cohorts, as many anthropologists of the late 19th and early 20th centuries assumed that anthropometrics did not change over time. Hence, the

[33] Figure 2 reveals the differences. A Figure will be made available in an internet appendix.

[34] Data from across the Indonesian archipelago were used for this purpose, with the exception of New Guinea or West Papua. A list of the publications from which these data were obtained is available from the authors.

birth decades of the measured individuals needed to be approximated, and it had to be accepted that a smaller proportion of the measured individuals was born before or after the most prominently represented birth decade. In a way, the time trend that results from these estimated birth cohorts resembles moving averages insofar as it smoothens the height development. Koepke and Baten (2005, 2008) and Stegl and Baten (2008) estimated these grouped and individual data jointly with weighted least square regressions (WLS) to estimate average heights for populations for which the study of anthropometric development would not otherwise be possible. This part of the paper uses the same methodology and follows Dickens (1990) by weighting each observation by the square root of its group size.

Table 3 shows the results of two regression models to capture trends in heights. The data yield a low point for the birth decade of the 1870s (relative to the constant that refers to the 1900s) and low heights for the 1880s and 1890s (although the 1880s coefficient is not statistically significant). Table 3 confirms the taller birth cohorts of the 1850s and 1860s that were found for the migrant evidence and the recovery of average height after the 1890s. If we assume some lags, then the low values of the 1870s and 1880s in both the migrant and anthropological datasets could provide an initial indicator that the Cultivation System may have had adverse effects on human stature.

For the 1920s and 1930s, some height data are available for young Indonesian male adults. In this case, the underlying sample size is large (N = 2,020), but most of these data are grouped.[35] The coefficient of the 1930s is not significantly different from the constant that represents the 1920s.

[35] The dummy variable for age group 20-21 yielded implausible values, partly because age rounding interacts here with age structure, as the observations include individuals whose age was rounded to 20. In Figures 1 and 2 we therefore use the average height, not the constant.

3.2.4 Indonesian Family Life Survey Datasets, 1940s-2000s

We used data from three rounds of the representative Indonesian Family Life Survey (IFLS), which comprises large-scale socio-economic and health surveys that were conducted throughout Indonesia in 1993, 2000 and 2007. Although not all regions were covered, the IFLS was organized with great care to ensure that it is as representative as possible. In Table 4, we find a more substantial increase in average heights between the 1940s and the 1980s.

Finally, we estimated adult heights for the 1990s and 2000s on the basis of the heights of children from the IFLS. We applied the method to estimate adult height from child-related evidence. Hence, to project adult height, we used the heights of 3,031 female and 2,893 male children aged 8 to 17 born during the 1990s as well as 3,324 female and 3,416 male children aged 4 to 7 born during the 2000s. The average adult heights of males who were born in the 1990s and 2000s were estimated at 165.9 and 167.7 cm, and those of females were 153.8 and 156.0 cm, respectively. In other words, economic development in Indonesia from 1990 to 2007 had positive effects on the stature of children who were born during these years, despite the 1997-1998 economic crisis. If those relatively favorable circumstances continue, then children in this area are likely to acquire higher adult stature than their parents.

3.3 Long-Term Trends in Heights in Indonesia

Figures 1 and 2 combine the evidence from Section 2 and present long-term trends in the average heights of adult males and females in Indonesia during a period spanning more than two centuries. These trend estimates were obtained after controlling for differences in the four samples in terms of age and region of origin. For the 1810s, 1990s and 2000s, the data are estimated on the basis of the heights of children.[36]

In Figure 2, we reveal broadly similar trends pertaining to the average heights of males and females. The gap between the two sexes did not increase because there were no substantial changes in the status of women in Indonesia.[37] Male slave children in the 1810s were projected to be taller than adults later in the 19th century. This result may suggest that male heights were overestimated, especially in the 1810s. As we possess little continuous information regarding height for the years prior to the second half of the 1850s, the trend in that period is ambiguous. Another key feature in Figures 1 and 2 is the decrease in average heights of especially adult males in the birth cohorts of the 1870s, the slow recovery during the 1880s-1900s and the decrease in the heights of females in the birth cohorts of the 1870s and 1880s. The decrease in female heights in the 1910s birth cohort may be related to a low number of observations. However, we seek to determine how the decline during the 1850s-1880s can be explained.

Most anthropologists agree that modest or severe malnutrition – particularly in infancy and childhood – in interaction with a disadvantageous disease environment is a major cause of stunted growth in developing countries today (Bogin 1988). It is difficult to be specific regarding the influence of individual events, but Indonesia did suffer the consequences of four calamities during these decades, particularly the core island of Java. First, a series of droughts during the 1870s-1900s, particularly 1875, 1877-1878, 1885-1886, 1888-1889, 1891, 1896-1897 and 1902-1903 (Van Bemmelen 1916; Paulus *et al.* 1918-21, vol.2: 339), had a negative effect on the

[36] There is also evidence on 54-55-year adults born in the 1930s, but their height is probably affected by old-age shrinking, which has been estimated to be around 1 cm at this age. Adding 1 cm to their age, actually fits the estimate based on the 18-22 year-olds quite well (the height of those aged 54-55 is still one centimeter lower, but the gap to those aged 18-22 is smaller). Hence we added this adjustment for old-age shrinking in Figure 1.

[37] Block *et al.* (2004) identified that reduction of micronutrient food intake during the crisis of 1997-1998 essentially affected the nutritional status of women and mothers. These findings are consistent with the hypothesis that mothers buffer children's caloric intake.

production of rice, which was the main staple crop in the core island of Java at a time when new technologies to advance rice production were still at least 20 years away (Van der Eng 1996).

Second, the 1883 eruption of the Krakatau volcano off the coast of West Java was one of the largest volcanic disasters in human history. The eruption and the subsequent tsunami claimed an estimated 36,147 lives (Tanguy *et al.* 1998: 139) and affected rice production in Java's coastal regions. The enormous quantities of ash that were released by the eruption and the subsequent showers of ash pouring down also affected crop production across the Indonesian archipelago.

Third, the 4th (1864-75) and 5th (1883-96) global cholera pandemics were brought to Indonesia by Muslim pilgrims returning from the annual Hajj to Mecca. At that time, cholera was endemic in Indonesia and contributed to significant increases in mortality rates, such as during the 1874-1875 and 1881-1884 periods (Boomgaard 1987: 50; Gardiner and Oei 1987: 71), although other diseases, such as dysentery, malaria, smallpox and measles, also contributed to these rates.

Fourth, a massive outbreak of cattle plague occurred from 1879 to 1883, and the only solution at the time was the wholesale slaughter of infected and suspected animals (Spinage 2003: 487). In total, the stock of buffaloes in Java declined by 17% relative to 1878, particularly in West Java. This decline is likely to have negatively affected the food supply because buffaloes were crucial to the preparation of fields for rice production and as a source of protein. The cattle plague problem arose again during the 1889-1893 and 1897-1899 periods (Paulus *et al.* 1917-21, vol. 4: 522) until it was finally eradicated in 1911.[38]

[38] Was animal protein consumption influenced by religious taboos? Early 20th century assessments of food consumption practices across Indonesia suggest that religious or cultural customs did not impose major restrictions on the use of animal proteins. Paulus *et al.* (1917-21, vol.4: 597-604) notes that most Muslims would not strictly observe the religious bans on the consumption of pork or meat that was not *halal*. Unlike India, the Hindu faith in some regions of Indonesia, particularly in Bali, did not inhibit the consumption of beef, which is still the case today.

During this period, per capita food supply was only 1,600 to 1,750 Kcal per day in Java, which was scarcely sufficient for subsistence and physical labor on small farms (Van der Eng 2000: 596-7). However, such disasters occasionally obstructed the production of the main staple crop, rice, and affected the delicate balance between population growth and the growth of food production in Java. Markets for food products in Java were still poorly integrated by 1880 (Van Zanden 2004: 1040); thus, insufficient food from surplus areas reached deficit areas in Java. Poor market integration contributed to food shortages and malnutrition, particularly during the months immediately before each rice harvest. In turn, malnutrition contributed to stunted human growth.[39]

The Cultivation System that was promoted by the colonial government may have exerted additional pressure on nutritional status, but the factors mentioned above were primarily exogenous to this system. Nevertheless, the spread of human and cattle disease was likely promoted by the intensified global integration of Indonesia.

Such occurrences assist us in understanding the reduction in average height during the 1870s and the absence of recovery during the 1880s, but endemic malnutrition and diseases also assist in accounting for the low average human heights in Indonesia according to modern standards over a long period. Today's developed countries were in the past also affected by a combination of malnutrition and a disease environment that stunted human growth. For example, the Dutch were among the shorter populations in mid-19th century Europe because rapid urbanization had rendered the provision of food, especially fresh milk, costly (Drukker and Tassenaar 1997). At that time, regional populations that had easy access to substantial amounts of

[39] With the exception of the 1940s (see below), comparable episodes of reduced food supply and malnutrition did not re-occur in Indonesia during the 20th century, despite occasional massive volcano eruptions and droughts. Effectively, the increasingly advanced integration of markets for food crops allowed the Indonesian economy to absorb the consequences of such events.

animal protein (such as the American Indians or some of the white American farmer populations) were particularly tall, whereas a low population density created a beneficial disease environment (Steckel and Prince 2001; Komlos 2003). By the late 19th century, these populations were closely followed by Australians of European origin, who had similarly protein-rich diets. Improvements in the protein and calcium content of the average diet are likely to be an important factor in explaining average height gains, and *vice versa* (Baten 2009). As the final stature of humans is largely determined during the early years of life, the availability of those nutrients to children was crucial for the purpose of maximising adult stature (Bogin 1988).

Although not conclusive, Figure 3 suggests a close correlation between per capita protein supply and average male heights, particularly during the colonial years until the 1940s. However, most of the protein that was consumed was of vegetable origin, despite the growth of the consumption of animal products, particularly in recent decades. Indonesia does not have a tradition of dairy farming. Until recently, the production of milk and dairy products for human consumption was marginal and provided primarily to the non-indigenous population in the country (Den Hartog 1986: 64-102). Buffaloes and cows were employed as domestic animals but were largely used as draught animals for agricultural or transport purposes and for fertilizer. Approximately 10% of these animals was slaughtered every year, and per capita beef consumption was only 2 to 2.5 kilograms per person and year, or 6 to 6.5 grams per day in the late 19th century (Van der Eng 2000: 596-7). The consumption of eggs, poultry, goat meat and mutton may have been more relevant at the time, but there are no data to confirm this possibility. The consumption of dairy products has increased significantly only since the 1970s, primarily in urban areas. Until then, the main sources of protein in the average diet in Indonesia were rice, maize and soybeans; fish and meat were luxuries. Although the consumption of protein was quantitatively sufficient, the fact that this protein was primarily of vegetable origin may have caused the Indonesian population to miss out on the consumption of important calcium and vitamins in dairy products (Baten 1999) as well as antibodies that allowed dairy-consuming populations to withstand the effects of an adverse disease environment (Bogin 1988: 132-33). Nevertheless, the imperfect correlation in Figure 3 suggests that other factors must have been relevant.

One relevant factor is that Indonesia's economy experienced gradual growth in Gross Domestic Product (GDP) per capita after 1900, and this growth may indicate a broader array of gradual changes that both directly and indirectly affected the BSL (Van der Eng 2002a). An example is a gradual increase in public spending on the services of government agencies that fostered welfare (Boomgaard 1986; Cribb 1993). In addition, physical infrastructure improved, and the economy diversified and created a growing range of new income opportunities across the country. Public facilities for health care and hygiene gradually improved, and the negative effects of common diseases and pests on popular health gradually decreased, as demonstrated, for example, by the successful case of plague eradication (Hull 1987; Hugo *et al.* 1987: 108-9). Nevertheless, infant mortality in urban areas remained high in the 1930s (Van der Eng 2002b), which implies that the influence of improved health care and hygiene facilities was gradual.

The opening of new land for farming and new food production technologies also contributed to significant improvements in the average diet, particularly from 1905 to 1920 and later since the 1960s (Van der Eng 2000). There were occasional setbacks in terms of regional food shortages that caused local famines, such as in Semarang from 1900 to 1902 (Van der Eng 2004b), and epidemics, particularly the Spanish flu epidemic that affected Indonesia in 1918 (Brown 1987). The economic crisis of the early 1930s reduced income opportunities and may have represented a setback for human growth (Van der Eng 2000; Boomgaard 2000: 44-45). Figures 1 and 2 show that the 1930s and 1940s birth cohort experienced a relatively low level of height. During these decades, Indonesia experienced not only the World Economic Crisis but also the Japanese occupation and the war of independence. This time frame was a difficult period of economic contraction and a major famine that caused the death of an estimated 2.4 million people in Java from 1944 to 1945 (Van der Eng 2000: 605-7). After the 1940s, sustained improvements in health care and hygiene caused mortality rates to decrease and population growth to accelerate (Hugo *et al.* 1987: 107-35). These changes are likely to have reduced the incidence of infectious diseases in infancy and may have thus benefited human growth.

Another important change was the improvement of per capita food supply since the late 1960s. Until then, population growth and the growth of domestic food production had been delicately balanced, particularly in densely populated Java, with some improvements in per capita food supply during the 1920s and 1940-1941 but lower levels in the 1950s and 1960s. Underlying the growth of food production after the 1960s was the 'Green Revolution' in rice agriculture, the development and integration of domestic markets for food products that enhanced the growth of the marketable surplus and the diversification of food production, and greater flows of food products from surplus areas to deficit areas (Van der Eng 2000: 605-7). Assisting these improvements was the accelerating rate of economic growth since the 1970s, which facilitated a significant increase in public and private investment in physical and health-related infrastructure. Infant mortality rates decreased further (Van der Eng 2002a) and thus yielded further improvements in health care and hygiene, which in turn encouraged human growth in Indonesia. According to Frankenberg *et al.* (2005: 6), midwife activity was particularly noticeable in Indonesia. The effects of improvements in health care and hygiene were provided by the introduction of village-midwife programs in 1989, which had large positive effects on the height-for-age values.[40]

3.4 Conclusion

In this paper, for the first time, we presented data on long-term trends in the average heights of adults in Indonesia since the birth decade of the 1770s. The data were obtained from four different sources, and they were closely scrutinised for the purpose of ensuring their comparability.

We were primarily interested in the question of how the BSL developed during colonial times. Did it increase substantially after decolonization? We established that human stature declined during the second phase of the colonial period, when the Dutch colonial government implemented the Cultivation System in much of Java after the 1830s. This system may have enhanced the cultivation of major export crops, such as coffee, sugar cane and indigo, in Java at the expense of food production for local subsistence, and may have had a detrimental effect on the nutritional status of Indonesians, given that markets were imperfect.

A second hypothesis was that the increased international interaction during the ‘First Era of Globalization’ of the late 19th century could have contributed to a deterioration of the disease environment in Indonesia. We demonstrated that the 1870s and 1880s constituted a difficult period for Indonesia. Specifically, we attribute the height decline to four disasters: a sequence of droughts, the massive eruption of the Krakatau volcano in 1883, cholera epidemics and cattle

40 Maccini and Yang (2009) studied weather variation and documented that higher early-life precipitation has large positive effects on the adult heights, health and a household asset index for women, but not for men. The positive impacts are the results of the effect of rainfall on crop output, impacting especially on the nutrition of infant girls (Maccini and Yang 2009: 11).

plague. The effects of the latter two disasters on heights may have been compounded by a situation of weakened antibodies resulting from less protein-rich nutrition of both humans and cattle.

Beginning in the 1890s, the Dutch colonial government implemented a number of welfare policies that involved agencies for hygiene and health care, agricultural extension, veterinary services, small-scale credit facilities and similar institutions. Nevertheless, the recovery of average heights during this period was slow, especially in international comparison (Baten and Blum 2012).

After decolonization, there was a gradual increase in average heights that was related to a gradual improvement in the general economic situation and, more specifically, to improvements in nutrition and the disease environment. Both factors enhanced human growth, particularly during the crucial period of infancy. Although these explanations are plausible, the relative importance of each of these factors remains uncertain and should thus be the subject of further research.

References

Abeyasekere, Susan (1983) 'Slaves in Batavia: Insights from A Slave Register.' In Reid, Anthony ed. *Slavery, Bondage, and Dependency in Southeast Asia*. (St Lucia: University of Queensland Press) 286-314.

Acemoglu, D., Johnson, S., and Robinson, J. A. (2001) 'The Colonial Origins of Comparative Development: An Empirical Investigation', *American Economic Review* 91(5): 1369-1401.

Acemoglu, D., Johnson, S., and Robinson, J. A. (2002) 'Reversal of Fortune: Geography and Institutions in the Making of the Modern World Income Distribution', *Quarterly Journal of Economics* 117(4): 1231-1294.

Austin, Gareth; Baten, Joerg and Van Leeuwen, Bas (2012) 'The Biological Standard of Living in Early Nineteenth-Century West Africa: New Anthropometric Evidence for Northern Ghana and Burkina Faso', *Economic History Review* (forthcoming).

Baten, Joerg (1999) *Ernährung und wirtschaftliche Entwicklung in Bayern, 1730-1880*. [Nutrition and Economic Development in Bavaria, 1730-1880] Stuttgart: Franz Steiner.

Baten, Joerg (2000) 'Height and Real Wages: An International Comparison.' *Jahrbuch für Wirtschaftsgeschichte* 2000-1: 17-32.

Baten, Joerg (2009) 'Global Height Trends in Industrial and Developing Countries, 1810-1984: An Overview.' Working Paper, University of Tuebingen, http://www.wiwi.uni-tuebingen.de/cms/fileadmin/Uploads/Schulung/Schulung5/Paper/baten_global.pdf

Baten, Joerg and Hira, Sandew (2008) 'Anthropometric Trends in Southern China, 1830-1864.' *Australian Economic History Review* 48: 209-226.

Baten, Joerg; Ma, Debin; Morgan, Stephen and Wang, Qing (2010) 'Evolution of Living Standards and Human Capital in China in the 18^{th}-20^{th} Centuries.' *Explorations in Economic History*, 47(3) 347-359.

Baten, Joerg; Blum, Matthias (2012) 'Growing Taller, but Unequal: Biological Well-Being in World Regions and Its Determinants, 1810-1989', *Economic History of Developing Regions* (forthcoming).

Block, Steven; Kiess, Lynnda; Webb, Patrick; Kosen, Soewarta; Moench-Pfanner, Regina; Bloem, Martin W.; Timmer, Peter (2004) 'Macro Shocks and Micro Outcomes: Child Nutrition during Indonesia's Crisis.' Economics & Human Biology, 2: 21-44.

Bogin, Barry (1988) Patterns of Human Growth. Cambridge: Cambridge University Press.

Boomgaard, Peter (1986) 'The Colonial Welfare Services.' Itinerario 10(1) 57-82.

Boomgaard, Peter (1987) 'Morbidity and Mortality in Java, 1820-1880: Changing Patterns of Disease and Death.' In Owen, Norman G. ed. Death and Disease in Southeast Asia: Explorations in Social, Medical and Demographic History. (Singapore: Oxford University Press) 48-69.

Boomgaard, Peter (2000) 'Surviving the Slump: Developments of Real Income during the Depression of the 1930s in Indonesia, Particularly Java.' In Boomgaard, Peter and Brown, Ian eds. Weathering the Storm: The Economies of Southeast Asia in the 1930s Depression. (Singapore: ISEAS) 23-52.

Booth, Anne (1998) The Indonesian Economy in the Nineteenth and Twentieth Centuries: A History *of Missed Opportunities.* Basingstoke: Macmillan.

Brennan, Lance, McDonald, John, and Shlomowitz, Ralph (1994a) 'Trends in the Economic Well-being of South Indians under British Rule: The Anthropometric Evidence.' *Explorations in Economic History* 31: 225-60.

Brennan, Lance, MacDonald, John, and Shlomowitz, Ralph (1994b) 'The Heights and Economic Wellbeing of North Indians under British Rule.' *Social Science History* 18: 271-307.

Brown, Colin (1987) 'The Influenza Pandemic of 1918 in Indonesia.' In Owen, Norman G. ed. *Death and Disease in Southeast Asia: Explorations in Social, Medical and Demographic History.* (Singapore: Oxford University Press) 235-256.

Cribb, Robert (1993) 'Development Policy in the Early Twentieth Century.' In Dirkse, Jan-Paul; Hüsken, Frans and Rutten, Mario eds. *Development and Social Welfare: Indonesia's Experiences in the New Order.* (Leiden: KITLV Press) 225-246.

Deaton, Angus (2008) 'Height, Health, and Inequality: The Distribution of Adult Heights in India.' *American Economic Review*, 98: 468-74.

Den Hartog, Adel P. (1986) *Diffusion of Milk as a New Food to Tropical Regions: The Example of Indonesia, 1880-1942.* Wageningen: Stichting Voeding Nederland.

Dick, Howard W.; Houben, Vincent J.H.; Lindblad, J. Thomas; and Thee Kian Wie (2002) '*The Emergence of a National Economy in Indonesia, 1800-2000.'* Sydney: Allen and Unwin.

Dickens, William T. (1990) 'Error Components in Grouped Data: Is it Ever worth Weighting?' *The Review of Economics and Statistics* 72: 328-33.

Drukker, Jan-Willem and Tassenaar, Vincent (1997) 'The Case of the Shrinking Dutchmen: Another Example of the "Early-Industrial-Growth Puzzle.' In Steckel, Richard and Floud, Roderick eds. *Health and Welfare during Industrialization.* (Chicago: University of Chicago Press) 331-78.

Eltis, David (1982) 'Nutritional Trends in Africa and the Americas: Heights of African, 1819-1839.' *Journal of Interdisciplinary History* 12: 453-475.

FAO (2005) *Livestock Sector Brief* (Indonesia and Thailand). Rome: Food and Agriculture Organization.

Frankenberg, Elizabeth; Suriastini, Wayan and Thomas ,Duncan (2005) 'Can expanding access to basic healthcare improve childrens's health status? Lessons from Indonesia's midwife in the village programme' *Population Studies*, 59: 5-19.

Földvári, Péter; Gáll, József; Marks, Daan and Van Leeuwen, Bas (2012) 'Indonesia's regional welfare development, 1900-1990: new anthropometric evidence', *Economics & Human Biology,* (forthcoming).

Gardiner, Peter and Oei, Mayling (1987) 'Morbidity and Mortality in Java, 1880-1940: The Evidence of the Colonial Reports.' In Owen, Norman G. ed. *Death and Disease in Southeast Asia: Explorations in Social, Medical and Demographic History.* (Singapore: Oxford University Press) 70-90.

Guntupalli, Aravinda Meera and Baten, Joerg (2006) 'The Development and Inequality of Heights in North, West and East India, 1915-44.' *Explorations in Economic History*, 43: 578-608.

Hugo, Graeme J.; Hull, Terence H.; Hull, Valerie J. and Jones, Gavin W. (1987) *The Demographic Dimension in Indonesian Development.* Singapore: Oxford University Press.

Hull, Terence H. (1987) 'Plague in Java.' In Owen, Norman G. ed. *Death and Disease in Southeast Asia: Explorations in Social, Medical and Demographic History.* (Singapore: Oxford University Press) 210-34.

Koepke, Nikola and Baten, Joerg (2005) 'The Biological Standard of Living in Europe during the Last Two Millennia.' *European Review of Economic History* 9: 61-95.

Koepke, Nikola and Baten, Joerg (2008) 'Agricultural Specialization and Height in Ancient and Medieval Europe.' *Explorations in Economic History* 45: 127-146.

Komlos, John (1985). “Stature and Nutrition in the Habsburg Monarchy: The Standard of Living and Economic Development in the Eighteenth Century,” *American Historical Review* 90 (5), 1149-61.

Komlos, John (2003) ‘Access to Food and the Biological Standard of Living: Perspectives on the Nutritional Status of Native Americans.’ *American Economic Review 93:252-256*.

Leigh, Andrew and Van der Eng, Pierre (2009) ‘Inequality in Indonesia: What Can We Learn from Top Incomes?’ *Journal of Public Economics* 93: 209-12.

Maccini, Sharon L. and Yang, Dean (2008) ‘Undter the Weather: Health, Schooling and Economic Consequences of Early-Life Rainfall’ *NBER Working Paper No. 14031*.

Maddison, Angus (2006) *The World Economy: Historical Statistics*. Paris: OECD.

Moradi, Alexander (2008) ‘Confronting Colonial Legacies: Lessons from Human Development in Ghana and Kenya, 1880-2000’, *Journal of International Development*, 20: 1107-20,

Moradi, Alexander (2009) ‘Towards an Objective Account of Nutrition and Health in Colonial Kenya: A Study of Stature in African Army Recruits and Civilians, 1880-1980.’ *Journal of Economic History* 69: 719-754.

Moradi, Alexander and Baten, Joerg (2005) ‘Inequality in Sub-Saharan Africa 1950-80: New Estimates and New Results.’ *World Development* 33: 1233-65.

Paulus, J.; De Graaff, S. and Stibbe, D.G. (1917-21) *Encyclopaedie van Nederlandsch-Indië* [Encyclopedia of the Netherlands Indies]. The Hague: Nijhoff (4 volumes).

Reid, Anthony (1987) ‘Low Population Growth and Its Causes in Pre-Colonial Southeast Asia' in Owen, Norman G. (ed.) *Death and Disease in Southeast Asia: Explorations in Social, Medical and Demographic History* (Singapore: Oxford UP) 33-47

Spinage, C.A. (2003) *Cattle Plague: A History*. New York/Dordrecht: Kluwer Academic.

Steckel, Richard H. and Prince, Joseph M. (2001) 'Tallest in the World: Native Americans of the Great Plains in the Nineteenth Century', *American Economic Review* 97(1): 287-94.

Stegl, Mojgan and Baten, Joerg (2009) 'Tall and Shrinking Muslims, Short and Growing Europeans: an Anthropometric History of the Middle East, 1840-2007.' *Explorations in Economic History* 46: 132-48.

Tanguy, J.C.; Ribière, Ch.; Scarth, A. and Tjetjep, W.S. (1998) 'Victims from Volcanic Eruptions: A Revised Database.' *Bulletin of Vulcanology* 60: 137-144.

Van Bemmelen, W. (1916) 'Droogte Jaren op Java.' [Years of drought in Java]. *Natuurkundig Tijdschrift voor Nederlandsch-Indië* 75: 157-179.

Van der Eng, Pierre (1995) 'An Inventory of Secular Changes in Human Growth in Indonesia' in Komlos, John ed. *The Biological Standard of Living in Three Continents: Further Explorations in Anthropometric History.* (Boulder: Westview Press) 175-88.

Van der Eng, Pierre (1996) *Agricultural Growth in Indonesia: Productivity Change and Policy Impact since 1880.* Basingstoke: MacMillan.

Van der Eng, Pierre (2000) 'Food for Growth: Trends in Indonesia's Food Supply, 1880-1995.' *Journal of Interdisciplinary History* 30: 591-616.

Van der Eng, Pierre (2002a) 'Indonesia's Growth Performance in the Twentieth Century.' In Maddison, Angus; Prasada Rao, D.S. and Shepherd, William eds. *The Asian Economics in the Twentieth Century.* (Cheltenham: Edward Elgar) 143-179.

Van der Eng, Pierre (2002b) 'Halting Progress: Indonesia's Economic Development since 1880.' *Itinerario* 26 (3/4): 15-34.

Van der Eng, Pierre (2004a) 'Cultivation System.' In Ooi Keat Gin ed. *Southeast Asia: A Historical Encyclopedia.* (Santa Barbara: ABC-Clio) 391-394.

Van der Eng, Pierre (2004b) ‘Famines.’ In Ooi Keat Gin ed. *Southeast Asia: A Historical Encyclopedia.* (Santa Barbara: ABC-Clio) 499-501.

Van Zanden, Jan Luiten (2004) ‘On the Efficiency of Markets for Agricultural Products: Rice Prices and Capital Markets in Java, 1823-1853.’ *Journal of Economic History* 64: 1028-55.

Van der Eng, Pierre (2010) ‘The Sources of Long-Term Economic Growth in Indonesia, 1880-2008.’ Explorations in Economic History 47: 294-309.

Wolff ,François-Charles and Maliki (2008) ‘Evidence on the impact of child labor on child health in Indonesia, 1993-2000’, Economics & Human Biology 6(1): 143-169 World Bank (2005) World Development Report 2006. Washington DC: The World Bank**.**

Tables

Table 1: Regressions of Heights of Indonesian Slaves Aged 20-55 by Region of Origin, Reported in Batavia (Jakarta) 1816

	(1)	(2)	(3)	(4)
Rounding	Only modest	Only modest	All	All
Gender	Males	Females	Males	Females
Bali	-0.56	5.04**	-1.49	1.15
Java (excl. Jakarta)	0.58	4.13	-3.91	1.11
Nusa Tenggara	0.96	5.26*	-2.67	2.47
Sulawesi	0.68	1.31	-0.93	-2.36
Sumatra	-6.10**	-1.75	-6.58***	-3.51*
Age 20-22	-0.76	-1.63	-0.56	-2.14
Constant	157.39***	144.11***	157.53***	145.32***
Observations	292	308	758	779
R-squared	0.02	0.03	0.01	0.02
Weighted average	156.3	146.0	153.9	144.5

	Pop share (=weight)	Sample share
Bali	0.002	0.140
Jakarta	0.032	0.192
Java (excl. Jakarta)	0.343	0.067
Nusatenggara	0.120	0.116
Sulawesi, Kalimantan, Maluku	0.240	0.400
Sumatra	0.263	0.087

Notes: All explanatory variables are included in the regression as dummy variables. The constant refers to slaves born in Batavia (Jakarta).
*** $p<0.01$, ** $p<0.05$, * $p<0.1$
Sources: On the slave data set, see Abeyasekere (1983). Population figures are mainly from Reid (1987), here pp.46 and 47.

Table 2: Regressions of Heights of Migrants to Surinam

	(1)	(2)	(3)	(4)
	Adult males (23-55)	Males, aged 18-22	Adult females (23-55)	Females, aged 18-22
Bdec1850	1.82**			
Bdec1860	0.88***		0.47	-1.6
Bdec1870	-0.1	-0.58*	-0.31	-0.28
Bdec1880	-0.47**	-1.20***	-1.27***	-1.31***
Bdec1890	0.39**	-0.38	0.16	-0.41*
Bdec1910	-0.73	-1.12***	-1.60***	-1.13***
Jakarta	1.08***	1.14	1.33**	1.79**
Central Java	-0.29	-0.51	-0.16	0.4
East Java	0.17	0.52	0.1	0.87*
Yogyakarta	-1.10***	-0.56	-0.42	0.21
age51+	-1.35		1.19	
age18		-2.77***		-2.80***
age19		-2.03***		-1.79***
age20		-1.55***		-1.14***
age21		-0.35		-1.01***
Constant	159.32***	158.10***	149.21***	147.90***
Observations	11,650	3776	6349	3501
R-squared	0.01	0.05	0.01	0.04

Notes: All explanatory variables were included in the regression as dummy variables. The constant refers in all models to a person born in West Java during the 1900 birth decade. *** p<0.01, ** p<0.05, * p<0.1
Source: See Figure 1.

Table 3: Regressions of Heights of Males from Anthropological and Medical Surveys

	(1) Male adult	(2) Male age 18-22
bdec1850	1.42*	
bdec1860	2.06***	
bdec1870	-1.65***	
bdec1880	-0.29	
bdec1890	-0.77***	
bdec1910	0.95***	
bdec1920	2.33***	
bdec1930		0.21
Central Java	-0.22	4.40**
Bali	2.29***	
Central Kalimantan	-0.34	
Nusa Tenggara	-1.78***	
North Sulawesi	-0.55	
North Sumatra	2.69***	3.49
West Nusa Tenggara	1.39***	
West Sumatra	-0.42	
Yogyakarta	2.81***	
age1819		-2.38*
age2021		-4.24**
Constant	158.60***	159.10***
N(underlying)	12,195	2,020

Notes: All explanatory variables are included in the regression as dummy variables. The constant of the regression of adult height refers those born in 1900s in West Java. The constant of the regression of adults aged 18-22 refers those born in the 1920s in West Java, aged 22. N(underlying) refers to the underlying, originally measured persons. For example, due to the nature of grouped data, the underlying number of measurements are 12,195 in the first column, but there are grouped into 2,155 groups for the adults. The 2,020 underlying height measurements for the young group (age 18-22) are grouped data into only ten different groups. The R-squares would be misleading here and are hence not reported.

Sources: On the anthropological and medical studies in Indonesia, see a list of references available from the authors.

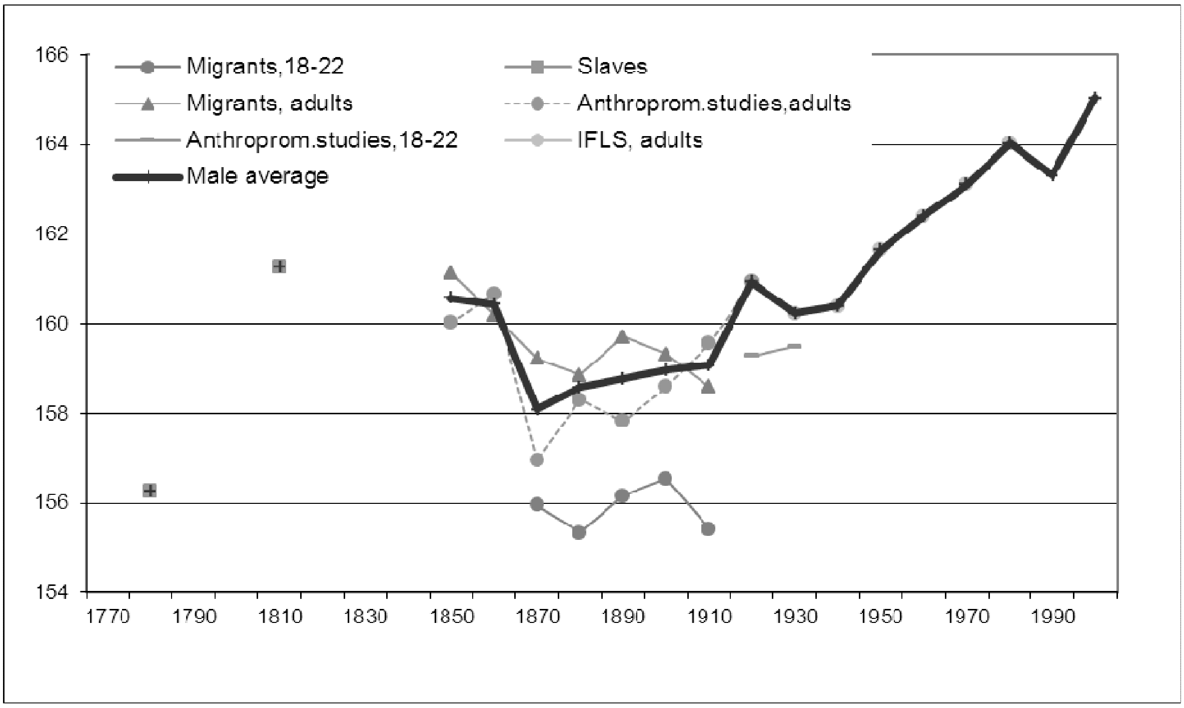
Table 4: Regressions of Heights from the IFLS Datasets for 1993, 2000 and 2007

	(1)	(2)
	Male Adults	Female Adults
Bdec1930	-3.87***	-2.66***
Bdec1940	-2.70***	-2.09***
Bdec1950	-1.46***	-0.73***
Bdec1960	-0.70***	-0.40**
Bdec1980	0.92**	0.81**
North Sumatra	0.18	-0.11
West Sumatra	-0.83**	-0.66**
Bali	1.03***	2.25***
Central Java	-1.33***	-0.50**
East Timor	-0.46*	-0.35
Jakarta	0.33	0.27
Lampung	-1.21***	-0.79**
Riau	4.27**	0.73
South Kalimantan	-1.72***	-1.40***
South Sulawesi	0.05	0.56*
South Sumatra	-1.03**	-0.15
West Nusa Tenggara	-1.21***	-0.62*
Yogyakarta	-0.17	0.63*
Constant	163.10***	150.97***
Observations	6,359	7,191
R-squared	0.04	0.03

Notes: The explanatory variables were included in the regression as dummy variables. The constant of the regression of adult height refers those born in 1970 in West Java. *** p<0.01, ** p<0.05, * p<0.1. We also estimated using the sample weight variable. The differences were very small. But as we control for regional composition effects anyway in Table 4, we only report the unweighted estimates here.
Sources: Indonesian Family Life Survey 1993, 2000 and 2007.

Figures

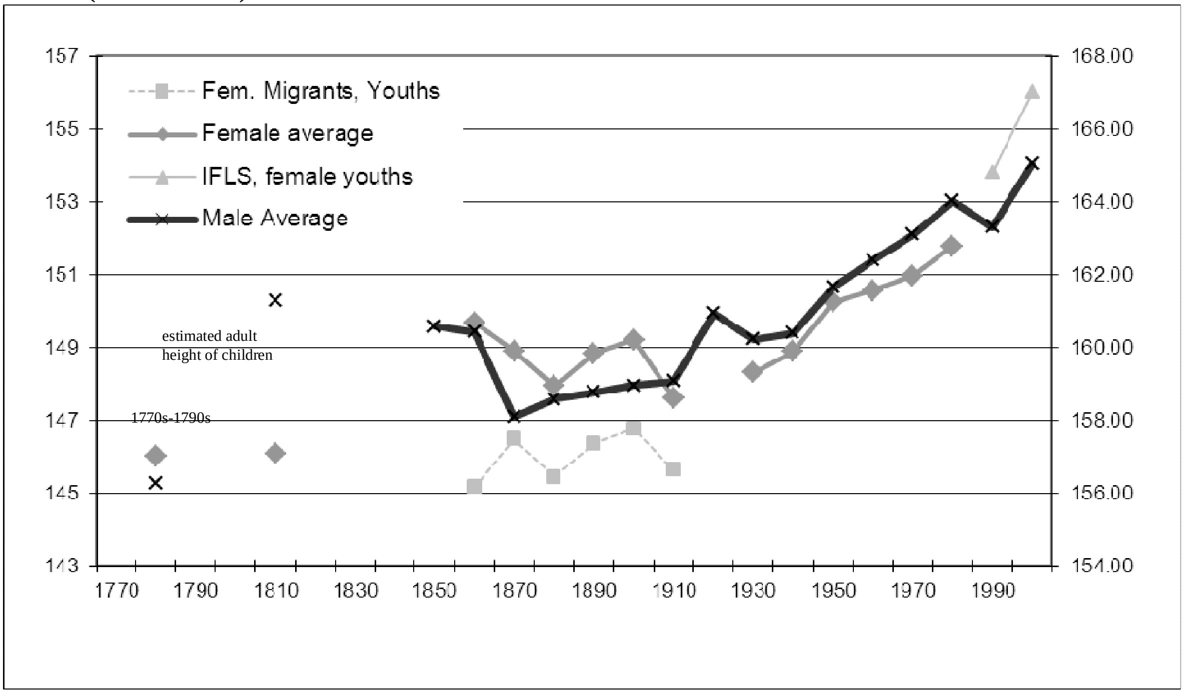
Figure 1: Average Male Height in Indonesia by Birth and Measurement* Decade, 1770s-2000s (centimetres)



Notes: *Measurement decade is used for children measured in the 1810s, 1990s and 2000s. Birth decade 1780s refers to 1770s-1790s. For males aged 54-55 (birth decade 1930s) in the IFLS dataset, 1 cm was added to account for old-age shrinking. For the adolescents in anthropological surveys (anth_age18-22), we included their average instead the regression results.

Sources: On the slave data set, see Abeyasekere (1983). Sources for migrant heights: Historical Database of Suriname, assembled by Maurits Hassankhan (University of Suriname) and Sandew Hira (Amrit Consultancy), based on the following original source: National Archives of Suriname, immigration registers. On the anthropological and medical studies in Indonesia, see a list of references available from the authors. On the post-war period: Indonesian Family Life Survey 1993, 2000 and 2007.

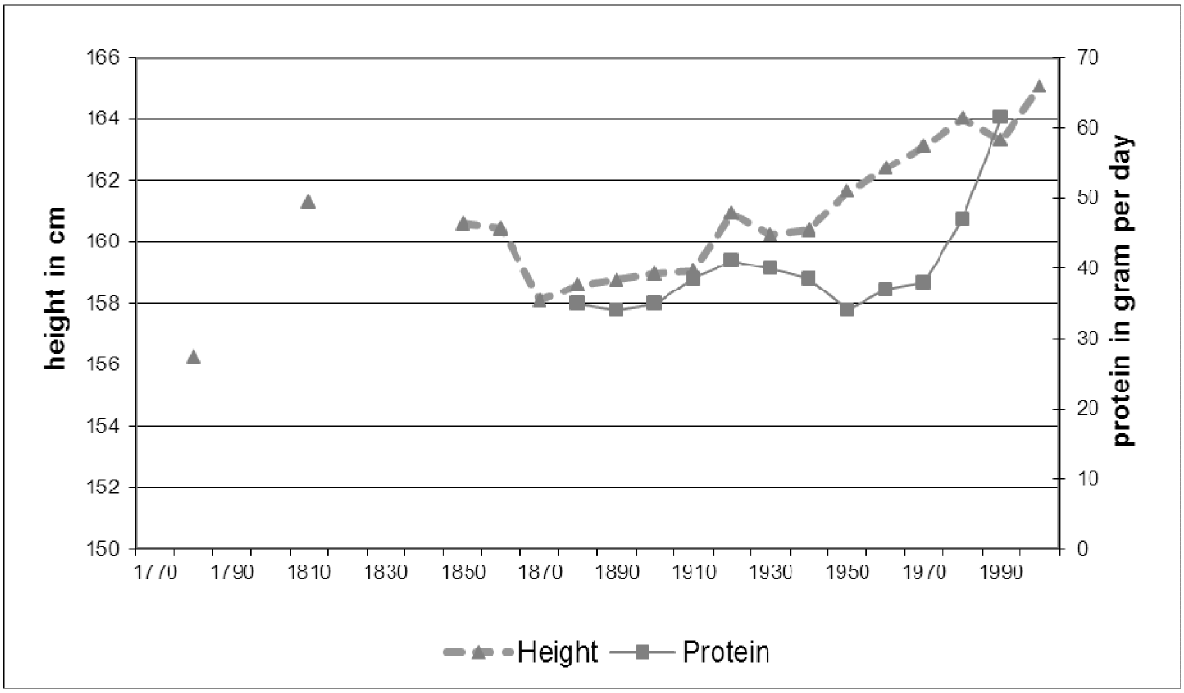
Figure 2: Female and Male Height in Indonesia by Birth and Measurement* Decade, 1770s-2000s (centimetres)



Note: *Measurement decade is used for children measured in the 1810s, 1990s and 2000s. Birth decade 1780s refers to 1770s-1790s. "Female average" refers to the following series: between 1780 and 1810 female slaves, between 1860 and 1910 to female migrants (adults) and between 1930 and 1980 to IFLS female adults.

Sources: See Figure 1.

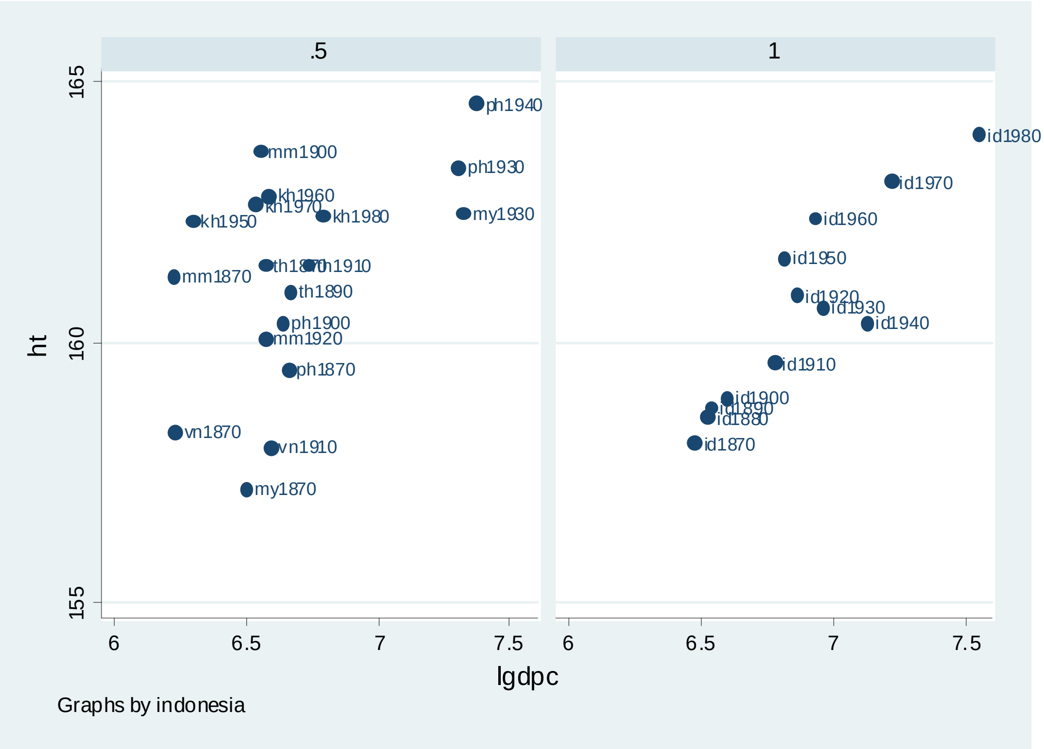
Figure 3: Average Male Heights and Per Capita Supply of Protein, 1880s-2000s



Note: Heights by birth decade, except: measurement decade is used for children measured in the 1810s, 1990s and 2000s. Measurement decade is used for children measured in the 1810s, 1990s and 2000s. Per capita protein supply averaged by decade.

Sources: Figure 1 and Van der Eng 2000.

Figure 4: Heights of Adult Males and GDP per Capita in Indonesia (right panel) and other Southeast Asian countries (left panel)



Notes: Heights by birth decade.
Abbreviations: left panel -- mm-Burma/Myanmar, kh-Cambodia, th-Thailand, ph-Phillippines, vn-Vietnam, my-Malaysia. Right panel: id-Indonesia.
Source: Compilation of global height by Baten and Blum (2012), thanks to Matthias Blum and Jörg Baten for providing the data. Decade averages of male heights calculated from Figure 1 (Indonesia); Decade averages of GDP per capita from Maddison (2006), extended for Indonesia to 2008 based on Van der Eng (2010).

4. Nutritional Status and Oil Production 1925-1995

Abstract:

Middle Eastern countries with oil abundance tend to grow slowly in terms of GDP per capita and in terms of the average heights of their countries' citizens in comparison to the other oil-producing countries. We run regressions on a sample of 25 oil-producing countries over the last 75 years and address the difficulties raised by the endogeneity. The database allows us to distinguish between Middle Eastern countries and other oil-producing countries. The results show clearly that an increase of petroleum production leads to an increase in Biological Standard of Living. The vast oil revenues may increase income and purchasing power and health and education infrastructure of the underlying population and thereby lead to growing mean heights.

Keywords: biological standard of living, human heights, welfare, economic development, oil abundance

4.1 Introduction

The standard of living of a country is determined by its economic output, its distribution of income and its wealth inheritance from past generations (Allen 2004). In terms of nutritional status or Biological Standard of Living, one disadvantaged world region over the last several decades is the Middle East[41]. During the late 19th century, the population of Western industrial countries overtook the Middle Eastern regions in terms of Biological Standard of Living. Thus, a strong divergence in human stature is observable when the height of Middle Eastern populations is compared with that of industrial countries (Baten and Stegl 2009). This feature is surprising given that oil revenues have culminated in an excess of $4 trillion over the past 25 years (Askari 2006).

Lower mean heights[42] may be attributed to nutritional, economic or cultural factors (Floud et al. 2011, Steckel 1995). Biological Standard of Living can decrease even as income and consumption increase if the disease environment worsens immensely or labor efforts are highly strenuous (Floud et al. 2011, Komlos et al. 1998, Baten, 2000). Therefore, the improvement in hygiene and medical care since the 1950s in several countries may raise the expectation that the relationship between height and income will rise over time in a country that receives large oil revenues. The theory of international trade asserts that every country has a comparative advantage and a free trade policy can enhance economic growth (Ricardo 1817). The basic expectation is that an increase in international trade, particularly in oil exports, is accompanied by a massive public investment in infrastructure, health and education. Because natural resource revenues may increase wealth and purchasing power, resource abundance may be expected to

[41] Throughout this article, the term Middle East is used to refer to the countries of Algeria, Egypt, Iran, Iraq, Kuwait, Qatar, Syria, Tunisia and Turkey.
[42] Genetic is a important determinant for the individual height, but across averages of population the differences are cancel out (Steckel 1995). The consideration of the Japanese-American and Italian-American population in the United States have shown clearly that height have not been constrained by any genetic factors (Floud et al. 2011).

raise an economy's output and growth rates and thereby lead to growing mean heights. However, for countries with an abundance of natural resources, an inverse relationship between economic growth and natural capital has been found (Gylfason 2001, Sachs and Warner 2001).

According to Issawi (1995, p. 93), the onset of the first era of globalization coincides with foreign trade expansion in many Middle Eastern countries. Oil production is a major item on the revenue side of government budgets, and oil tends to be controlled by governments (Cremer et al. 1989). The following question arises at this point: is there a relationship between the development of oil production and Biological Standard of Living? In the case of the Middle East, oil production is an inevitable factor.

From 1960 to 1985, the GDP per capita growth in the Middle Eastern and North African regions was 3.7 percent per year. This figure lags 4.3 percent behind the GDP per capita growth of the East Asian and Pacific regions, whereas the Latin American and Caribbean regions had a 1.6 percent higher annual increase in per capita GDP compared with the Middle East and North African regions (Yousef 2004, Askari 2006). Despite the large oil exports from the region, the share of exports plus imports to GDP has declined since the mid-1970s and stagnated since the mid-1980s. Excluding oil, trade declined from 53 percent of GDP in the early 1980s to 43 percent in 2000 (Askari 2006, p.14). The Middle East has become one of the least integrated regions in the global economy while also being engaged in an unusually large number of conflicts over the past four decades (Sørli et al. 2005).

Scholars have offered a wide range of explanations for the dismal economic situation in the Middle East. These explanations include structural economic imbalances, the so-called "curse of natural-resources", deficient political systems, conditions of war and conflict and even cultural and religious factors (Yousef 2004). The existing empirical literature underlines rent-seeking behavior and poor political governance to explain the curse of natural resources in Middle

Eastern countries (Collier et al. 1996). Furthermore, oil revenues are used to finance military buildup to consolidate their funding for internal security (Ross 2001 p. 335). These expenditures and the concurrent conflicts and wars have devoured valuable resources from productive economies over the last three decades (Askari 2006). Regarding the issue of conflict and war, the Middle East is the most militarized region in the world (Sørli et al. 2005). Several empirical studies have emphasized that oil production is significantly related to the onset of conflicts (Fearon et al. 2003). As a consequence, oil wealth may impede the formation of human capital and social institutions. In turn, improvements in Biological Standard of Living will be hindered.

The negative connection between resource affluence and GDP growth is based on the post-war dataset (Sachs et al. 1995, 1997, Gelb 1988, Gylfason 2001 and Kronenberg 2004). These studies have argued that the curse of natural resources is an empirical fact. These findings are robust to the introduction of several control variables, such as initial per capita income, trade policy, government efficiency and investment rates. High resource intensity tends to correlate with slow growth (Sachs et al. 2001).

Mean height can be used to measure changes in Biological Standard of Living respectively nutritional status. This measurement accounts for the development of nutrition, health, and longevity. Nutritional status is a net measure and is based on the concept of capability, which tends to reflect a population's use of resources over the long term (Floud et al. 2011, Baten 1999). Moreover, as an indicator, mean height represents a proxy for human capital and the current consumption of social resources (Schultz 2005). Changes in mean height are driven by multiple causes, though only a portion of the variations may be explained by socioeconomic variables (Floud et al. 2011).

This paper focuses on determining whether the curse of natural resources remains if human height is used as another indicator. Was human height been significantly affected by oil production and exports? The connection between mean height and oil production will be the main topic of this paper.

The paper is organized as follows. The second section of this study describes the results of a wide range of quantitative studies. It discusses some of the theories that explain the curse of natural resources. The third section highlights the dataset and section four examines the empirical analysis. Section five summarizes the results.

4.2 Oil production and a brief overview of the related literature

In the trade literature, authors consider the positive statistical correlation between trade and growth in real income. According to theoretical conclusions, opening up to international trade benefits a country's economic development by allowing the country to use its comparative advantages. Countries that move from autarky to free trade realize gains (Ricardo 1817, Samuelson 1962). However, in the case of oil-rich countries, other mechanisms are tightly entangled with the oil trade. The next section briefly explores additional aspects of the resource curse to understand the conceptual framework and mechanisms in the literature.

First, because the manufacturing sector in many Middle Eastern countries is not strongly developed and unable to compete in the global economy (Owen et al. 1999), the implication is that the growth contribution of the manufacturing sector is small. Baldwin et al. (2004) and Seers (1964) assert that the manufacturing sector can create a more differentiated division within the economy and a complex labor market. The positive wealth shocks from the export of natural resources raise the demand for non-tradable products and draw skilled workers and physical capital from other sectors. These crowding-out effects and the inflow of oil revenues tend to increase the price of non-tradable goods, such as housing and services, relative to the price of tradable goods (Gylfason et al., 1999). As a result, manufacturing activity declines, and non-export economic growth is relatively slow. The booms in the natural resource sector pull resources in and out of the non-traded sector and induce a de-industrialization. Accordingly, this process is the first channel summarized under the hyponym ‘Dutch disease’ in several studies (Frankel et al. 1999, Sachs et al. 2001).

Oil-producing countries seem to reveal symptoms of the Dutch disease, which are mostly induced by policy (Auty 2001). In particular, necessary economic and political reforms are delayed, and rent-seeking behavior in the government and the elite produce distortions in the factor and labor markets. In many Middle Eastern countries, huge wage differentials exist because of the predominant role played by the government as an employer (Assad 1997, Askari 2006). Thus, the allocation of labor may exacerbate the situation for the private sector. In addition, interventionist-redistributive governments create significant distortions in product and factor markets. These externalities are closely connected to high corruption and rent-seeking behavior. Furthermore, weak institutional structures and a lack of political reform have handicapped renewal processes (Auty et al. 2001, Auty 2001, Fidrmuc 2003).

Gylfason (2001) presents empirical evidence for the negative connection between natural resources and growth because of the low investment in human capital and education. In the empirical examinations, low levels of public expenditures on education are correlated with natural resource abundance. The absence of governmental economic policies and institutions induces structural unemployment and hinders economic development. Furthermore, the quality of education and healthcare is weak. As a result the author concludes, that only more effective institutions can improve the allocation of education and health care, and both are necessary conditions for a proper labor force market.

Countries with abundant natural resources are more likely to suffer from unpredictable and disruptive shocks in global commodity prices (Alexeev et al. 2009). Additionally, their growth rates are quite volatile because of their high dependence on oil revenues. For example, the real GDP per capita growth rate in oil-exporting countries has been twice as volatile as that of non-oil exporting countries. In many countries, protective policies and subsidies are commonly used to offset the volatile foodstuff and service prices (Alexeev et al. 2009).

For many of these countries, even approximate GDP statistics became available for the first half of the twentieth century. Therefore, Pamuk (2006) estimated the economic growth rates of Middle Eastern countries since 1820 based on various data sources. In this study, one of the determinants of per capita income was oil.

Several empirical studies drop the oil-rich Middle East states from their examinations because of the dearth of information[43]. By using height data, the aim is to develop an empirical model that integrates nutritional status component and oil abundance with economic development over the last 75 years.

4.3 Data Discussion

A new and comprehensive source of anthropometric data has become available for many world regions, and a comprehensive description of the estimated mean height is provided in the Baten and Blum (2012) study. The mean heights for several countries are empirically derived based on anthropometric sources[44]. According to this study, after the 1880s, a divergent process can be observed throughout the different world regions. The main determinants of height are protein availability; disease environment, lactose tolerance, and geography (see Baten and Blum 2012 and the sources cited therein). The mean height of a given population indicates the availability of medical, nutritional and economical resources.

[43] See Przewosrki et al. (1997) and Przeworski et al. (1996).
[44] For a more detailed description of the dependent variable height, see Baten (2006), Baten and Stegl (2009), Baten and Blum (2012): see Data Appendix D.

In this paper the hypotheses is, whether increased oil production and petroleum revenues lead to a reduction or an enhancement in nutritional status while simultaneously controlling for the main determinants of human height. We aim to use the height data and introduce crude oil production data from Mitchell (1980, 1982 and 1983)[45]. By using petroleum production data as the main explanatory variable, this study focuses only on the supply of oil while excluding the effects of oil prices. Oil supply shocks and determinant of real oil prices have been studied extensively by Hamilton 2003 and Kilian 2008, 2009. The results suggest that production plans are changed only infrequently and slowly. Crude oil supply does not respond to the demand shocks, because of the slow cost adjustment of the oil producing countries (Kilian 2009). Supply shocks tend to be mainly determined by the current physical availability of the crude oil. While variation of the historical oil prices seem to be caused by global aggregated demand shocks, precautionary demand shocks and exogenous shortfalls in crude oil production (Kilian 2009). In this situation oil supply/ production accurately reflect the contemporaneous technology adoption.

Although real oil prices are not used for the empirical examinations, it is noteworthy that real oil prices increased from an index of 1.0 in 1973 to 5.83 in 1981 before declining to 2.42 in 1989 (Askari 2006). These immense changes in oil prices have had a huge impact on the exporting economies because oil trade has been a dominant factor in the economic development of Middle Eastern countries (Pamuk 2006).

More important for this study are the oil production figures. The movements in oil production were large if we consider the development by country (Figure 1). These Figures helps

[45] To confirm the oil production source, we use data from International Energy Outlook (IEO) 2010, which are available online ("http://www.worldenergyoutlook.org/" \t "_parent" ¶ http://www.worldenergyoutlook.org/). For every country in the world from 1970 to 2008, IEO provides the crude oil production data per capita. There are differences between these two datasets, but in sum, the estimated crude oil production from IEO almost matches the estimates of Mitchell B. R. (1980, 1982 and 1983) for the overlapping country years (see Table 1).

to place the development in a broader international context. In four cases – Iran, Saudi Arabia, United States and Venezuela the increase of oil production is substantial.

We classified the oil-producing countries into two categories. Table 1 shows the countries that are used to build up the groups. We had to restrict the sample of countries because of the availability of information for both the dependent and independent variables. The oil-producing Middle Eastern countries are considered separately because they are producing, per capita, large amounts of the oil in the world.

Consequently, the panel is composed of 25 countries, and the time span covers the period from 1925 to 1995. Figures 2 and 3 shows scatter plots of height and crude oil production. The regression lines indicate that an increase of 1 percentage point is associated with an increase in mean height of 1.0 cm for our benchmark country group (Figure 2). A similar pattern is observed for the Middle Eastern countries. If only the core oil-producing Middle Eastern countries are considered separately, the relationship remains the same. An increase of 1 percentage point is associated with an increase in mean height of 0.4 cm (Figure 3).

Although the per capita oil values of Egypt, Syria and Tunisia are not as high as those of the core oil-producing countries, we include these three countries in the Middle Eastern group because these governments earn large rents from pipeline crossings, transit fees and worker remittances (Ross 2001 p. 329). One might imagine that increased oil production affects major producers with high oil endowments much more than minor producers. If the dataset is split into industrial countries with major oil production, the positive relationship remains (Figure 4).

OPEC began to set quotas after 1982. Before 1982, OPEC did not exhibit the characteristics of an effective cartel. Rather, it was primarily a contentious political organization (Askari 2006). Nevertheless, the exclusion of the time period (1980 to 2000) with significant output quotas changed the coefficient in the below estimation.

The data for each of the variables are summarized in Table 2. The dependent variable mean height ranges from 156.86 to 183.4 cm, with a standard deviation of 4.63. The mean height for the Middle Eastern countries is 1.12 cm less than that of the benchmark group countries (see Table 2). The height data support the view that the benchmark countries enjoyed a relatively favorable situation throughout the 20th century. The independent variable crude oil production (in log) ranges from -6.67 to 5.43. Crude oil production is used as a measure of resource abundance because the measurement errors of this statistic are typically smaller than those of oil trade statistics. Only four countries are above the mean and are extremely resource rich.[46] To summarize the available evidence on crude oil production summary statistics have been listed in ascending order in Table 3. Although mean values are not directly comparable with each other for the course of the period, because of the substantial population growth rate differences. One way of illustrating the effects is by looking at changes between 1925-1945 and 1950-1995 (see Appendix A Tables 2 and 3). To sum up the majority of the countries began to experience a significant population growth and crude oil production per capita during the second half of the twentieth century.

By using the Polity IV dataset, we introduce the characteristics of states and governments in the following empirical framework. In particular, the presence of institutions and regime changes can have massive distortion effects on the development of height. Public accountability is important for the level of political institutions in a country. The degree to which free, transparent and fair political participation exists is measured through the variable Institutionalized democracy. Ross (2001) examines oil abundance and democratization for a pooled cross-section of 113 states from 1971 to 1977. His main question is whether oil actually has antidemocratic prosperities. The author finds that the harmful effects of resource abundance are not only

[46] The four countries are Venezuela, Saudi Arabia, Qatar and Kuwait (see Table 3).

restricted to the Middle Eastern countries. Moreover, he finds that other non-fuel minerals also impede democratization.

In this study, the basic model includes democracy, which is an indicator on an 11 point scale. If democracy has a score of +10, it means that full democracy has been established. The introduction of democracy is necessary to control for the political dimensions. However, the variable institutionalized democracy provides little variation for the Middle Eastern countries. Many countries were classified as authoritarian nations in the Polity IV project. In the Middle East region, only Turkey appears to be democratic. The scores of democracy in the Middle East are significantly lower than the overall average in our dataset (see Table 2). Despite the small variation, the relative importance of the variable remains.

4.4 Estimating the effect of oil production – model and result

As a baseline model, we follow Beck et al. (1995) and first estimate using the panel-corrected standard error techniques[47] that account for panel-level heteroskedasticity and contemporaneous spatial correlation. Furthermore, in this study, an interactive model[48] is used to capture the interaction between oil production and regional effects (Friedrich 1982).

Regarding the disappointing performance of resource-abundant economies, many economic and political factors are important. In this paper, some basic hypotheses are tested on the basis of cross-country data. Crude oil production is determined by the technological capacities of nations and develops in response to the fundamental conditions in a country (Ding

[47] If T is not significantly higher than N, as is the case in our dataset, the resulting standard errors will be too small and therefore lead to overconfident results. Panel-corrected standard errors are better in terms of heteroskedasticity and contemporaneous correlation of the errors. The results of the Hausman test suggest that unobserved heterogeneity across countries played a minor role and that a random effect model may capture the relationship between height and oil production (see Appendix).

[48] In an additive model, the effect of each independent variable on the exogenous variable is constant, and the level of the other dependent variable is not considered (Friedrich 1982 p. 804).

et al. 2005). The main assumption for using production is that only a country that can use current technologies to produce oil can transform resource wealth into economic and social development. Hence, production data are dependent on contemporaneous technology diffusion and are highly endogenous. Crude oil production is a function of the adoption of new technologies and the ability to cope with this condition. Hence, the diffusion of new technologies[49] may play a role in the production of oil. One of the potential difficulties in assessing the effect of oil on height is the endogeneity and the choice of instrumental variables.

In this study, the exogenous stock of crude oil reserve in each country[50] is used as an instrument for crude oil production. This instrument takes a part of the variation in oil production and is not determined simultaneously with our dependent variable mean height. The main strategy in this study is to regress oil production on height. Indeed, a large number of hypotheses can be tested, but in the following, we concentrated on the baseline model with multiplicative terms, which served as a starting point for our exploration:

$$y_{it} = \alpha_i + \beta_1 coilpc_{it} + \beta_2 ME_{it} + \beta_3 MEoil_{it} + \beta_4 (\log f_{it}) + \beta_5 (\log p_{it}) + \beta_6 (\log m_{it}) + \beta_7 Democ_{it} + \varepsilon_{it}$$

y_{it} is the human height levels[51], which is defined by country i and year t. $coilpc$ is the logarithm of crude oil production. The independent variable ME_{it} is a dummy variable that takes the value of 1 if the country is a Middle Eastern oil-producing country and 0 otherwise (see Tables 1 and 2). $MEoil$ is the interaction between oil production and regional effects for the Middle Eastern countries. f_{it} is the logarithm of GDP per capita growth rate[52], p_{it} is the logarithm of population density, m_{it} is the logarithm milk production per capita, the

[49] Perkins et al. (2011) suggest that the adoption and uptake of new telecommunication technologies, such as telegrams, telephones, and the internet, are related to the development of income, education and trade openness.
[50] Information on stock of proved reserves is obtained from the world Factbook: https://www.cia.gov/library/publications/the-world-factbook/rankorder/2178rank.html
[51] By using the logarithm of the height, the result obtained the same qualitative validity.
[52] The natural log of the GDP per capita indicator is corrected for purchasing power parity (PPP) and is specified in the international dollar.

$Democ_{it}$ variable denotes the different scale for institutionalized democracy and ε_{it} is the i.i.d. error term.

According to the Baten and Blum (2012), proximity to protein may strongly influence Biological Standard of Living. Mean height are determined by the consumption of milk and lactose tolerance of the underlying population's. The inclusion of milk per capita as an explanatory variable highlights the role of protein proximity. We expect a positive influence on height.

The role of real GDP per capita is considered and may have a beneficial effect on human stature. Per capita income is mostly correlated with democracy. In this model, the simple correlation between the democracy scale and per capita income is -0.08 for the Middle Eastern countries and 0.27 for the benchmark country group.

To understand the coefficient in the above model with multiplicative terms, we must convert the general statement to a conditional statement. These OLS results can be interpreted by comparing the estimated marginal height effect for each of the country categories (Middle Eastern and benchmark group countries).

1. Benchmark country group:

$$y_{it} = \alpha_i + \beta_1 coilpc_{it} + \ldots + \varepsilon_{it} \qquad (1)$$

2. Middle Eastern countries – core oil-producing countries:

$$\begin{aligned} y_{it} &= \alpha_i + \beta_1 coilpc_{it} + \beta_2 ME_{it} + \beta_3 MEoil_{it} + \ldots + \varepsilon_{it} \\ y_{it} &= \alpha_i + \beta_1 coilpc_{it} + \beta_2 (1) + \beta_3 (1) coilpc_{it} + \ldots + \varepsilon_{it} \\ y_{it} &= (\alpha_i + \beta_2) + (\beta_1 + \beta_3) coilpc_{it} + \ldots + \varepsilon_{it} \end{aligned} \qquad (2)$$

The OLS regression results appear in Table 4. The regression coefficient suggests that a one percentage point increase in oil production is accompanied by an increase of 1.0 cm in height (Table 4 column I). For the Middle Eastern countries, the assessment of the expected effect on height requires the computation of its marginal effects conditional on the specific values of ME_{it}.

The marginal effects with p-values are shown in Table 4.1. For the Middle Eastern countries, the estimated effect on the percentage of oil production is 0.86 cm (see Table 4.1 column I). For the benchmark country group, oil production has a greater positive effect (1.00 cm see Table 4 column I).

The corresponding relationship in a model with time dummies is virtually the same (see Table 4 column II), and all coefficients are statistically significant. Across both country categories, oil production varies positively with height. However, oil abundance seems to be less beneficial to the Middle Eastern countries than to the other countries. In terms of coefficient size, oil production clearly has a greater effect on human height in the benchmark country group.

Milk per capita is positively correlated with height, and in all models, it is highly significant. Proximity to protein yields increases in mean height. Thus, the milk production per capita has an impact on the variations in height. The impact of population density[53] is significantly positive in all specifications, and the logarithm of GDP per capita is positive and significant. The impact of different categories of democracy, which uses an eleven-point scale (0-10), are changing and sometimes significant. The effect of the quality of legal and government institutions is large.[54]

It should be mentioned that oil production is not exogenous, especially for the OPEC members, because of the cartel output quotas. But if we exclude this period with significant output quotas (1980 – 1995), oil production has a definitively higher positive effect on both country groups. From the results in Tables 4 and 4.1, one could deduce that oil production quotas

[53] Higher population density may have a negative effect on height, because of the contagion of the diseases environment. But the connection depends on the time period and the stage of economical development. Higher population density can increase agricultural output due to the improvement of technology.

[54] To consider the robustness, we added other specifications to the regression. In Tables 4 and 5 in the appendix A, the first column contains a replication of the original regression with a newly added variable. The introduction of a new independent variable indicates that the coefficients are quite robust. All of the introduced variables are of the expected sign, and the variables are statistically significant.

appear to be significant. The regression coefficient suggests that a one percentage point increase in oil production is accompanied by an increase of 1.19 cm in height and 1.34 cm for the benchmark countries (Table 4 column III).

The examinations of the residuals from the preliminary regression suggest the presence of first-order autocorrelation. The assumption is that the disturbances share an AR (1) process, while the unit roots do not present a problem[55] (see Appendix A, Table 6). A GLS regression with an AR(1) is estimated, and the results are reported (see Tables 5 and 5.1.). The coefficients of the independent variables shift to some degree, but they do not alter the sign or the conclusion about the relationship. The overall impact of crude oil production on height is positive and significant in all model specifications. For the benchmark country group, the estimated effect of oil proved to be less than the effect for those in the OLS specification. A 1 percent increase in the crude oil production implies an increase in height of 0.58 cm for our benchmark group (Table 5 column I). For the Middle Eastern countries, the estimated effect of a 1 percentage point increase in oil production is 0.50 cm (see Table 5.1). If significant output quotas are accounted for and excluded from consideration, these figures do not change (columns II of Tables 5 and 5.1).

To address the concern that oil production is endogenous, using an instrumental variable strategy, where the log of stock of proved reserves of crude oil per capita serves as an instrument are presented in (Tables 6 and 6.1) [56]. These estimators are two-stage least-squares generalization (2SLS) of panel data estimators. The stock of proved oil reserves are assumed to influence the

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[55] The xtfisher Stata command is used to compute the Fisher test. The xtfisher test in Stata is appropriate for calculating the ADF test for unit root if unbalanced panel data are used. The null hypothesis in this case is that all series are non-stationary, and the alternative is that there is at least one series that follows a unit root. For each of the six variables, the test was conducted with a time trend included. Mean height, oil production per capita, milk production per capita, and GDP per capita series were included because they clearly have an upward trend over time, and an intercept was included because the variables do not have a zero mean. The results reported in Appendix Table 6 suggest that we have statistically significant evidence to reject the null hypothesis that all of the series follow a unit root.

[56] The estimation of a two-stage least squares model with a Stata iv regress command.

crude oil production per capita without influencing mean heights through other channel. The effect of crude oil production on mean height is larger in the 2SLS model than in the OLS estimation. The OLS and 2SLS estimates of coefficients are significantly different, as shown by the hausman tests and 2SLS instrumental variable estimation is efficient (Table 7 Appendix A). According to the reduced form, crude oil production is positively related to the stock of crude oil reserves (Table 6 column I). The instrumented log of crude oil production coefficient is now about twice as large for the other benchmark countries in comparison to the GLS with an AR(1) model (i.e. 1.04 cm instead 0.58cm) and about the same size in comparison to the OLS model (i.e. 1.04 cm instead 1.01 cm or 1.34 cm). In the instrumental variable estimation a 1 percent change of oil production will lead to a 0.89 cm change in the Middle Eastern countries (Table 6.1). The results of the IV-regression strongly confirm the positive relationship between height and crude oil production. Regardless of the estimation methods, crude oil production per capita is positively associated with mean height.

4.5 Conclusion

This paper proposes an empirical analysis of the interaction between petroleum production per capita and the development of mean height. As a result, increasing oil production leads to enhanced human growth for both country categories. But the Middle Eastern countries grow more slowly with each additional unit of oil production per capita. This statement holds if the periods of output quotas are not considered. With the exclusion of the output quotas, height differences between citizens of Middle Eastern countries and those of other countries increase. An instrumental variable model allowed us to rule out the most obvious source of endogeneity in the crude oil production data. Oil production is highly and significantly affected by the stock of proved oil reserves. The result of this specification suggests that crude oil production played a much greater role in the benchmark country group than in the Middle East in terms of mean height. The list of the additional variables in the models supports the general idea that protein proximity, population density, the quality of government institutions, political stability and economic growth are key determinants of human height.

On a broader note, whereas most of the empirical studies on growth and development have excluded the oil-producing countries from analysis because standard economic variables in these countries are less accessible, this study included these countries. Thus, this study focuses on these neglected countries. Although the contributions of oil production in the Middle East were considerable, the results of all estimations clearly show that an increase in petroleum production leads to a lower growth rate in terms of mean height in Middle Eastern countries.

References

Alexeev, M. and Conrad R., (2009). The elusive curse of oil, The Review of Economics and Statistics 91(3): 586-598.

Allen, R., (2004). Agriculture during the Industrial Revolution, 1700-1850. In The Cambridge Economic History of Modern Britain, Volume 1, ed. Floud, R., Johnson, P. Cambridge University Press.

Askari, H., (2006). Middle East oil exporters: what happened to economic development? Northampton.

Assad, R., (1997). The Effect of Public Sector Hiring and Compensation Policies on the Egyptian labor Market. World Band Economic Review. 11 (1), pp. 85-118.

Auty, R. M.,(2001). The political economy of resource-driven growth, European Economic Review 45, pp. 839-846.

Auty, R. M. and Gelb, A. H., (2001). Political economy of resource abundant states, in Auty, R. M. (ed.), Resource Abundance and Economic Development, Oxford: Oxford University Press.

Beck N., Katz JN., (1995). What to do (and not to do) with time-series cross-section. American Political Science Review. Vol. 89, (3), pp. 634-647.

Baten, J. (1999). *Ernährung und wirtschaftliche Entwicklung in Bayern, 1730–1880*. Steiner Verlag, Stuttgart.

Baten, J. (2000). *Economic development and the distribution of nutritional resources in Bavaria, 1797–1839*; Journal of Income Distribution 9, 89–106.

Baten, J. (2006). Global Height Trends in Industrial and Developing Countries, 1810-1984: An Overview (Working Paper).

Baten, J. (2009). Protein supply and nutritional status in nineteenth century Bavaria, Prussia and France. Econ.Hum. Biol. Volume 7, (2) pp. 165–180.

Baten, J., Stegl, M. (2009). Tall and Shrinking Muslims, Short and Growing Europeans: The Long Run Welfare Development of the Middle East, 1850-1980 in Explorations in Economic History 46, pp. 132-148.

Baten, J., Blum, M. (2012) Growing Taller, but Unequal: Biological Well-Being in World Regions and Its Determinants, 1810-1989, with Matthias Blum, *Economic History of Developing Regions* (forthcoming 2012).

Baldwin J. R., Wulong G., (2004). Trade Liberalization: Export-market Participation, Productivity Growth, and Innovation. Oxford review of economic Policy, Vol. 20, (3) pp. 372-392.

Cremer, J. and D. Salehi-Isfahani (1989). The Rise and Fall of Oil-Prices: A Competitive View, Annales d'Economie et de Statistiques 15/16, pp. 427-454.

Collier, P., Gunning, J. W. (1996). Policy Towards Commodity Shocks in Developing Countries. No 96/84, IMF Working Papers.

Ding, N., Field B. C. (2005), Natural Resource Abundance and Economic Growth. Land Economics, 81, No. 4, pp. 496-502.

Fearon, J. D, Laitin D. D., (2003). Ethnicity, Insurgency, and Civil War, American Political Science Review 97 (1), pp. 275-301.

Fidrmuc, J., (2003). Economicreform, democracy and growth during post-communist transition. European Journal of Political Economy. 19 (3), pp. 583–604.

Floud, Roderick; Fogel, Robert W.; Harris, Bernard and Hong; Sok Chul (2011) 'Health, Nutrition, and Human Development in the Western World Since 1700'. (Cambridge University Press).

Frankel, J.A., Romer, D., (1999). Does trade cause growth? American Economic Review 89, pp. 379 - 399.

Friedrich, R., (1982). In Defense of Multiplicative Terms in Multiple Regression Equations. American Journal of Political Science 26, pp. 797-833.

Gylfason, T., Herbertsson, T.T. and Zoega, G., (1999). A mixed blessing: Natural resources and economic growth. Macroeconomic Dynamics 3, pp. 204–225. View Record in Scopus | Cited By in Scopus (43)

Gylfason, T., (2001). Natural resources, education and economic development. European Economic Review 45, 4-6, pp. 847-59.

Gelb, A.H., (1988). Windfall Gains: Blessing or Curse? Oxford University Press, New York.

Hamilton, J. D. (2003). What is an Oil Shock? Journal of Econometrics 113 (2), pp. 363-398.

Issawi, C., 1995. The Middle East Economy: Decline and Recovery. Princeton: Markus Wiener.

Jaccard, J., Turrisi, R., (2003). Interaction Effects in Multiple Regression Second Edition. Thousand Oaks: Sage Publications.

Kilian, L. (2008). A Comparison of the Effect of Exogenous Oil Supply shocks on Output and Inflation in the G7 countries. Journal of the European Economics Association. 6 (1), pp. 78-121.

Kilian, L. (2009). Not all Price Shocks Are Alike: Disentangling Demand and Supply Shocks in the Cruod Oil Markets. The American Economic Review. 99 (3), pp. 1053-1069.

Komlos, J., Baten, J. eds. (1998). The Biological Standard of Living in Comparative Perspective. Stuttgart: Franz Steiner Verlag.

Kronenberg, T.,(2004). The curse of natural resources in the transition economies, Economic of Transition, 12 (3), 399-426.

Maddison, A. (2001). The World Economy: A Millennial Perspective. OECD

Development Centre.

Mitchell, B.R., (1980). International Historical Statistics: European Historical Statistics 1750-1975. London Macmillan.

Mitchell, B.R., (1982). International Historical Statistics: Africa and Asia. London Macmillan.

Mitchell, B.R., (1983). International Historical Statistics: The American and Australia. London Macmillan.

Owen, R., Pamuk S., (1999). A history of Middle East economies in the twentieth century. Cambridge, MA: Haverd University Press.

Pamuk, S. (2006). Estimating Economic Growth in the Middle East since 1820. The Journal of Economic History, 66 No. 3 pp. 809-828.

Perkins, R., Neumayer, E. (2011). Is the Internet Really New After All? The Determinants of Telecommunication Diffusion in Historical Perspective. The Professional Geographer, 63 (1), pp. 55-72.

Przeworski, A., Limongi, F. (1997). Modernization: Theories and Facts, World Politics 49.

Przeworski, A., Limongi, F., Alvarez, M., Cheibub, J. A. (1996). What Makes Democracies Endure? Journal of Democracy 7.

Ricardo, D. (1817). Principles of political economy and taxation. London: J. Murray.

Ross, M. L, (2001). Does Oil Hinder Democracy? World Politics, 53 (3), pp. 325-361.

Sachs J. D., Warner A. M., (2001). The curse of natural resources. European Economic Review, 45 (4-6), pp. 827-838.

Sachs J. D., Warner A. M., (1997). Fundamental sources of long run growth. American Economic Review, 87 (2), pp. 184-88.

Sachs J. D., Warner A. M., (1995). Natural Resource Abundance and Economic Growth. Revised. NBER Working paper 5398. National Bureau of Economic Research, Cambridge, MA.

Samuelson, P., A., (1962). The gains from international trade once again, The Economic Journal 72, pp. 820-829.

Schultz, T.P. (2005). Productive benefits of health: Evidence from low-income countries. In Health and Economic Growth, ed. Lopez-Casanovas, G., Rivera, B., Currais, L., 257-286. Cambridge, Mass.: MIT Press.

Seers, D. (1964). The mechanism of an open petroleum economy, Social and Economic Studies, 13, pp. 233-242.

Sørli,,M. E. Gleditsch, N. P., Strand H. (2005). Why Is There so Much Conflict in the Middle East? The Journal of Conflict Resolution, 49c(1), pp. 141-165

Steckel, R. H., (1995). Stature and the Standard of Living, Journal of Economic Literature, 33 (4), pp. 1903-1940

Yousef, T. M., (2004. Development, Growth and Policy Reform in the Middle East and North Africa since 950. Journal of Economic Perpective. 18 (3), pp. 91-116.

Tables

Table 1: The examined countries and number of observations

Middle East oil-producing countries	Oil-producing benchmark countries
Algeria	Argentina
Egypt	Australia
Iran	Brazil
Iraq	Canada
Kuwait	Chile
Qatar	China
Saudi Arabia	Indonesia
Syria	Mexico
Tunisia	Netherlands
Turkey	Nigeria
	Norway
	Peru
	Poland
	United States
	Venezuela

Table 2: Summary statistics

Oil-producing benchmark countries	Obs.	Mean	Std. Dev.	Min	Max
Mean height (in cm)	121	171.36	5.85	156.86	183.40
Oil production per capita (in log)	129	-0.87	1.72	-6.76	2.93
Milk production per capita (in log)	92	-2.10	1.27	-5.67	-0.38
Population density (in log)	129	2.72	1.36	0.25	6.00
GDP per capita (in log)	129	8.40	0.94	6.41	10.06
Institutionalized Democracy	129	2.67	14.69	-88.00	10.00
Oil-producing Middle Eastern countries					
	Obs.	Mean	Std. Dev.	Min	Max
Mean height (in cm)	90	170.08	1.86	165.30	174.89
Oil production per capita (in log)	91	0.79	2.25	-3.63	5.43
Milk production per capita (in log)	52	-2.94	0.42	-3.61	-2.06
Population density (in log)	91	3.01	1.02	0.56	4.79
GDP per capita (in log)	73	8.42	0.85	6.80	10.56
Institutionalized Democracy	91	0.87	11.80	-88.00	9.00
All countries					
	Obs.	Mean	Std. Dev.	Min	Max
Mean height (in cm)	211	170.81	4.63	156.86	183.40
Oil production per capita (in log)	220	-0.18	2.12	-6.76	5.43
Milk production per capita (in log)	144	-2.40	1.12	-5.67	-0.38
Population density (in log)	220	2.84	1.24	0.25	6.00
GDP per capita (in log)	202	8.41	0.91	6.41	10.56
Institutionalized Democracy	220	1.21	13.66	-88.00	10.00

Sources: Crude Oil production: Mitchell B. R. (1980, 1982 and 1983) Heights: Baten (2006, 2009 and 2012 see Data Appendix D); GDP: Maddison 2001; Milk: Baten et al. (2012). See Data Appendix D. Institutionalized Democracy: Marshall et al. (2008) Polity IV Project dataset was last accessed in 2010.

Table 3: Crude oil production per capita by country 1925-1995 (ascending order)

	Obs.	Mean	Std. Dev.	Min	Max
Poland	3	0.024	0.005	0.018	0.028
Turkey	7	0.059	0.021	0.027	0.084
China	9	0.060	0.051	0.001	0.119
Brazil	7	0.089	0.054	0.258	0.188
Chile	7	0.131	0.041	0.085	0.186
Netherlands	5	0.136	0.042	0.078	0.180
Indonesia	11	0.276	0.167	0.047	0.533
Peru	14	0.292	0.080	0.169	0.474
Egypt	11	0.354	0.285	0.067	0.760
Argentina	14	0.414	0.303	0.055	0.821
Mexico	5	0.540	0.496	0.235	1.410
Tunisia	6	0.648	0.091	0.552	0.749
Norway	2	0.650	0.036	0.624	0.675
Nigeria	7	0.894	0.522	0.128	1.615
Australia	6	1.154	0.455	0.235	1.451
United States	14	1.603	0.466	0.764	2.254
Canada	11	1.615	1.208	0.059	3.295
Algeria	8	1.825	0.956	0.190	2.967
Syria	6	1.968	2.681	0.421	7.410
Iran	15	2.317	2.249	0.258	8.035
Iraq	13	4.249	3.290	0.225	9.980
Venezuela	14	10.002	5.979	0.346	18.749
Saudi Arabia	11	19.738	14.888	0.308	46.502
Qatar	6	83.716	52.535	31.586	145.289
Kuwait	8	115.758	82.340	30.536	228.519
Total	220	9.01	30.35	0.00	228.52

Sources: Crude Oil production: Mitchell B. R. (1980, 1982 and 1983).

Table 4: The effect of oil production per capita on human heights with multiplicative terms (panel models)

	(I)	(II)	(III)
Oil production per capita in log	1.00***	1.01***	1.34***
	[3.83]	[3.78]	[4.05]
Middle Eastern countries (ME)	-2.76***	-3.07***	-4.00***
	[-4.68]	[-4.88]	[-4.71]
ME x Oil production	-0.43	-0.44	-0.59
	[-1.22]	[-1.20]	[-1.54]
Milk production per capita in log	2.56***	2.72***	2.63***
	[5.76]	[5.32]	[3.57]
Population density in log	1.08***	1.00***	1.11***
	[6.16]	[5.16]	[5.29]
GDP per capita in log	-0.49	-0.74	-0.98
	[-0.75]	[-1.00]	[-0.88]
Institutionalized Democracy Scale = -88	-4.28**	-3.71**	-3.90**
	[-2.56]	[-2.52]	[-2.44]
Institutionalized Democracy Scale = 0	-2.26**	-2.07*	-1.96
	[-2.31]	[-1.95]	[-1.59]
Institutionalized Democracy Scale = 1	-2.78	-2.98	-5.45**
	[-1.30]	[-1.23]	[-2.13]
Institutionalized Democracy Scale = 2	-1.23	-1.21	-0.66
	[-0.93]	[-0.83]	[-0.43]
Institutionalized Democracy Scale = 3	-2.82***	-3.53***	-3.57***
	[-5.70]	[-5.36]	[-5.03]
Institutionalized Democracy Scale = 4	-5.97***	-5.66***	-5.84**
	[-2.70]	[-3.03]	[-2.57]
Institutionalized Democracy Scale = 5	-3.01	-3.57	-3.69
	[-1.34]	[-1.42]	[-1.37]
Institutionalized Democracy Scale = 6	-2.38*	-2.62**	-2.53*
	[-1.93]	[-1.99]	[-1.87]
Institutionalized Democracy Scale = 7	-3.00**	-2.95**	-4.26*
	[-2.19]	[-1.96]	[-1.65]
Institutionalized Democracy Scale = 8	-1.51	-1.43	-1.76
	[-1.20]	[-1.03]	[-0.93]
Institutionalized Democracy Scale = 9	-2.63***	-2.47***	-3.24***
	[-3.48]	[-3.03]	[-3.37]
Constant	182.09***	184.86***	186.92***
	[28.67]	[24.62]	[16.61]
Observations	132	132	99
R-sq: within	0.26	0.27	0.39
R-sq: between	0.84	0.86	0.87
R-sq: overall	0.75	0.76	0.80
Time-fixed effects	NO	YES	YES

Robust z statistics in brackets; the constant refers to 1995. *** p<0.01, ** p<0.05, * p<0.1.

Sources: Crude Oil production: Mitchell B. R. (1980, 1982 and 1983) Heights: Baten (2006, 2009 and 2012 see Data Appendix D); GDP: Maddison 2001; Milk: Baten et al. (2012). See Data Appendix D. Institutionalized Democracy: Marshall et al. (2008) Polity IV Project dataset was last accessed in 2010. Institutionalized Democracy is an eleven-point scale (0-10). Full Democracy is achieved at a score of 10 on the scale. The indicator is derived from the Polity IV project dataset. However, three more scales (-66, -77,-88) are included in both variables. If a country is occupied by a foreign power and re-established, the democracy indicator is -66-type encoded. If the indicator is -77-type encoded, there was an internal war, and the central political authority completely collapsed. Finally, -88 indicates a transition period in which new institutions were planned. In total, in these three scales, seven countries and eight time periods are included. The constant refers to the birth decade 1995 and an Institutionalized Democracy score of 10. In column III, the time period with significant oil production quotas is excluded.

Table 4.1: Marginal effect of oil production in a multiplicative interaction model for Middle Eastern countries (panel models)

	(I)	**(II)**	**(III)**
Coef.	0.86***	0.86***	1.19***
	[4.55]	[4.46]	[4.17]
95% Conf. interval lower bounds	0.49	0.48	0.63
95% Conf. interval upper bounds	1.23	1.24	1.75

The first derivatives of height with respect to the log of crude oil production and Middle East Dummy z statistics are in brackets. In Model III, the time periods with significant oil production quotas are excluded.

Sources: Crude Oil production: Mitchell B. R. (1980, 1982 and 1983) Heights: Baten (2006, 2009 and 2012 see Data Appendix D); GDP: Maddison 2001; Milk: Baten et al. (2012). See Data Appendix D. Institutionalized Democracy: Marshall et al. (2008) Polity IV Project dataset was last accessed in 2010.

Table 5: The effect of oil production per capita on human heights with multiplicative terms (panel data model using GLS with an AR(1) autocorrelation)

	(I)	(II)
Oil production per capita in log	0.58**	0.58***
	[2.50]	[2.86]
Middle Eastern countries (ME)	-2.22*	-2.93***
	[-1.89]	[-2.79]
ME x Oil production	-0.25	-0.33
	[-0.77]	[-0.96]
Milk production per capita in log	1.46***	0.89*
	[2.82]	[1.84]
Population density in log	0.97**	1.10***
	[2.51]	[3.22]
GDP per capita in log	0.36	0.84
	[0.61]	[1.09]
Institutionalized Democracy Scale = -88	-4.25**	-4.27***
	[-2.53]	[-2.74]
Institutionalized Democracy Scale = 0	-4.45***	-4.51***
	[-2.76]	[-3.04]
Institutionalized Democracy Scale = 1	-2.81*	-4.47***
	[-1.68]	[-2.82]
Institutionalized Democracy Scale = 2	-3.59**	-3.77**
	[-2.12]	[-2.42]
Institutionalized Democracy Scale = 3	-4.64***	-4.65***
	[-2.59]	[-2.86]
Institutionalized Democracy Scale = 4	-3.87**	-4.38***
	[-2.14]	[-2.64]
Institutionalized Democracy Scale = 5	-4.38***	-4.87***
	[-2.59]	[-3.16]
Institutionalized Democracy Scale = 6	-4.31***	-4.52***
	[-2.62]	[-3.00]
Institutionalized Democracy Scale = 7	-3.64**	-4.86***
	[-2.26]	[-3.09]
Institutionalized Democracy Scale = 8	-3.19**	-4.43***
	[-1.98]	[-2.74]
Institutionalized Democracy Scale = 9	-3.76**	-4.94***
	[-2.29]	[-3.15]
Constant	173.59***	168.21***
	[27.54]	[21.32]
Observations	132	99
R-sq: within	0.44	0.61
R-sq: between	0.80	0.80
R-sq: overall	0.72	0.74
Time-fixed effects	YES	YES

Robust z statistics in brackets; constant refers to 1995. *** p<0.01, ** p<0.05, * p<0.1.
In column II, the time periods with significant oil production quotas are excluded.
Sources: Crude Oil production: Mitchell B. R. (1980, 1982 and 1983) Heights: Baten (2006, 2009 and 2012 see Data Appendix D); GDP: Maddison 2001; Milk: Baten et al. (2012). See Data Appendix D. Institutionalized Democracy: Marshall et al. (2008) Polity IV Project dataset was last accessed in 2010.

Table 5.1: Marginal effect of oil production in a multiplicative interaction model for Middle Eastern countries (panel data model using GLS with an AR(1) autocorrelation)

	(I)	**(II)**
Coef.	0.50***	0.50***
Z	[2.57]	[2.53]
95% Conf. interval lower bounds	0.12	0.11
95% Conf. interval upper bounds	0.88	0.88

Robust z statistics in brackets; constant refers to 1995. *** p<0.01, ** p<0.05, * p<0.1.

Sources: Crude Oil production: Mitchell B. R. (1980, 1982 and 1983) Heights: Baten (2006, 2009 and 2012 see Data Appendix D); GDP: Maddison 2001; Milk: Baten et al. (2012). See Data Appendix D. Institutionalized Democracy: Marshall et al. (2008) Polity IV Project dataset was last accessed in 2010.

Table 6: The effect of oil production per capita on human heights with multiplicative terms (panel data model using stock of proved oil reserves as an instrument)

VARIABLES	IV first stage Oil production per capita in log	IV second stage Height
Stock of proved oil reserves in barrels per capita in log	0.28***	
	[5.53]	
Middle East countries (ME)	1.09***	-3.12***
	[4.66]	[-3.57]
ME x Oil production	0.41***	-0.46
	[4.06]	[-1.19]
Milk production per capita in log	-1.10***	2.76***
	[-5.59]	[4.04]
Population density in log	0.05	1.01***
	[0.67]	[4.15]
GDP per capita in log	1.71***	-0.79
	[6.18]	[-0.83]
Institutionalized Democracy Scale = -88	-0.53	-3.67**
	[-1.25]	[-1.99]
Institutionalized Democracy Scale = 0	-0.88**	-2.02*
	[-2.38]	[-1.77]
Institutionalized Democracy Scale = 1	-0.61	-2.94*
	[-1.25]	[-1.79]
Institutionalized Democracy Scale = 2	-1.87***	-1.15
	[-4.51]	[-0.62]
Institutionalized Democracy Scale = 3	0.08	-3.52*
	[0.23]	[-1.82]
Institutionalized Democracy Scale = 4	-0.72	-5.60***
	[-0.84]	[-2.74]
Institutionalized Democracy Scale = 5	-0.8	-3.52*
	[-1.49]	[-1.84]
Institutionalized Democracy Scale = 6	-0.90*	-2.56*
	[-1.69]	[-1.82]
Institutionalized Democracy Scale = 7	-0.39	-2.93**
	[-1.03]	[-2.30]
Institutionalized Democracy Scale = 8	-0.79*	-1.39
	[-1.67]	[-1.03]
Institutionalized Democracy Scale = 9	-0.46	-2.47**
	[-1.35]	[-2.05]
Oil production per capita in log		1.04***
		[3.16]
Constant	-20.88***	185.44***
	[-7.94]	[19.06]
Observations	136	132
Overall R-squared	0.77	0.76
F test	27.3	
Time-fixed effects	YES	YES

Robust z statistics in brackets; constant refers to 1995. *** p<0.01, ** p<0.05, * p<0.1. Sources: Crude Oil production: Mitchell B. R. (1980, 1982 and 1983) Heights: Baten (2006, 2009 and 2012 see Data Appendix D); GDP: Maddison 2001; Milk: Baten et al. (2012). See Data Appendix D. Institutionalized Democracy: Marshall et al. (2008) Polity IV Project dataset was last accessed in 2010. Stock of proved oil reserves in barrels: https://www.cia.gov/library/publications/the-world-factbook/rankorder/2178rank.html.

Table 6.1: Marginal effect of oil production in a multiplicative interaction model for Middle Eastern countries (panel data model using stock of proved oil reserves as an instrument)

	(I)
Coef.	0.89***
z	3.39
95% Conf. interval lower bounds	0.37
95% Conf. interval upper bounds	1.40

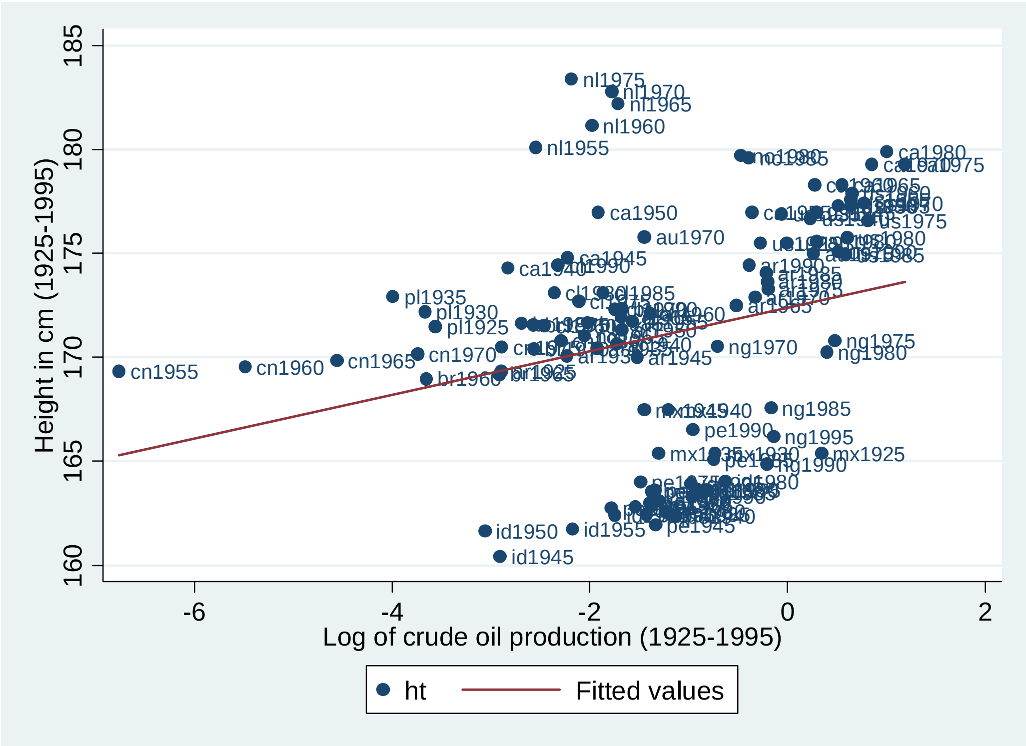
Robust z statistics in brackets; constant refers to 1995. *** p<0.01, ** p<0.05, * p<0.1.
Sources: Crude Oil production: Mitchell B. R. (1980, 1982 and 1983) Heights: Baten (2006, 2009 and 2012 see Data Appendix D); GDP: Maddison 2001; Milk: Baten et al. (2012). See Data Appendix D. Institutionalized Democracy: Marshall et al. (2008) Polity IV Project dataset was last accessed in 2010. Stock of proved oil reserves in barrels: https://www.cia.gov/library/publications/the-world-factbook/rankorder/2178rank.html.

Figures

Figure 1: Oil production by country

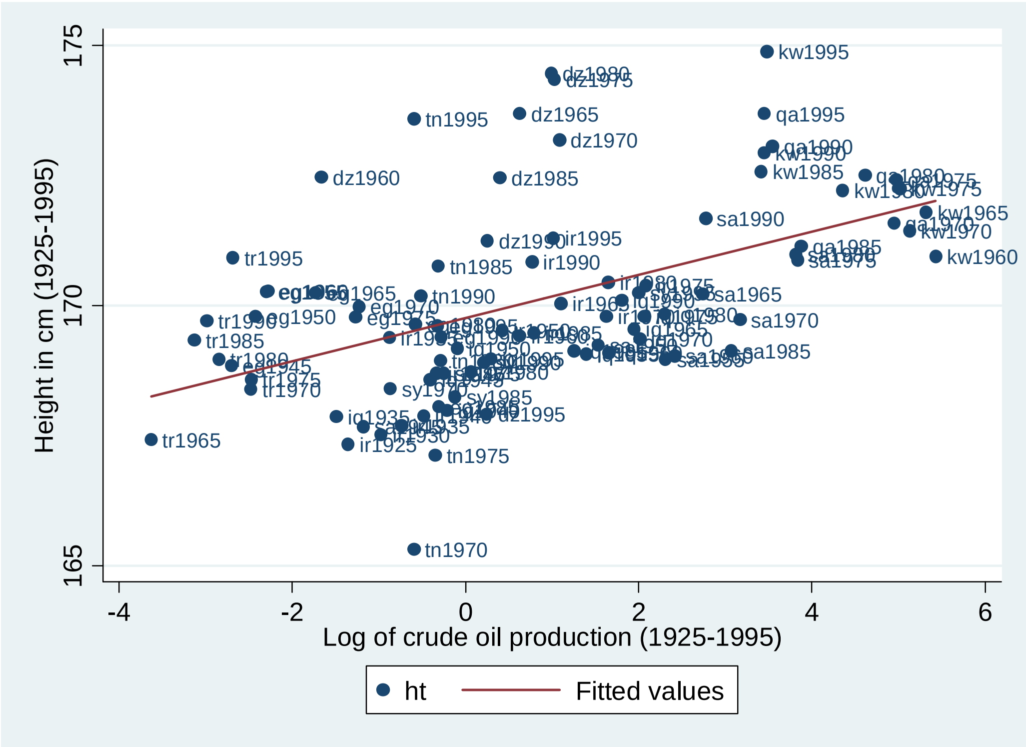
Sources: Crude Oil production: Mitchell B. R. (1980, 1982 and 1983) Heights: Baten (2006), Baten and Stegl (2009), Baten and Blum (2012).

Figure 2: Oil production per capita and human height for oil-producing benchmark countries



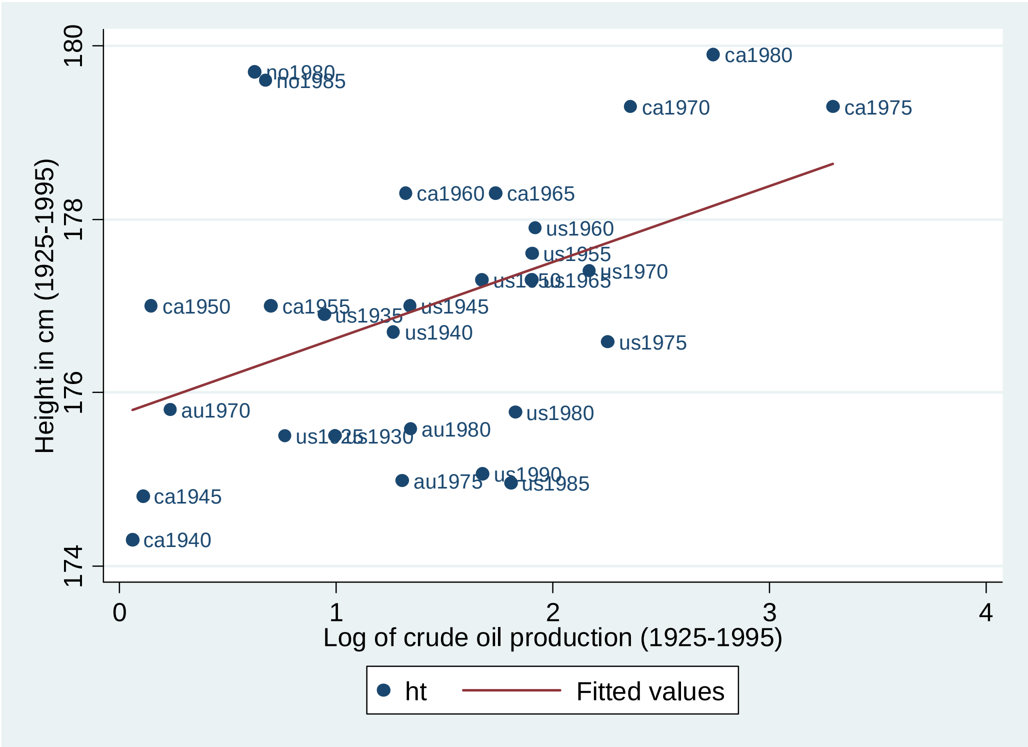
Sources: Crude Oil production: Mitchell B. R. (1980, 1982 and 1983) Heights: Baten (2006), Baten and Stegl (2009), Baten and Blum (2012).

Figure 3: Oil production per capita and human height for Middle Eastern countries



Sources: Crude Oil production: Mitchell B. R. (1980, 1982 and 1983) Heights: Baten (2006), Baten and Stegl (2009), Baten and Blum (2012).

Figure 4: Oil production per capita and human height for industrial countries



Sources: Crude Oil production: Mitchell B. R. (1980, 1982 and 1983) Heights: Baten (2006), Baten and Stegl 2009, Baten and Blum 2012).

Appendix A:

Table A.1: Comparing crude oil production sources

Variable	Obs.	Mean Difference	Std. Dev.	Min	Max
Algeria	6	0.02	0.17	-0.17	0.31
Argentina	5	-0.05	0.09	-0.18	0.04
Australia	6	-0.23	0.34	-0.86	0.08
Brazil	5	-0.02	0.03	-0.07	0.00
Canada	5	-0.10	0.34	-0.68	0.20
Chile	5	0.01	0.03	-0.04	0.03
China	6	-0.01	0.01	-0.03	0.00
Egypt	6	-0.09	0.08	-0.17	0.01
Indonesia	6	-0.02	0.05	-0.11	0.02
Iran	6	-0.06	1.91	-2.64	3.31
Iraq	6	-0.72	1.03	-2.33	0.53
Kuwait	6	2.50	5.41	-5.56	8.76
Netherlands	2	0.02	0.02	0.01	0.04
Nigeria	6	-0.22	0.38	-0.98	0.08
Norway	2	-0.51	1.51	-1.58	0.55
Peru	5	-0.02	0.09	-0.17	0.08
Qatar	6	-0.12	9.10	-11.97	14.29
Saudi Arabia	6	-1.21	5.37	-5.48	8.53
Syria	6	0.66	2.27	-0.52	5.27
Tunisia	6	-0.08	0.13	-0.26	0.07
Turkey	6	0.00	0.01	-0.01	0.01
United States	5	0.02	0.20	-0.15	0.29
Venezuela	5	0.17	1.37	-1.13	2.45

Sources: Mitchell, B.R. (1980, 1982 and 1983) and International Energy Outlook 2010 (http://www.worldenergyoutlook.org/). Mean difference is defined as the estimate of crude oil production from Mitchell minus the data from International Energy Outlook 2010 for the 1970-1995 period.

Table A.2: Crude oil production per capita by country 1925-1945

	Obs.	Mean	Std. Dev.	Min	Max
Poland	3	0.024	0.005	0.018	0.028
Canada	1	0.059	.	0.059	0.059
Argentina	4	0.122	0.053	0.055	0.178
Peru	4	0.271	0.070	0.169	0.322
Iran	4	0.433	0.153	0.258	0.619
Iraq	2	0.516	0.412	0.225	0.808
Mexico	4	0.616	0.538	0.272	1.410
Total	30	0.931	1.656	0.018	7.091
United States	4	0.992	0.207	0.764	1.266
Venezuela	4	4.260	2.864	0.346	7.091
Total	30	0.931	1.656	0.018	7.091

Sources: Crude Oil production: Mitchell B. R. (1980, 1982 and 1983).

Table A.3: Crude oil production per capita by country 1950-1995

	Obs.	Mean	Std. Dev.	Min	Max
Turkey	7	0.059	0.021	0.027	0.084
China	9	0.060	0.051	0.001	0.119
Brazil	7	0.089	0.054	0.026	0.188
Chile	7	0.131	0.041	0.085	0.186
Netherlands	5	0.136	0.042	0.078	0.180
Indonesia	10	0.298	0.158	0.047	0.533
Peru	9	0.305	0.090	0.226	0.474
Egypt	10	0.382	0.283	0.089	0.760
Argentina	9	0.566	0.273	0.187	0.821
Tunisia	6	0.648	0.091	0.552	0.749
Norway	2	0.650	0.036	0.624	0.675
Nigeria	7	0.894	0.522	0.128	1.615
Australia	6	1.154	0.455	0.235	1.451
Algeria	8	1.825	0.956	0.190	2.967
United States	9	1.904	0.198	1.673	2.254
Canada	9	1.956	1.052	0.148	3.295
Syria	6	1.968	2.681	0.421	7.410
Iran	10	3.231	2.251	0.417	8.035
Iraq	10	5.354	2.922	0.909	9.980
Total	179	10.857	33.379	0.001	228.519
Venezuela	9	12.791	5.403	5.026	18.749
Saudi Arabia	10	21.682	14.147	4.634	46.502
Qatar	6	83.716	52.535	31.586	145.289
Kuwait	8	115.758	82.340	30.536	228.519

Sources: Crude Oil production: Mitchell B. R. (1980, 1982 and 1983).

Table A.4: Interactive model

Oil production per capita in log	0.55***	1.21***	1.14***	0.98***	1.00***
	[3.81]	[6.89]	[6.18]	[4.85]	[3.83]
Middle Eastern countries (ME)	-2.56	-2.64	-2.84*	-3.53**	-2.76***
	[-1.25]	[-1.64]	[-1.82]	[-2.35]	[-4.68]
ME x Oil production	-0.18	-0.97***	-0.94***	-1.15***	-0.43
	[-0.98]	[-3.63]	[-3.42]	[-3.95]	[-1.22]
Milk production per capita in log		2.26***	2.27***	2.15***	2.56***
		[4.51]	[4.49]	[4.46]	[5.76]
Population density in log			0.44	0.67**	1.08***
			[1.38]	[2.21]	[6.16]
GDP per capita in log				0.46	-0.49
				[1.01]	[-0.75]
Institutionalized Democracy Scale = -88					-4.28**
					[-2.56]
Institutionalized Democracy Scale = 0					-2.26**
					[-2.31]
Institutionalized Democracy Scale = 1					-2.78
					[-1.30]
Institutionalized Democracy Scale = 2					-1.23
					[-0.93]
Institutionalized Democracy Scale = 3					-2.82***
					[-5.70]
Institutionalized Democracy Scale = 4					-5.97***
					[-2.70]
Institutionalized Democracy Scale = 5					-3.01
					[-1.34]
Institutionalized Democracy Scale = 6					-2.38*
					[-1.93]
Institutionalized Democracy Scale = 7					-3.00**
					[-2.19]
Institutionalized Democracy Scale = 8					-1.51
					[-1.20]
Institutionalized Democracy Scale = 9					-2.63***
					[-3.48]
Constant	172.60***	179.12***	177.87***	172.89***	182.09***
	[139.34]	[154.67]	[129.66]	[44.29]	[28.67]
Observations	211	140	140	132	132
R-squared	0.0745	0.5357	0.5715	0.6449	0.7505
Time dummies	No	No	No	No	No

Robust z statistics in brackets. *** p<0.01, ** p<0.05, * p<0.1
Sources: Crude Oil production: Mitchell B. R. (1980, 1982 and 1983) Heights: Baten (2006, 2009 and 2012 see Data Appendix D); GDP: Maddison 2001; Milk: Baten et al. (2012). See Data Appendix D. Institutionalized Democracy: Marshall et al. (2008) Polity IV Project dataset was last accessed in 2010.

Table A.5: Interactive model with time dummies

	M1	M1	M1	M1	M1
Oil production per capita in log	0.30*	0.97***	1.07***	1.25***	1.01***
	[1.90]	[4.20]	[4.48]	[5.42]	[3.78]
Middle Eastern countries (ME)	-2.47	-2.40**	-2.74**	-3.81***	-3.07***
	[-1.54]	[-2.30]	[-2.10]	[-6.34]	[-4.88]
ME x Oil production	-0.15	-0.72**	-0.83**	-0.52**	-0.44
	[-0.90]	[-2.24]	[-2.44]	[-2.09]	[-1.20]
Milk production per capita in log		2.36***	2.33***	3.76***	2.72***
		[5.12]	[4.65]	[7.69]	[5.32]
Population density in log			0.59	1.27***	1.00***
			[1.45]	[6.44]	[5.16]
GDP per capita in log				-1.35*	-0.74
				[-1.90]	[-1.00]
Institutionalized Democracy Scale = -88					-3.71**
					[-2.52]
Institutionalized Democracy Scale = 0					-2.07*
					[-1.95]
Institutionalized Democracy Scale = 1					-2.98
					[-1.23]
Institutionalized Democracy Scale = 2					-1.21
					[-0.83]
Institutionalized Democracy Scale = 3					-3.53***
					[-5.36]
Institutionalized Democracy Scale = 4					-5.66***
					[-3.03]
Institutionalized Democracy Scale = 5					-3.57
					[-1.42]
Institutionalized Democracy Scale = 6					-2.62**
					[-1.99]
Institutionalized Democracy Scale = 7					-2.95**
					[-1.96]
Institutionalized Democracy Scale = 8					-1.43
					[-1.03]
Institutionalized Democracy Scale = 9					-2.47***
					[-3.03]
Constant	172.77***	179.33***	177.58***	190.66***	184.86***
Observations	211	140	140	132	132
R-squared	0.0614	0.5657	0.5930	0.7213	0.7636
Time dummies	Yes	Yes	Yes	Yes	yes

Robust z statistics in brackets. *** p<0.01, ** p<0.05, * p<0.1
Sources: Crude Oil production: Mitchell B. R. (1980, 1982 and 1983) Heights: Baten (2006, 2009 and 2012 see Data Appendix D); GDP: Maddison 2001; Milk: Baten et al. (2012). See Data Appendix D. Institutionalized Democracy: Marshall et al. (2008) Polity IV Project dataset was last accessed in 2010.

Table A.6: Testing for unit roots: augmented Dickey-Fuller test

	chi2(32)	p value
Mean height (in cm)	70.75	0.01
Oil production per capita (in log)	81.34	0.00
Milk production per capita (in log)	207.57	0.00
Population density (in log)	89.84	0.00
GDP per capita (in log)	108.27	0.00
Institutionalized Democracy	29.51	0.97

Notes: Tests were conducted with one lag of the dependent variable, and a trend for time was included.
Sources: Crude Oil production: Mitchell B. R. (1980, 1982 and 1983) Heights: Baten (2006, 2009 and 2012 see Data Appendix D); GDP: Maddison 2001; Milk: Baten et al. (2012). See Data Appendix D. Institutionalized Democracy: Marshall et al. (2008) Polity IV Project dataset was last accessed in 2010.

Fixed effects versus random effects – Hausmann test

Country-fixed effects control for characteristics that are specific to one country and do not change across time. To address time invariant variables, we use the Hausman test Stata command in the following.

Prob>chi2 = 0.8083 >0.05 (Random Effect

Table A.7: Hausman test comparing IV with OLS regression

	IV (b)	OlS (B)	Difference (b-B)	sqrt(diag(V _b-V_B)) S.E.
Oil production per capita (in log)	1.04	1.01	0.03	0.17
Middle East countries (ME)	-3.12	-3.07	-0.05	0.29
ME x Oil production	-0.46	-0.44	-0.02	0.14
Milk production per capita in log	2.76	2.72	0.04	0.25
Population density in log	1.01	1.00	0.01	0.04
GDP per capita in log	-0.79	-0.74	-0.06	0.32
Institutionalized Democracy Scale = -88	-3.67	-3.71	0.04	0.23
Institutionalized Democracy Scale = 0	-2.02	-2.07	0.05	0.26
Institutionalized Democracy Scale = 1	-2.94	-2.98	0.04	0.23
Institutionalized Democracy Scale = 2	-1.15	-1.21	0.07	0.39
Institutionalized Democracy Scale = 3	-3.52	-3.53	0.02	0.11
Institutionalized Democracy Scale = 4	-5.60	-5.66	0.06	0.34
Institutionalized Democracy Scale = 4	-3.52	-3.57	0.06	0.33
Institutionalized Democracy Scale = 5	-2.56	-2.62	0.06	0.33
Institutionalized Democracy Scale = 6	-2.93	-2.95	0.02	0.13
Institutionalized Democracy Scale = 7	-1.39	-1.43	0.04	0.23
Institutionalized Democracy Scale = 8	-2.47	-2.47	0.00	0.02
bdec1925	0.72	0.72	-0.01	0.05
bdec1930	-2.22	-2.19	-0.02	0.12
bdec1935	-0.90	-0.87	-0.03	0.17
bdec1940	-0.79	-0.78	-0.01	0.05
bdec1945	-1.59	-1.57	-0.01	0.08
bdec1950	-0.06	-0.03	-0.03	0.17
bdec1955	0.16	0.18	-0.02	0.13
bdec1960	0.68	0.69	-0.01	0.07
bdec1965	0.32	0.33	-0.01	0.06
bdec1970	-0.06	-0.05	0.00	0.03
bdec1975	0.07	0.07	0.00	0.01
bdec1985	-0.26	-0.27	0.01	0.04
bdec1990	-0.25	-0.25	0.01	0.05
bdec1995	0.82	0.81	0.01	0.05

b = consistent under Ho and Ha; obtained from xtivreg

B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic Prob>chi2 = 1.0000 >0.05 (xtivreg

5. Human Capital Development in Iran and Iraq in the 20th Century: Was There a Quality-Quantity Trade-Off?

Abstract

As is the case for most developing countries, Iran and Iraq offer little reliable socio-demographic data that are disaggregated at the district level. This study's objective is to estimate the trade-off between child quality and quantity in Iran and Iraq. Data from the Iranian national census in 1956, 1966 and 1976 and the Iraqi census in 1965 are used to examine the association between child quantity and quality. To illuminate the endogenous factors of child quantity and quality, an instrumental variable (IV) approach is used in this paper. A clear inverse relationship between fertility rates and school enrolment rates is evident for Iran but not for Iraq. A trade-off between child quantity and quality has clearly occurred in Iran since the 1960s, and the country has experienced a major fertility decline in recent years.

Keywords: Child Quantity-Quality Trade-Off, Demographic Transition, Human-capital Development

5.1 Introduction

The quality-quantity model implies that there is a trade-off between child outcome and the number of children per family (Becker 1960, Becker 1973, Becker 1976). In several empirical studies, a negative correlation between family size and child quality has been found (Knodel et al. 1991, Ahn et al. 1998, Becker et al. 2010, Montgomery et al. 2000, Schultz 1994)[57]. It has been shown that higher quality and lower quantity offspring are necessary for long-term economic growth (Becker, Murphy and Tamura 1990, Lucas 2002). Parents will limit the number of offspring and invest in their children's development if the parents are sufficiently educated and the expected returns to human capital are high (Becker, Murphy and Tamura 1990).

Becker (1960) explained that increases in education parallel fertility reduction, thus creating a quality-quantity substitution. Technological progress, along with an increase in per capita income, triggered an accumulation of human capital in the form of literacy rates and schooling. Additionally, a qualitative change in the economic environment increased the demand for human capital and encouraged households to invest in the education of their offspring. Hence, demographic transitions can enhance a nation's economic growth (Galor 2005).

The two countries covered in this study, Iran and Iraq, have often been in the political news. Conflicts, riots and wars have occurred throughout these countries' histories. There are some circumstances that link both countries by their pasts, but both countries are culturally diverse, comprising numerous religious and ethnic minorities (Aghajanian 1995, Abbasi et al. 2007). High rates of marital fertility and declining mortality rates caused rapid population increases in both countries, but their subsequent decreases in population growth vary from one to the other.

[57] Most of these models' estimations are based on individual examination units. Only Becker et al. used large aggregates such as Prussian districts. When using aggregated data, one must make many tenuous assumptions.

Iran's population growth rate has decreased rapidly since the 1980s, whereas Iraq's decline in population growth has been slower. During the 1970s, the fertility rate of Iranian women was 6.5 children. Today, the fertility rate in Iran is even lower than in Europe (the 2010 rate in Iran was 1.7 children). This sharp decrease in fertility in Iran since the 1980s was most pronounced after the Islamic Revolution. Although there were policy-induced family planning programmes in the 1980s, those yielded negligible effects; the rapid decrease in fertility in Iran has been attributed to improved mass education, political upheaval and war (Aghajanian 1995, Abbasi et al. 2002).

The relevant decades for the investigation of the relationship between education and fertility are the 1950s through the 1980s. Fertility time series (see Figure 1) reveal that neither country was experiencing a fertility decline before the 1980s. A downward trend is observable from the 1980s onward. Explorations of the pre-transition period provide some insight into the connection between Child Quality-Quantity trade-off (Q-Q trade-off). Because of improving health conditions and declining child mortality rates, fertility had begun to decline in many other developing countries in the 1950s (Reher 2004). Figure 2 reveals the trajectory of crude birth and death rates in Iraq and Iran from the period of the 1950s through the 2000s. Iraqi birth rates decreased gradually and steadily after the 1970s, compared with a more rapid decline in Iran. The death rates began at the same level in the 1950s and decreased in both countries until the 1980s. After the 1980s, the Iraqi death rate increased.

The findings presented in this study show that, in Iran, there exists a significant negative relationship between fertility and education in the period after the 1960s; in contrast, in Iraq, there exists a positive relationship. Looney (1992) attributed the apparent decline in human development in Iraq to an insufficient investment in human capital compared with Iran, which had increased its human capital accumulation over the same period. Additionally, the number of years of education required in Iran is 12 years, whereas in Iraq, only 6 years of education are required (World Bank Human Development Report Middle East and North Africa 1999).

The major empirical challenge of studying quantity-quality trade-offs is that both variables are endogenous. This paper will attempt to estimate the existence and size of the child quality-quantity trade-off by diminishing the endogeneity problem. Using the natural occurrence of twins as an instrumental variable (IV), Rosenzweig and Wolpin (1980) find a negative correlation between family size and children's education (child quality) in a sample for India. In Norway, Black et al. (2005), using the same IV specification, find a negative correlation between family size and educational attainment. Most of the empirical studies of the trade-off between fertility and education are based on micro-level data only, although Becker et al. (2010) used district-level data for Prussia in the nineteenth century and found evidence of a quantity-quality trade-off.

The National Censuses[58] of Population and Housing conducted for Iran in 1956, 1966 and 1976 and for Iraq in 1965 offer detailed insights and key indicators that reveal the connection between fertility and education. The micro-regional datasets of Iranian (*Shahrestans*) and Iraqi (*Qadha*) districts allow the incorporation of education and fertility data for the period prior to the demographic transition. The use of census waves at this disaggregate level makes it possible to investigate cross-country variations among fertility and education rates.

The geographic pattern of educational and fertility development in both countries has been examined at the provincial level. The focus of this study is to provide a possible explanation for the timing of the onset of the quantity-quality trade-off. We should keep in mind the theory of path dependence, which suggests that fertility in each country will follow its own path, a direct comparison of both countries fertility path can be biased because of the patchy data sources

[58] Both states have collected population information at intervals of approximately 10 years.

(Bulatao et al. 2001 p.7). Nevertheless, the empirical indicators in this study may operationalise the relationship between fertility rates and educational attainment in Iran and Iraq.

The remainder of the paper is organised as follows. Section 2 discusses briefly the economic history of Iran and Iraq and highlights aspects such as land tenure, education, fertility, urbanisation and child-mortality rates. For the sake of brevity, this overview examines regional differences only at the provincial level. Section 3 examines the evidence and the general empirical strategy and presents the primary empirical results. Section 4 concludes.

5.2 Data and Regional Characteristics

5.2.1 Iran's economic development

Iranian economic development throughout the nineteenth and twentieth centuries was quite different from similar countries, partly because Iran was never formally colonised by any major power. The first oil concession was granted in 1910, and since then, economic interest in Iran has focused on oil (Najmabadi 1987). Recently, the decline in fertility rates in Iran has attracted international attention (Aghajanian 1991, Obermeyer 1994, Ladier-Fouldi 1997, Abbasi-Shavazi et al. 2006, Abbasi-Shavazi et al. 2007. Abbasi-Shavazi et al. 2008). Iranian births per woman were between 6 and 7 from the 1960s to the beginning of the 1980s and fell to approximately 1.8 in 2008 (Figure 1). This transition, from having one of the world's highest fertility rates to being at replacement levels,[59] is remarkable for Iran compared with other Middle Eastern countries. In Egypt, Iraq and Turkey, the declines in fertility rates were gradual, whereas the decline in fertility in Iran was substantial.

(Figure 1 about here)

[59] According to the Princeton rule, transition can be assumed to be under way if fertility declines by 10 percent.

In Table 1, a brief overview of the literature for Iran about schooling and fertility connection is shown. In almost all of the surveys, the data demonstrate that an improvement in education is associated with the fertility decline, but none of the studies specifically addresses the onset of the Q-Q trade-off at the disaggregated district level for the pre-transition period. Furthermore, none of the surveys presents a valid solution for the endogeneity problem that arises when using schooling and fertility data. In other words, in this study, both issues are considered. First, a new dataset for the pre-transitional period is presented. Second, an instrumental variable approach will most likely predict the relationship between child quality and child quantity in an adequate way. To our knowledge, no econometric research focusing on Q-Q trade-off for Iran and Iraq has been performed.

Despite internal migration,[60] Iran's population is divided geographically by its different ethnic and linguistic groups (Mohtadi 1990, Aghajanian 1983). Many Kurdish communities are situated in the west and northwest, with Baluchis in the east, Turks and Aseris in the north and northwest, and Arab groups in the south. Almost all of the communities in the central areas are ethnically Persian (Aghajanian 1983). Because of Iran's modernisation and integration into the world economy over the course of the twentieth century, the gaps in educational attainment among ethnic groups may have been even wider, as most economic development was concentrated in the central area (Aghajanian 1983).

Figures 3a-3c provide an overview of the spatial distribution[61] of school enrolment rates for each census wave. The central provinces *Markazi, Qom and Semnan* displayed quite good values compared with the north and southeast, which displayed a low value. The demonstrated figures contained provinces with missing values—as in the 1966 census—but the bulk of the

[60] Iran's migration process was a massive movement from the periphery to the core geographic regions (Kamiar 1988 p. 333).
[61] The maps of the province levels are included to illustrate the educational and residential environment of each province, as relates to the discussion of the provinces' varying stages of economic development. They allow for the inspection of the geographical distribution of the used variables. The statistical analyses, however, are based on district-level information.

observations covers nearly 83 percent of the population. In summary, there is an upward trend in school enrolment across all provinces, but the rankings of the regions do not change significantly over the three census waves.

(Figures 3a-3c about here)

The Law of Education, approved by the Iranian Parliament in 1911, contained in Article 3 the stipulation that elementary education was compulsory for all Iranians. However, full enrolment in elementary schools was achieved only towards the end of the 20th century. In the first comprehensive census of 1956, only 29.4 percent of the total population ages 10 and older were literate. School enrolment rates ranged from 3 to 64 percent across Iranian districts in 1956. The minimum and maximum rates for the 1966 census (9 percent and 91 percent) indicate an improvement in enrolment for children of 7 years and older; in 1976, the minimum and maximum enrolment rates were 23 percent and 96 percent, respectively (columns 3 and 4, Table 2). These decades also witnessed enormous improvements in educational quality.

Improvements in female mass education and rising opportunity costs are preconditions for a sustainable fertility decline (Mason 1984). The increase in school enrolment rates among Iranian females in urban areas accelerated at the same pace as the rates for males in the 1950s and 1960s. However, the enrolment rates of females in rural areas began to increase substantially after 1966. Furthermore, greater educational attainment for women meant a delay in marriage and childbearing in many other countries, but not in Iran, where the pressure to marry is intense. Additionally, job opportunities for women are negligible in Iran (Darabi 1976). From province to province, the percentage of working women varied from 1 to 47 percent of Iran's total population in 1956 (1percent to 43 percent in 1966 and 1 percent to 45 percent in 1976).

The child-woman ratio (CWR), defined as the number of children aged 0 to 5 years per woman of child-bearing age (aged 15 to 45 years), allows us to reconstruct fertility behaviour in Iran. Our measure for fertility comprises only surviving children, and therefore it is possible that infant mortality may bias our distribution of fertility. We do not have data on child mortality at the district level; however, we do have such data at the province level. The results of the related research suggest that infant mortality varies widely among provinces. Furthermore, differences in child mortality rates across provinces may reflect the economic status of the household that exist in Iran (Hosseinpoor, et al. 2005)[62].

The distributions of CWRs for each census year are shown in Figure 4. There is a clear shift to the left in the distribution for 1956 and 1976. Because we compare CWRs in cross sections at three points in time and the used child mortality in this study remains constant for each census year, the error caused by the variation in mortality will cancel out. By using the natural logs of the CWRs in 1966, we narrow the range of the dependent variable.

(Figure 4 about here)

Provinces in the west, presumably *Khuzestan, Lorestan and Ilam*, had higher child-woman ratios compared with the eastern and central provinces. In Iran, the largest variation in child-woman ratios is between the provinces and not within the same province. Table 2 provides descriptive statistics of the variables. The minimum and maximum CWRs are similar in 1956 (0.64 and 1.10, respectively), 1966 (0.69 and 1.70, respectively) and 1976 (0.58 and 1.10, respectively).

(Figures 5a – 5c about here)

[62] In this study the economic status of the household was the most important determinant of inequality of infant mortality. The index of economic status was constructed by using the following variables: number of rooms per capita, having a car, having a fridge, having a TV, telephone and kind of heating devices.

Another important claim for understanding fertility is the employment structure of women. The employment structure of women has been considered to obtain information about the stage of the emancipation and the role of women in the economic development. The mechanisms that promote change in Iran are not the same as in other Asian and Islamic countries. Delayed childbirth is not a major factor because there is strong cultural pressure on Iranian women to marry at a young age. Although in 1974, legal changes had raised the minimum marriage age,[63] these changes had no effect on the number of early marriages (Ladier-Fouladi 1997 pp.198-200). These observations also help to explain Iranian women's low levels of participation in the labour force.

Iran had previously offered a family planning programme that had only a negligible effect, particularly in rural areas. In an empirical prediction, Salehi-Isfahni et al. (2010) stated that initial literacy and educational institutions might have played a larger role in the fertility-rate decline in the conservative Islamic state of Iran than the family planning programme.

Finally the distribution of land, highlight some of key themes, which are worth mentioning by linking schooling and fertility figures. The history of Iran's 1962 land reform deserves a separate, detailed consideration. Landownership inequality is one of the explanatory variables that has in many setting a strong negative effect on human capital accumulation (Galor et al. 2009). The first comprehensive agricultural census of Iran in 1960 provided information on landholdings. It also contained information about various types of tenure[64] but not about the concentration and distribution of landownership. The land reform law limited the size of

[63] Article 23 of the Family Protection Law increased the minimum age to 18 for females and 20 for males (Ladier-Fouladi 1997).

[64] Forms of landed property have previously coexisted in Iran: common peasant lands, state lands, conditional land rights such as *Iqta* or *toyul* (circumstances in which revenues from agricultural land were given to local governors or military officers), unconditional land rights such as *soyurqal* (circumstances in which revenues from agricultural land were bestowed as a reward for previous services rendered to the state), Crown lands, private lands, and *awqaf* (religious endowments and tribal pastures).

landholdings of individuals to the equivalent of a single village. Landholdings above this limit had to be sold to the government. In turn, the government sold these holdings to peasants, who then had to pay for the holdings in installments over a fifteen-year period. Over the next decade, two-thirds of Iranian peasants became beneficiaries of approximately half of the total available agricultural land. Land reform was seen as a necessary precondition for diverse economic development in the decades after the 1950s (Najmabadi 1987 p. 68)[65].

Despite limited and inconclusive data, the results[66] of the 1962 land reform show that landowner inequality did not decrease. Several sources give inconclusive estimates of ownership distribution. All studies indicated highly concentrated landownership, which is typical of many Middle Eastern countries (Najmabadi 1987 pp. 100-103).

Given the dearth of data on land inequality—presumably, we are lacking district-level information—we used data on the type and construction of tenure to calculate a Gini-Index. This index provides the grade of concentration of housing construction across Iranian districts. For each district, we have information about the distribution of materials used to build housing units. For example, in the *Danavand* district in the census year 1956, 59 percent of housing units were constructed with sun-dried bricks, and 33 percent were constructed with mud. The remaining units were constructed with stone, wood and other materials.

The primary assumption when using type and construction of tenure to determine landownership inequality is that the quality of housing material corresponds to landownership. Allocations of land, housing and housing construction material are determined by the social stratification in Iran. People with higher socio economic background have higher opportunity of

65 The land reform programmes of third world countries after WWII aimed to transform the internal socioeconomic order of society: "Unsatisfactory forms of agrarian structure and in particular systems of land tenure, tend in a variety of ways to impede economic development in third world." (UN 1951 a: 65).
66 The number of small holdings—less than 1 hectare—increased by 19 percent between 1960 and 1974, and the number of very large holdings—more than 100 hectares—increased by 134 percent. Information on medium-sized holdings is not available.

homeownership and vice versa of landownership. Housing conditions have improved in last 50 years in general, but in rural areas the access to piped water and central heating was modernized more slowly than the urban regions. The predominant housing material across Iran districts is sun dried bricks, probably displaying the low condition of the people with lower socioeconomic background. These are some reason which reinforced that an unequal distribution of housing material reflects an inequality in land tenure.

The spatial distributions of the Gini-Index are shown in Figures 6a-6c. The inequality measure was highest in 1956 in *East Azarbayjan, Zanjan Esfahan, Kerman* and *Sistan Baluchestan*. In the 1966 census, we can observe material inequality in *Esfahan, Hamadan* and *Sistan Baluchestan*. Finally, inequality was more prevalent in the eastern provinces in 1976. The minimum and maximum values of our Gini-Index vary widely (see Table 2).

(Figures 6a – 6c about here)

If these patterns do, in fact, reflect landownership inequality, the calculated indices may help to establish the relationship between child outcome and child quantity.

5.2.2 Economic and social change in Iraq

Iraq was ruled by the Ottoman Empire until the Empire's collapse in 1918. As a modern state, Iraq was constructed from the rudimentary administrative structures of three Ottoman provinces. Iraqi independence occurred in 1932. During the period from 1958 to 1968, Iraq underwent four violent and bloody changes in political power. The Ba'th party had taken control once in 1963, but military conflicts with the Iraqi Communist Party allowed the Ba'th party to return to power after the revolution in July 1968 (Hashimi et al. 1961 pp. 55-70). After the formation of the Republic of Iraq in 1958, a new agrarian reform law was introduced. This reform capped the size of individuals' property to establish a more equitable system of ownership. The maximum landholding was limited to 1000 *donums*[67] (618 acres) of irrigated land or 2000 *donums* of non-irrigated land (Hashimi et al. 1961 p. 76). In Iraq, this reform led to a disruption of the tribal system. The majority of the Iraqi population is Arab (77 percent), with Kurds comprising a large minority group (20 percent), mostly located in cities such as *Kirkuk*, *Sulaymaniyah* and *Arbil*.

Large-scale landholdings, which were tribal in origin, were an important feature of Iraq's landownership system. Landownership built up the tribal *dirah*[68], and private property emerged as a result of land appropriation by tribal sheikhs after pump irrigation systems were implemented in the 1920s. In her study, Warriner (1962) used the agricultural census of 1952, which counts and classifies agricultural holdings by size.

Notably, the land system in the northern regions of Iraq differs markedly from that in the south. In particular, the tradition of inheritance in northern Iraq was regulated by the *Ottoman Land Code*. In that region, equal division between heirs was allowed, whereas in the southern regions, the *Sharia law* bestowed the inheritance privilege on the eldest son (Warriner 1962 p. 138). As described in the literature mentioned previously, large-scale landholding was prevalent in the irrigation zone between the two rivers. Figure 7 suggests that the provinces with the greatest concentration of landholding and the strongest tribal authority are *Maysan* and *Thi-Qar* in the south. The Statistical Abstract of 1965 provides a classification of the sequestered land.

(Figure 7 about here)

[67] The unit of area used in Iraq is the *donum*, which is equal to 618 acres or 0.25 hectare
[68] Customary right

There is also considerable evidence that the expropriation of land took place predominantly in northern Iraq, where the average holding was smaller (Warriner 1962 p.145). In summary, expropriation efforts seem to have been politically motivated, presumably to disadvantage ethnic groups in northern Iraq.

Iraq instated a compulsory primary education law in 1958, almost 50 years after Iran; however, widespread implementation of the law did not occur until the 1970s. Although district-level statistics from Iraq are scarce, education data seem likely to be accurate. The educational system in Iraq comprises four parts: a pre-school stage, a compulsory six-year primary education stage, a secondary stage and tertiary stage. The educational system was adopted from the British and Soviet method and was characterised by a high level of discipline (Delwin 1993 p. 185).

For purposes of comparison, we mapped the education data on the provincial level. The details of the descriptive statistics for Iraq are shown in Table 2. Of particular interest are the low levels of school enrolment in the north and in the irrigation zone between the two rivers, which is the agricultural region of Iraq. Only *Baghdad, Nadschaf and Al-Basrah* show high enrolment rates. Meanwhile, the northern regions with agricultural industries (*Duhok*, *Arbil* and *As-Sulymaniyyah*) show comparatively high fertility rates.

(Figures 8 and 9 about here)

What do these figures imply about the relationship between child-woman ratios and school enrolment rates? The map of child-woman ratios shows clear regional differences: fertility is high in the northern provinces, low in the southern areas and moderate in the western region of Iraq. The population of the northern regions, which were Kurdish minorities at the time, clearly had inferior access to education.

The available data from the 1965 census reveal the same traditional marriage pattern in Iraq as in many other Arab and Muslim countries. In the Iraqi districts measured, 83 percent of the women were married. Tabutin et al. (2005) show that mean age at first marriage has changed over the last thirty years. The mean age of marriage for Iraqi women was 20.8 years in 1975, and it increased to 22.3 years in 1998 (Tabutin et al. 2005, Table A4, p. 596).

5.3 Estimation strategy and results

The last section has emphasised the variables that can play a substantial role in the relationship between fertility and education. In this section, we perform OLS and 2SLS regressions to test whether school enrolment rate (child quality) has an effect on fertility (child-woman ratio) in Iran and Iraq for each census wave. An empirical exploration at the disaggregate level, at which the units of analysis are districts, can help us to identify determinants of the Q-Q trade-off.

5.3.1 Quantity-quality trade-off in Iran and Iraq: OLS regression

Simple scatter plots are used to examine each census wave (Figure 10a-10c). A visual inspection across districts confirms a negative association in Iran. In the bivariate regressions (Column 1, Table 3a-3c), education and child-woman ratios are significantly negatively correlated across Iranian districts in all census years. In the subsequent columns, we introduce additional control variables.[69] In all three census years, we found that the trade-off between education and fertility may have existed before the fertility decline in the 1980s. Adding further control variables increases the negative relationship, as observed for census year 1956 (Table 3a). The results reported in Tables 3b and 3c—for the 1966 and 1976 census waves—generally show

[69] For Iraq, the following independent variables are not available: percentage of working women, non-mover and population density.

the negative effects of schooling on the fertility rate. The size of the estimated coefficient decreases with the introduction of additional covariates, although the negative relationship still exists. It is noteworthy that the enrolment rates in 1956 are not directly comparable to enrolment rates in later census waves. Only information about the enrolment rate of children aged 10 to 14 years is available from 1956; therefore, a slight decline in the proportion of this age group could cause measurement errors for the first census wave.

The marital status of women is significantly and positively correlated with fertility for the census years 1966 and 1976 (s.e. = 0.76 and 0.73, respectively) but not for the first Iranian census in 1956. The marriage effect seems to generate a negligible effect on fertility (see column 4, Table 3a) in 1956. One of the primary problems with evaluating the impact of the marriage effect on fertility in Iran is the underreporting of early marriage; if these marriages were included in the data, one might expect to find stronger evidence of a relationship between child-woman ratios and marital status.

Women's participation in the labour market can decrease the time available for childbearing, especially in the case of rising wage rates. Furthermore, women's participation in the labour market can weaken traditional paternalistic structures (Mason 1984, Aghajanian 1995). Married women without many opportunities to participate in labour markets—as was the case in Iran—are likely to have little knowledge of contraception[70] and tend to have higher birth rates. Not surprisingly, the effect of women's participation in the labour market on fertility is negative in 1956 (Columns 6 and 7, Table 3a). The corresponding effects for subsequent census year are negative but not statistically significant (Columns 6 and 7, Tables 3b, 3c).

[70] An increase in contraceptive knowledge could increase the quality of children as well as decreasing birth rates. Contraceptive knowledge diffused greatly in Iran in the 1970s, but it is not possible to estimate the precise effects (Aghajanian A, 1995).

A final result of note is the percentage of the urban population. The OLS estimates suggest that child-woman ratios in Iran are negatively correlated with the percentage of the urban-dwelling population. Only in the 1976 census are these findings statistically significant.

In contrast, OLS estimates for Iraq show a positive effect of fertility rate on schooling. After adding almost all[71] of the same control variables, the positive relationship increased (Tables A.1 and A.2). The coefficients for the percentage of the population that is Moslem indicate a negative relationship. Higher infant mortality rates and urbanisation decrease fertility rates across Iraqi districts. By introducing the percentage of urban population variable, the explanatory power of the model and the positive coefficient of the school enrolment rate increased (Column 4, Table 4).

These results have important implications for the debate regarding the timing of the Q-Q trade-off. They suggest that the increasing enrolment rate in Iran may have had a significant effect on the rapid decline in fertility rates before the 1980s, and it is likely that in Iraq these mechanisms did not occur. The coefficient sign of the estimations may indicate whether such a trade-off existed. In light of these arguments, it is important to consider that the estimated results are valid only if endogeneity does not create a bias.

5.3.2 Determining quantity-quality trade-off: instrumental variable estimation

Next, we turn to the possibility of an endogeneity bias in our estimates. Fertility rates may influence human-capital formation, and human capital may influence fertility rates. OLS may overestimate this effect, and it cannot deliver conclusive evidence given the possibility of reverse causality. We avoid this potential bias by using an instrumental variable (IV) approach. To use an

[71] To allow for an accurate comparison between the countries, we estimate the same specifications, and the results do not change (see Appendix A, Table A.1, A.2).

IV[72] approach, we need convincing instruments. A convincing instrument should be highly correlated with quality in children but should not directly affect child-woman ratios, except via schooling.

5.3.3 Identifying Instruments

For our empirical model, each district's distance to the capital (Tehran and Baghdad), its percentage of land and its building ownership inequality are used as instruments. Along with others, Galor et al. (2009) note that landownership inequality has a negative effect on the development of human-capital accumulation. Large-scale landowners normally do not support tax-financed schooling; hence, this socioeconomic group would not support the implementation of human-capital–generating institutions (Galor et al. 2009 p. 144). Large-scale landownership was a widespread practice in both countries, and land reforms in the 1960s, enacted to limit the size of properties, produced inconclusive results. In light of these factors, the calculated Gini-Index is used as an instrument for Iran. For Iraq, the instrument is the distributions of expropriated land obtained from the census of 1965.

The districts' distances from the country's capital could be used as an instrument because of the exogenous character of the variable. In other studies, distance variables have proven to be controversial but theoretically valid instruments. In our case, a district's distance to the Iranian or Iraqi capital has a curvilinear relationship to school enrolment rates (Figures 11a-11d). With the addition of the quadratic term of our distance variable, the functional form is properly defined. For example, in 1956 Iran, the relationship between schooling and distance from the capital is negative up to 1500 km, and then the relationship becomes positive. The curvilinear relationship

[72] Below the IV estimation, we report the F-test and the Sargan/Hansen test for over-identifying restriction. The first-stage statistics confirm that our excluded instruments are highly connected with the endogenous variable. The F-statistics from the first stage are mostly high. The null hypothesis of the over-identifying restriction is rejected, suggesting the validity of the instruments.

may reflect the centralised systems of government in both countries. Provincial administrations were responsible for implementing the central governments' laws. Enforcement of schooling varied across districts, as revealed in Table 2. In summary, geographic proximity to the capital correlates with higher school enrolment rates, up to a certain distance. In our empirical analysis, the F-statistic values for the distance variables suggest no signs of weak instruments. As a result, the distance to Tehran and Baghdad seems to be a valid instrument.

As the preceding discussion has shown, landownership is theoretical important, and finding an economic coherent suitable instrument is the aim in this specification. However, the lower F-statistic in our specification may be due to the fact that data about landowner inequality in Iraq were available at the provincial level. For Iran, our second instrument seems not to be truly exogenous. To maintain consistency with our theoretical arguments, the results of the IV estimation using our inequality proxy are presented in Tables B1 and B2 in appendix B. However, a set of robustness checks implies that using both instruments together will not deliver accurate results.

5.3.4 Interpretation of the IV results - distance to capital as instrument

Table 5 and Table 6 provide the results of the instrumental variable estimations for Iran and Iraq, respectively. It is notable that school enrolment rates for all census waves are instrumented by districts' distance to the capital. The first three columns show the first-stage results. The estimated results suggest that distance to the capital is significantly associated with school enrolment rate. The results indicate that distance to the capital could be a valid instrument for the potentially endogenous variable of child-woman ratio.

The basis associations between the variables of interest are obvious. A 1 percent rise in educational enrolment was associated with decreases in child-woman ratios of 0.22, 0.40 and

0.90 in 1956, 1966 and 1976, respectively. These results are significant for the census years 1966 and 1976 but not for the first Iranian census (columns 4, 5 and 6, Table 5). A 1 percent rise in enrolment accounts for approximately 9 fewer children per 100 women in 1976. This is a strong effect, considering that the mean value is approximately 87 children per 100 women (2 fewer children were born per 100 women in 1956, and 4 fewer children were born per 100 women in 1966). Nevertheless, it should be mentioned that this calculation is based on only 112 observations in 1956, 58 observations in 1966 and 128 observations in 1976. However, the estimated effects of rising enrolment rates show that the expansion of mass education in Iran had led to fewer childbirths.

Another important implication is indicated by the percentage of married women, which is positively connected with child-woman ratios. It is evident that in an Islamic country such as Iran, children are most often born in wedlock. Meanwhile child-woman ratios are negatively connected with the percentage of working women. The coefficient is statistically significant but only for the census of 1956.

In contrast, for Iraq, we observe a positive and significant relationship between child-woman ratios and school enrolment rates (column 2, Table 6). The coefficient for the school enrolment rate is positively significant at the one-percent level, suggesting that fertility rates in Iraq increased with higher school enrolment rates. Note that the instrument Distance to Baghdad is highly statistically significant, with a t-statistic near three. Distance from Baghdad is associated with lower enrolment rates up to 350 km, beyond which the relationship increased. The IV coefficient for Iraq in Table 6 shows that an increase in the enrolment rate by one percent causes an increase in the child-woman ratios by 3 children per 100 women. The average child-woman ratio in Iraq was approximately 111 children per 100 women in 1965. As noted in our OLS estimation, the coefficient for urbanisation is statistically significant, which means that the Q-Q trade-off in urban counties was more pronounced.

For both countries, it could be concluded that the estimated coefficient confirms our primary finding in the OLS estimates. The 2SLS estimate shows a larger effect of education on fertility compared with the OLS estimate. The OLS and 2SLS estimates of the schooling coefficient are not significantly different, as shown by the endogeneity tests. Hence, we can conclude that school enrolment rates are negatively associated with child-woman ratios in Iran and positively associated in Iraq.

5.4 Conclusion

In this paper, we test the theory of quantity-quality trade-off for children using representative census datasets. The primary question in this study is whether the fertility decline starting in the 1980s can be attributed to higher rates of school enrolment in both countries. The evidence reported by our OLS estimations suggests that the quantity-quality trade-off in a Becker-Lewis setup is present in Iran but not in Iraq. The consistency of the results across the census years may indeed be an argument that "exogenous" schooling decreased fertility rates in Iran. A quantity-quality trade-off is less obviously apparent in Iraq in 1956.

The effects are robust to various specifications, including those that control for urbanisation patterns and religious characteristics. We then instrumentalise school enrolment rates with districts' distances to the capital to examine the causal link between fertility rates and children's education, and we find evidence supporting this link. There may be alternative explanations for Iran's sharply declining fertility rate in the mid-1980s, but the pre-1980s data used in the analyses reveal a consistent negative connection between fertility and school enrolment rates, which means that a quality-quantity trade-off was already occurring in Iran. The fertility transitions in

Iraq and Iran have been the topics of several studies, but empirical surveys that account for the quantity-quality trade-off are not available.

References:

Abbasi-Shavazi, M.J., Lutz W., Hosseini-Chavoshi, M., Samir K.C. (2008). Education and the World's Most Rapid Fertility Decline in Iran, Working Paper Interim Report: International Institute for Applied System Analysis.

Abbasi-Shavazi, M.J., Hosseini-Chavoshi, M., McDonald, P. (2007). The path to below – replacement fertility in Iran, Asia-Pacific Population Journal, Asia-Pacific Population Journal, 22 (2): 91-112.

Abbasi-Shavazi, M. J., McDonald, P. (2006). The fertility decline in the Islamic Republic of Iran, 1972-2000, Asian Population Studies, 2(3): 217-237.

Abbasi M. J., Mehryar A., Jones G., McDonald P. (2002). Revolution, war and modernization: Population policy and fertility change in Iran, Journal of Population Research 19 (1): 25-46

Aghajanian A, Adrian E. Raftery, Lewis S. M. (1995). Demand or Ideation? Evidence from the Iranian Marital Fertility Decline. Demography, Vol. 32 (2): 159-182.

Aghajanian A, New direction in population policy and family planning in the Islamic Republic of Iran, Asian-Pacific Population Journal, 1995, 10(1):3-20.

Aghajanian A, Population change in Iran, 1966-1986: stalled demographic transition? Population and Development Review, 1991, 17(4):703-715.

Aghajanian, A. (1983). Ethnic Inequality in Iran: An Overview, Int. J. Middle East Stud. 15,: 211-224.

Ahn, T. S, Knodel, J., Lam D., Friedman J. (1998). Familiy size and children' education in Vietnam, Demography, 35 (1): 57-70.

Becker, G. S. (1960). An Economic Analysis of Fertility. In: Gary S. Becker (ed.), Demographic and Economic Change in Developed Countries, pp. 209-240. Princeton, NJ: Princeton University Press.

Becker, G. S., H. Gregg L. (1973). On the Interaction between the Quantity and Quality of Children. Journal of Political Economy 81 (2, part 2): 279-S288.

Becker, G. S., Nigel T. (1976). Child Endowments and the Quantity and Quality of Children. Journal of Political Economy 84 (4, part 2): 143-S162.

Becker G.S., Murphy K.M., Tamura R.(1990). Human capital, fertility, and economic growth - Journal of Political Economy, 98, (5): 12-37.

Becker, S. O., Cinnirella F., and Woessman L. (2010). The Trade-off between Fertility and Education: Evidence before the Demographic Transition, Journal Economic Growth 15: 177-204.

Black SE, Devereux PJ, Salvanes KG, 2005. The More the Merrier? The Effect of Family Size and Birth Order on Children's Education, Quarterly Journal of Economics. 120:669–700.

Bulatoa R.A., Casterline J.B., (2001). Global fertility transition. New York: Population Council.

Darabi, K. F., (1976). Education and Fertility in Iran. Community Development Journal Vol. 11, No. 2.

Delwin A. R., (1993). The Educational System of Iraq. Middle Eastern Studies, Vol. 29, pp. 167-197.

Galor, O. (2005). From Stagnation to Growth: Unified Growth Theory. In: Philippe Aghion, Steven N. Durlauf (eds.), *Handbook of Economic Growth*, vol. 1A, pp. 171-293. Amsterdam: Elsevier.

Galor ,O., Moav, O., Vollrath, D. (2009). Inequality in land ownership, the emergence of human capital promoting institutions, and the great divergence. Review of Economic Studies, 76 (1), 143-179.

Hashimi R. M. H., Edwards A. L. (1961). Land Reform in Iraq: Economic and Social Implication. Land Economics, 37 (1): 68-81.

Hosseinpoor, A. R., Mohaamad K., Majdzadeh R., Naghavi M., Abolhassani F., Sousa A., Speybroeck N., Jamshidi H.R. and Vega J. (2005). Socioeconomic inequality in infant mortality in Iran and cross its provinces. Bulletin of the World Health Organization, 83 (11).

Kamiar, M. (1988). Changes in spatial and temporal pattern of development in Iran. Political Geography Quarterly, 7 (4): 323-337.

Knodel, J. and M. Wongstih (1991). Familiy Size and Children's Education in Thailand: Evidence from a National Sample. Demography 28: 119-31.

Ladier-Fouladi, M. (1997). The Fertility Transition in Iran Population: An English Selection 9: 191-213.

Looney, R. E. (1992). Economic Development in Iraq: Factors Underlying the Relative Deterioration of Human Capital Formation. Journal of Economic Issues 26 (2): 615-619.

Lucas, R. E. (2002). Lectures on economic growth. Cambridge, MA: Harvard University Press

Obermeyer, M. (1994). Reproductive choice in Islam: gender and state in Iran and Tunisia. Stud. Fam. Plann 25 (1): 41-41

Mason, K.O (1984). The status of Women: A Review of its Interrelationship to Fertility and Mortality. New York: Rockefeller Foundation.

Mohtadi, H. (1990). Rural Inequality and Rural-Push versus Urban-Pull Migration: The Case of Iran, 1956-1976. World Development, 18 (6):837-844.

Montgomery, M. R., Arends-Kuenning, M., Mete C., (2000). The Quantity-Quality Transition in Asia. Population and Development Review 26, Supplement: Population and Economic Change in East Asia: 223-256.

Najmabadi, A. (1987). Land Reform and Social Change in Iran. University of Utah Press Salt Lake City.

Polit, D. (1982). Effects of Family Size: A Critical Review of Literature since 1973. Final Report. Wachington, DC: American Institutes for Research.

Reher D.S. (2004). The Demographic Transition Revisited as a Global Process. Popul. Space Place 10, 19-41.

Rosenzweig, M. R., Wolpin K. I. (1980). Testing the Quantity-Quality Fertility Model: The Use of Twins as a Natural Experiment. *Econometrica* 48 (1): 227-240.

Salehi-Isfahani D., Abbasi M. J., Hosseini-Chavoshi, M. (2010). Family Planning and Fertility Decline in Rural Iran: The Impact of Rural Health Clinics, Health Economics 19 (1): 159-180.

Schultz, T. P. (1994). Human Capital, family planning and their effect on population growth. American Economic Review 84(2): 255-260.

Tabutin, D., Schoumaker, B., Godfrey, R., Mandelbaum, J., Dutreuilh, C., (2005). The Demogrphy of the Arab World and the Middle East form the 1950s to 2000s. A Survey of Changes and a Statistical Assessment. Population 60 (5/6): 505-616.

Warriner, D. (1962). Land Reform and Development in the Middle East: A Study of Egypt, Syria and Iraq, London: Royal Institute of International Affairs.

Tables

Table 1: Overview of the literature

Author, year	Data	Method	Result
Abbasi-Shavazi, M. J., McDonald, P. (2006)	Census data for 1986 and 1996 and Iran Demographic and Health Survey, 2000	Descriptive analysis	Rate of female educational attainment has increased substantially
Abbasi-Shavazi, M. J., Lutz, W., Hosseini-Chavoshi, M. (2008)	Census data for 1966	Decomposition estimate	Co-evolution of education and childbearing behaviour
Aghajanian, A. (1991)	Census data for 1966, 1976, 1986	Descriptive analysis	Structural and social change decreased fertility
Darabi, K. F. (1976)	Micro level: 338 women	Descriptive analysis	Literacy is unrelated to fertility
Ladier-Fouladi, M. (1997)	Census data for 1996, 1976, 1986, 1991	Log-linear modelling	Social and cultural progress has been the keystone for fertility development
Obermeyer, C. M. (1994)	World Bank 1992, 1991	Descriptive analysis	Socioeconomic changes contributed to the onset of a fertility decline
Raftery, A. E, Leweis S. M, Aghajanian A. (1995)	Micro level: IFS 1977, 4,932 women	Discrete event analysis	Mass education caused fertility decline
Salehi-Isfahani D., Abbasi M. J., Hosseini-Chavoshi, M. (2010).	District level: census 1986, 1996, 2006	Difference in difference estimation	Initial literacy played a larger role in fertility decline than other socioeconomic changes

Table 2: Summary statistics

Iraq 1965	mean	sd	min	max
Child-women ratio	1.11	0.12	0.87	1.41
School enrolment	0.11	0.06	0.01	0.33
Percentage Moslem	0.97	0.10	0.42	1.00
Infant mortality	2540	2451	460	11951
Percentage urban population	0.36	0.23	0.06	0.97
Percentage married women	0.83	0.09	0.15	0.97
Distance to Baghdad	298	158	8	638
Expropriated land	198274	216302	5503	582627
Iran 1956				
Child-woman ratio	0.89	0.10	0.62	1.10
School enrolment	0.20	0.11	0.03	0.64
Percentage Moslem	99.21	0.93	92.70	99.90
Infant mortality	2.59	0.73	1.38	4.07
Percentage urban population	17.98	15.77	2.07	84.12
Percentage married women	0.84	0.36	0.16	4.39
Percentage of working women (% of total pop)	0.07	0.08	0.00	0.53
Percentage of working women (% of total occupied pop)	0.10	0.08	0.01	0.47
Percent for whom place of birth is the same district	91.95	10.26	47.00	99.80
Distance to Tehran	750	476	0	3419
Gini-Index proxy for landownership inequality	0.73	0.09	0.33	0.91
Iran 1966				
Child-woman ratio	0.98	0.12	0.69	1.70
School enrolment	0.42	0.16	0.09	0.91
Percentage Moslem	99.44	1.25	92.40	99.90
Infant mortality	2.52	0.60	1.38	4.07
Percentage urban population	28.78	20.68	3.50	96.80
Percentage married women	0.81	0.04	0.70	0.88
Percentage of working women (% of total pop)	0.10	0.10	0.00	0.50
Percentage of working women (% of total occupied pop)	0.15	0.11	0.01	0.43
Percentage for whom place of birth is the same district	89.70	11.25	44.40	98.80
Distance to Tehran	581	355	0	1287
Gini-Index proxy for landownership inequality	0.76	0.06	0.62	0.87
Iran 1976				
Child-woman ratio	0.87	0.10	0.58	1.10
School enrolment	0.67	0.14	0.28	0.96
Percentage Moslem	99.66	0.41	97.70	100.00
Infant mortality	2.54	0.71	1.38	4.07
Percentage urban population	32.24	19.38	3.90	84.20
Percentage married women	0.75	0.05	0.63	0.88
Percentage of working women (% of total pop)	0.08	0.08	0.00	0.36
Percentage of working women (% of total occupied pop)	0.14	0.11	0.01	0.45

Percentage for whom place of birth is the same district	90.44	8.21	57.40	99.00
Distance to Tehran	733	427	66	3419
Gini-Index proxy for landownership inequality	0.76	0.07	0.55	0.91

School enrolment rate is the percentage of children aged 7 to 14 enrolled in primary schools for the census years 1966 and 1976. In the first Iranian census data, only children aged 10 to 14 are considered. The child-woman ratio is the number of children aged 0 to 5 divided by the number of women aged 15 to 45.
Sources: Data for 113 districts from the first Iranian Census (1956); Data for 59 districts from the second Iranian Census (1966) covering 89 percent of the total population; Data for 129 districts from the third Iranian Census (1976). To construct a Gini coefficient as a proxy of landownership inequality, we use the type of construction by tenure of the housing units.

The relationship between education and fertility in different Iranian censuses

Table 3 (a) The relationship between education and fertility – Iran, 1956

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable				Child-woman ratio			
School enrolment	-0.14	-0.14	-0.14	-0.15	-0.15	-0.22*	-0.25**
	[-1.27]	[-1.34]	[-1.34]	[-1.58]	[-1.65]	[-1.92]	[-2.22]
Percentage Moslem		0	0	0	0	0	-0.01
		[0.01]	[0.01]	[-0.00]	[0.05]	[-0.27]	[-0.56]
Infant mortality			0	0	0	-0.02	-0.03
			[0.02]	[0.02]	[0.03]	[-0.38]	[-0.52]
Percentage urban population				0	0	0	0
				[0.10]	[0.04]	[0.07]	[-0.18]
Percentage married women					-0.02	-0.02	-0.02
					[-0.48]	[-0.98]	[-1.07]
Percentage of working women						-0.03**	-0.03**
						[-2.40]	[-2.35]
Non-mover						0.02**	0.02**
						[2.44]	[2.38]
Population density							0.02
							[1.69]
Constant	0.92***	0.92***	0.92***	0.91***	0.91***	0.81***	0.80***
	[30.92]	[33.24]	[18.13]	[11.14]	[11.04]	[9.07]	[9.75]
Observations	112	112	112	112	112	112	112
R-squared	0.02	0.02	0.02	0.02	0.03	0.21	0.25

OLS regression: Child-woman ratio is the number of children aged 0 to 5 divided by the number of women aged 15 to 45. School enrolment rate is the percentage of children aged 10 to 14 who were enrolled in public primary school. *** $p<0.01$, ** $p<0.05$, * $p<0.1$ t-statistics in brackets

Source: Data for 113 districts from the first Iranian Census (1956)

Table 3 (b): The relationship between education and fertility – Iran, 1966

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable				Child-woman ratio			
School enrolment	-0.31**	-0.30**	-0.33**	-0.29**	-0.24*	-0.21	-0.20*
	[-2.79]	[-2.63]	[-2.32]	[-2.29]	[-2.05]	[-1.73]	[-1.77]
Percentage Moslem		-0.01	-0.02	-0.01	-0.02	-0.01	-0.02
		[-1.29]	[-1.20]	[-1.28]	[-1.57]	[-1.41]	[-1.72]
Infant mortality			0.11	0.1	0.11	0.11	0.11
			[0.93]	[0.90]	[0.87]	[1.13]	[1.02]
Percentage urban population				-0.02	-0.02	-0.02	-0.03
				[-0.78]	[-0.86]	[-0.73]	[-1.00]
Percentage married women					0.56	0.65	0.76*
					[1.39]	[1.46]	[1.87]
Percentage of working women						-0.03	-0.03
						[-1.37]	[-1.23]
Non-mover						-0.01	-0.01
						[-0.74]	[-1.05]
Population density							0.02
							[1.52]
Constant	1.11***	1.09***	1.00***	1.05***	1.18***	1.12***	1.11***
	[18.78]	[17.93]	[12.95]	[19.66]	[15.23]	[14.26]	[15.25]
Observations	59	58	58	58	58	58	58
R-squared	0.16	0.17	0.21	0.22	0.26	0.31	0.33

OLS regression: Child-woman ratio is the number of children aged 0 to 5 divided by the number of women aged 15 to 45. School enrolment rate is the percentage of children aged 6 to 14 for census years 1966 and 1976 who were enrolled in public primary schools. *** p<0.01, ** p<0.05, * p<0.1 t-statistics in brackets.

Source: Data for 58 districts from the first Iranian Census (1966).

Table 3 (c): The relationship between education and fertility – Iran, 1976

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable				Child-woman ratio			
School enrolment	-0.41***	-0.37***	-0.37***	-0.30***	-0.05	-0.04	-0.04
	[-6.19]	[-5.32]	[-5.33]	[-4.45]	[-0.72]	[-0.56]	[-0.53]
Percentage Moslem		-0.02***	-0.02***	-0.01	-0.01	-0.01	-0.01
		[-3.14]	[-2.89]	[-1.53]	[-0.98]	[-1.44]	[-1.47]
Infant mortality			-0.05*	-0.04	-0.02	-0.02	-0.02
			[-1.73]	[-1.37]	[-0.65]	[-0.64]	[-0.60]
Percentage urban population				-0.05***	-0.04***	-0.05***	-0.05***
				[-3.18]	[-3.87]	[-4.45]	[-4.77]
Percentage married women					0.73***	0.73***	0.73***
					[6.42]	[6.06]	[5.76]
Percentage of working women						0	0
						[0.29]	[0.30]
Non-mover						0.01	0.01
						[1.37]	[1.33]
Population density							0
							[-0.16]
Constant	1.14***	1.08***	1.14***	1.26***	1.31***	1.30***	1.30***
	[24.82]	[22.19]	[19.37]	[17.07]	[17.40]	[19.37]	[19.47]
Observations	128	128	128	128	128	128	128
R-squared	0.32	0.37	0.39	0.43	0.54	0.55	0.55

OLS regression: Child-woman ratio is the number of children aged 0 to 5 divided by the number of women aged 15 to 45. School enrolment rate is the percentage of children aged 6 to 14 for census years 1966 and 1976 who were enrolled in public primary schools. *** p<0.01, ** p<0.05, * p<0.1 t-statistics in brackets.

Source: Data for 128 districts from the first Iranian Census (1976).

Table 4: The association between education and fertility in Iraq

	(1)	(2)	(3)	(4)	(5)
Dependent variable		Child-woman ratio			
School enrolment	0.03	0.03	0.03	0.09***	0.09***
	[1.34]	[1.44]	[1.42]	[3.44]	[3.41]
Percentage Moslem		-0.17*	-0.15*	-0.17**	-0.17**
		[-1.84]	[-1.74]	[-2.04]	[-2.02]
Infant mortality			-0.04**	-0.03*	-0.03*
			[-2.13]	[-1.97]	[-1.95]
Percentage urban population				-0.08***	-0.08***
				[-3.36]	[-3.33]
Percentage married women					0
					[0.02]
Constant	0.16***	0.16***	0.43***	0.44***	0.44***
	[3.25]	[3.25]	[3.06]	[3.34]	[3.31]
Observations	76	76	71	71	71
R-squared	0.02	0.07	0.13	0.26	0.26

OLS-regression. Dependent variable: child-women ratio. *** p<0.01, ** p<0.05, * p<0.1 Child-women ratio is the number of children aged 0-5 over the number of women aged 15-45. School enrolment rate is the percentage of children aged 6-14 receiving elementary-level schooling. Source: District-level data from Iraq Census 1965. See main text and appendix for details.

Table 5: Instrumental Variable Estimation for Iran

	IV first stage			IV second stage		
	(1)	(2)	(3)	(4)	(5)	(5)
	1956	1966	1976	1956	1966	1976
Dependent variable	School enrolment			Child-woman ratio		
Percentage Moslem	0.02*	0	0	-0.01	-0.01	-0.01
	[2.08]	[-0.15]	[-0.10]	[-0.36]	[-1.39]	[-0.86]
Infant mortality	0	0.03*	-0.03**	-0.01	0.05	-0.03*
	[0.01]	[1.92]	[-2.42]	[-0.41]	[1.44]	[-1.82]
Percentage urban population	0.09***	0.12***	0.06**	0	0	0
	[4.74]	[5.33]	[2.59]	[-0.07]	[0.06]	[-0.05]
Percentage married women	-0.02*	-0.62	-1.23***	0.04**	0.75*	0.53
	[-1.88]	[-1.67]	[-9.29]	[2.14]	[1.79]	[0.66]
Percentage of working women	0.01	0	0.02**	-0.03*	-0.02	0.01
	[1.32]	[0.05]	[2.10]	[-1.70]	[-1.19]	[1.06]
Non-mover	0.03***	0.04***	0	0.02	0	0.01
	[4.57]	[3.59]	[-0.10]	[1.39]	[0.30]	[0.51]
Population density	0	-0.02	0	0.02**	0.02	0.01
	[-0.05]	[-0.55]	[0.32]	[2.06]	[1.36]	[0.36]
Distance to Tehran	-0.01**	-0.06***	-0.02**			
	[-2.53]	[-3.79]	[-2.27]			
(Distance to Tehran)^2	0	0.00**	0.00**			
	[1.69]	[2.77]	[2.26]			
School enrolment				-0.26	-0.47***	-0.92**
				[-0.50]	[-2.96]	[-2.20]
Constant	0.02	-0.04	0.26*	0.84***	0.29	1.96**
	[0.37]	[-0.40]	[1.93]	[10.06]	[0.75]	[2.43]
Observations	112	58	128	112	58	128
R-squared	0.59	0.62	0.64	0.26	0.28	.
F-statistic 1st stage	16.55	14.40	10.25			
p-value	0.24	0.05	0.05			

2SLS regression. The results of second-stage estimates are in columns (4), (5), and (6). The corresponding first-stage results are in columns (1), (2), and (3). Wu-Hausman F-test. Robust t-statistics in brackets *** p<0.01, ** p<0.05, * p<0.1.

Sources: Data for 113 districts from the first Iranian Census (1956); Data for 59 districts from the second Iranian Census (1966) covering 89 percent of the total population; Data for 129 districts from the third Iranian Census (1976).

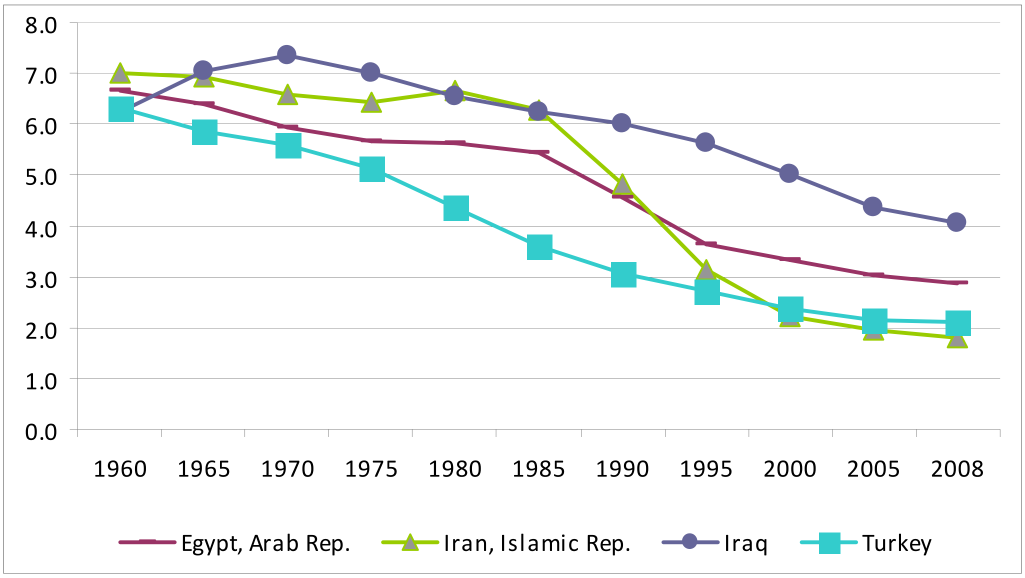
Table 6: The effect of education on fertility in Iraq in 1965

	IV first stage	IV second stage
	(1)	(2)
Dependent variable	School enrolment	Child-woman ratio
Percentage Moslem	0.314	-0.200***
	[1.386]	[-3.619]
Infant mortality	-0.053	-0.027
	[-0.603]	[-1.044]
Percentage urban population	0.592***	-0.177**
	[4.804]	[-2.383]
Percentage married women	-0.129	0.013
	[-1.414]	[0.269]
Distance to Baghdad	-0.348***	
	[-3.482]	
(Distance to Baghdad)^2	0.058***	
	[3.241]	
School enrolment		0.239**
		[2.399]
Constant	-0.903	0.645***
	[-1.228]	[2.590]
Observations	71	71
R-squared	0.538	
Partial F-statistic 1st stage	12.76	

2SLS regression. The results of second-stage estimates are in columns (2). The corresponding first-stage results are in columns (1). Wu-Hausman F-test. Robust t-statistics in brackets *** p<0.01, ** p<0.05, * p<0.1.
Source: Central Population Census, Baghdad (1965).

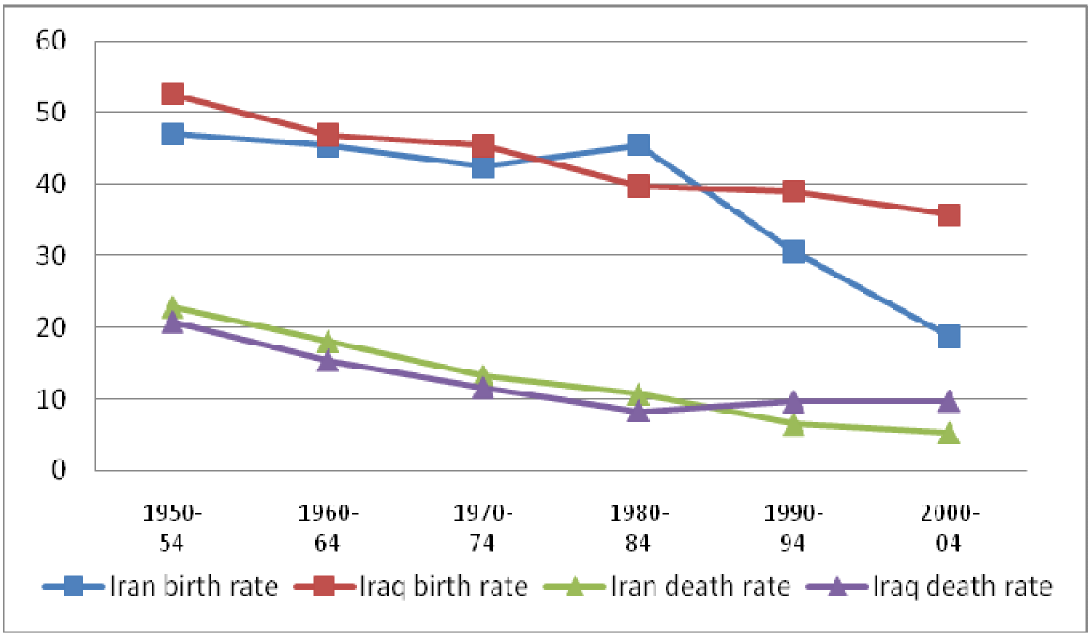
Figures

Figure 1: Decline of fertility in Egypt, Iran, Iraq and Turkey



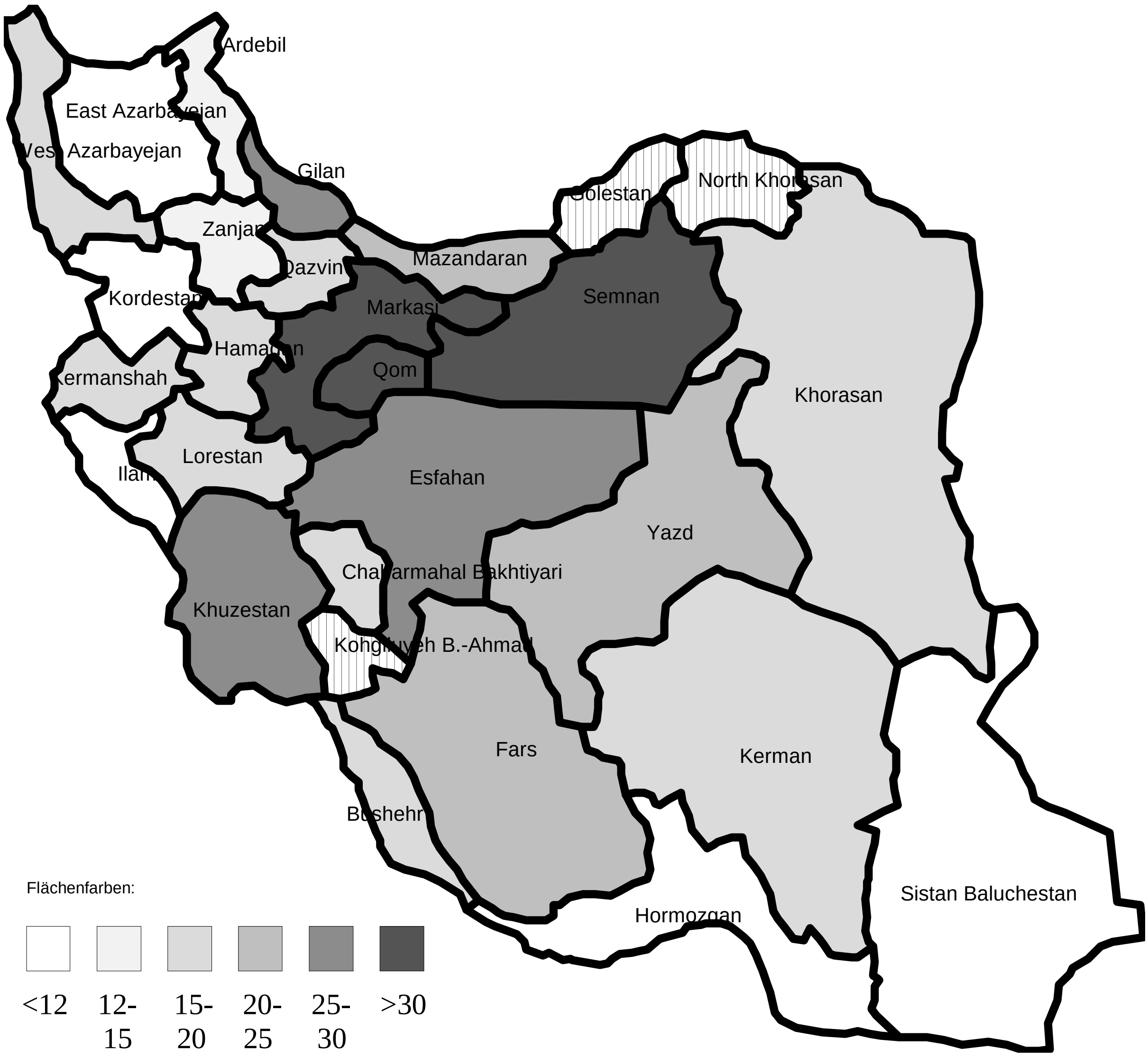
Source: World Bank Development Indicators (2008)

Figure 2: Crude birth and death rates (per thousand)



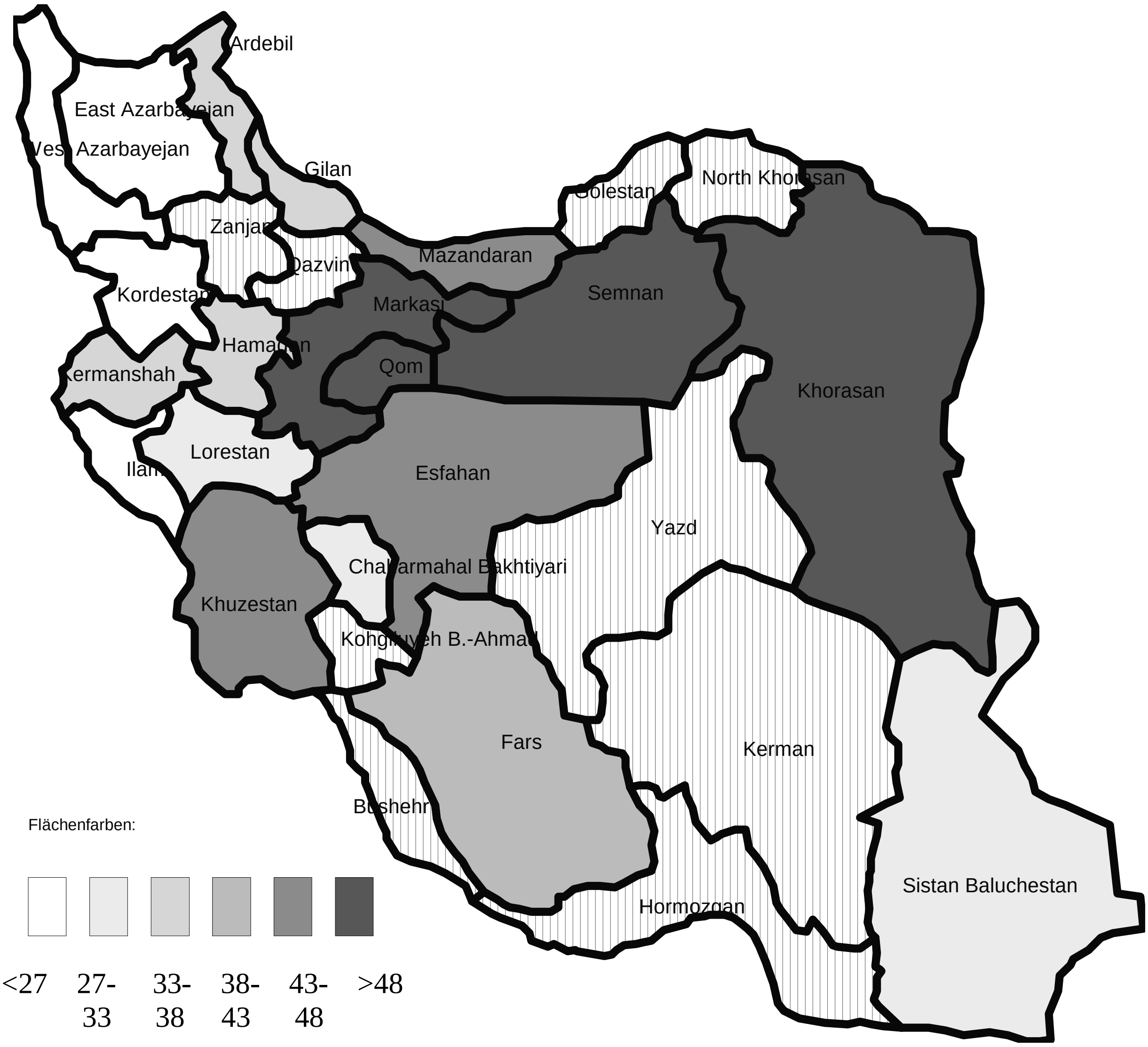
Source: United Nations (2005)

Figure 3a: School enrolment rate, 1956 census



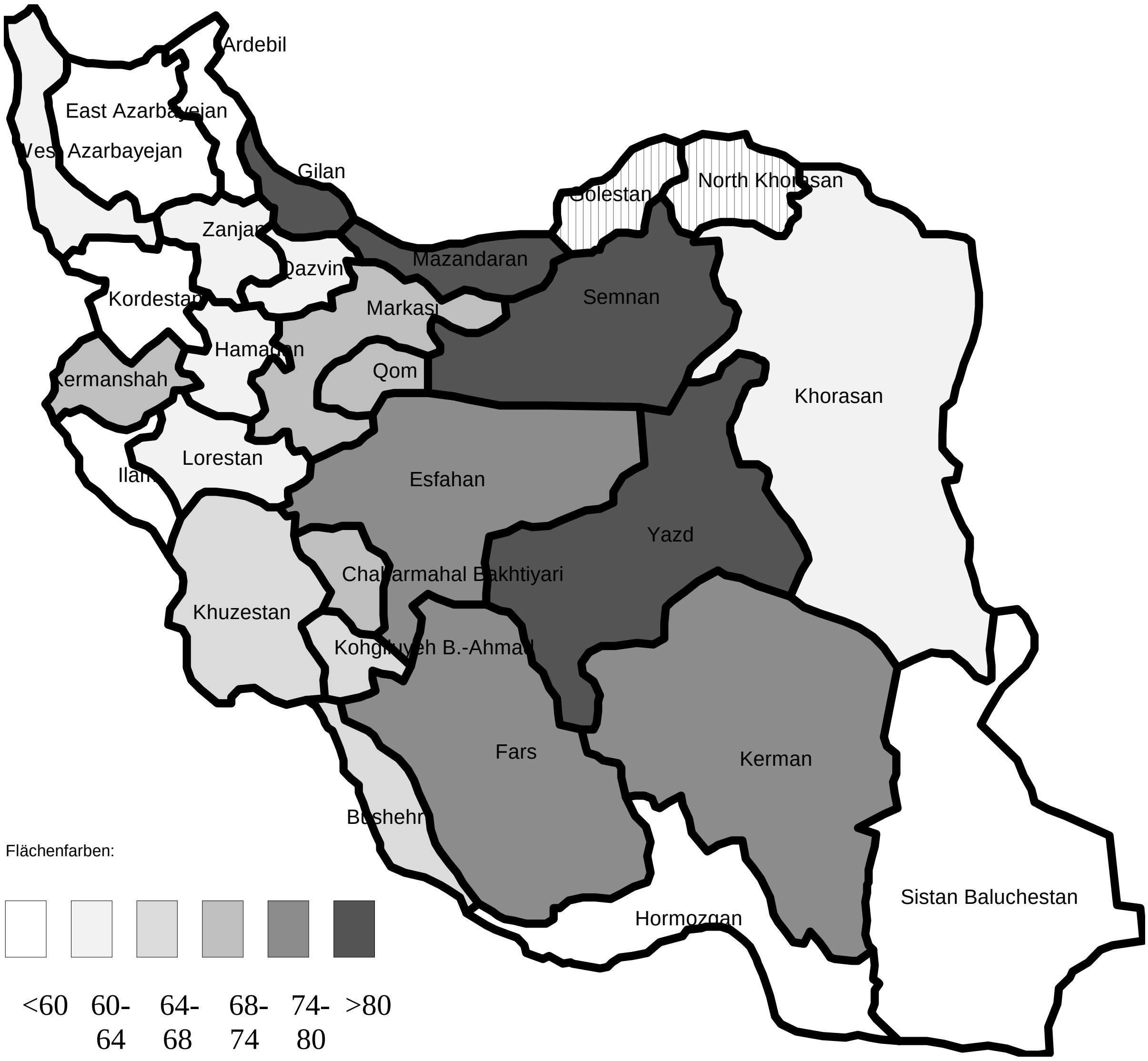
Sources: National Censuses of Population and Housing, Tehran (1956). The grey stripped lengthways provinces are not included as detailed data are missing.

Figure 3b: School enrolment rate, 1966 census



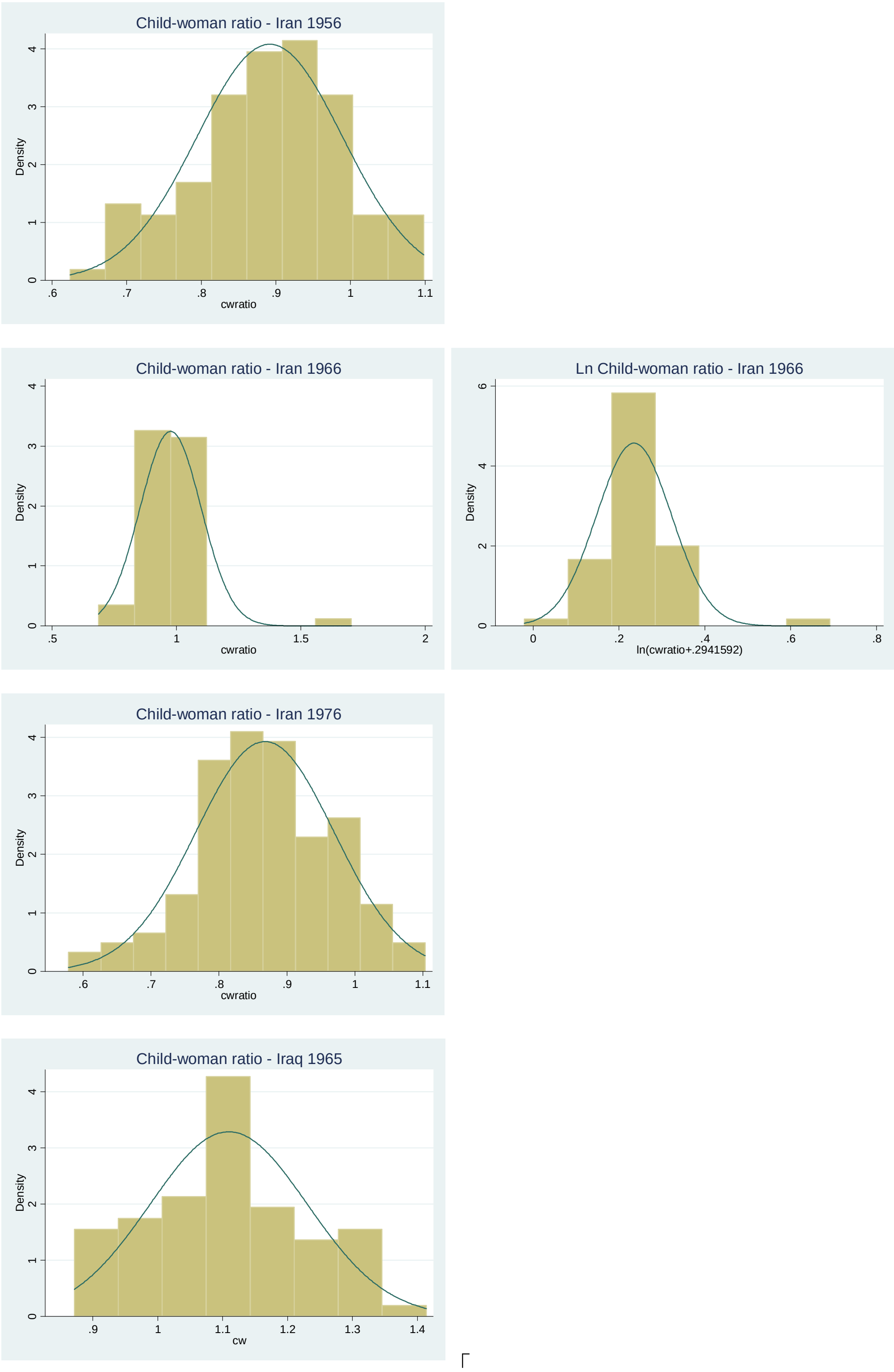
Sources: National Censuses of Population and Housing, Tehran (1966). The grey stripped lengthways provinces are not included as detailed data are missing.

Figure 3c: School enrolment rate, 1976 census



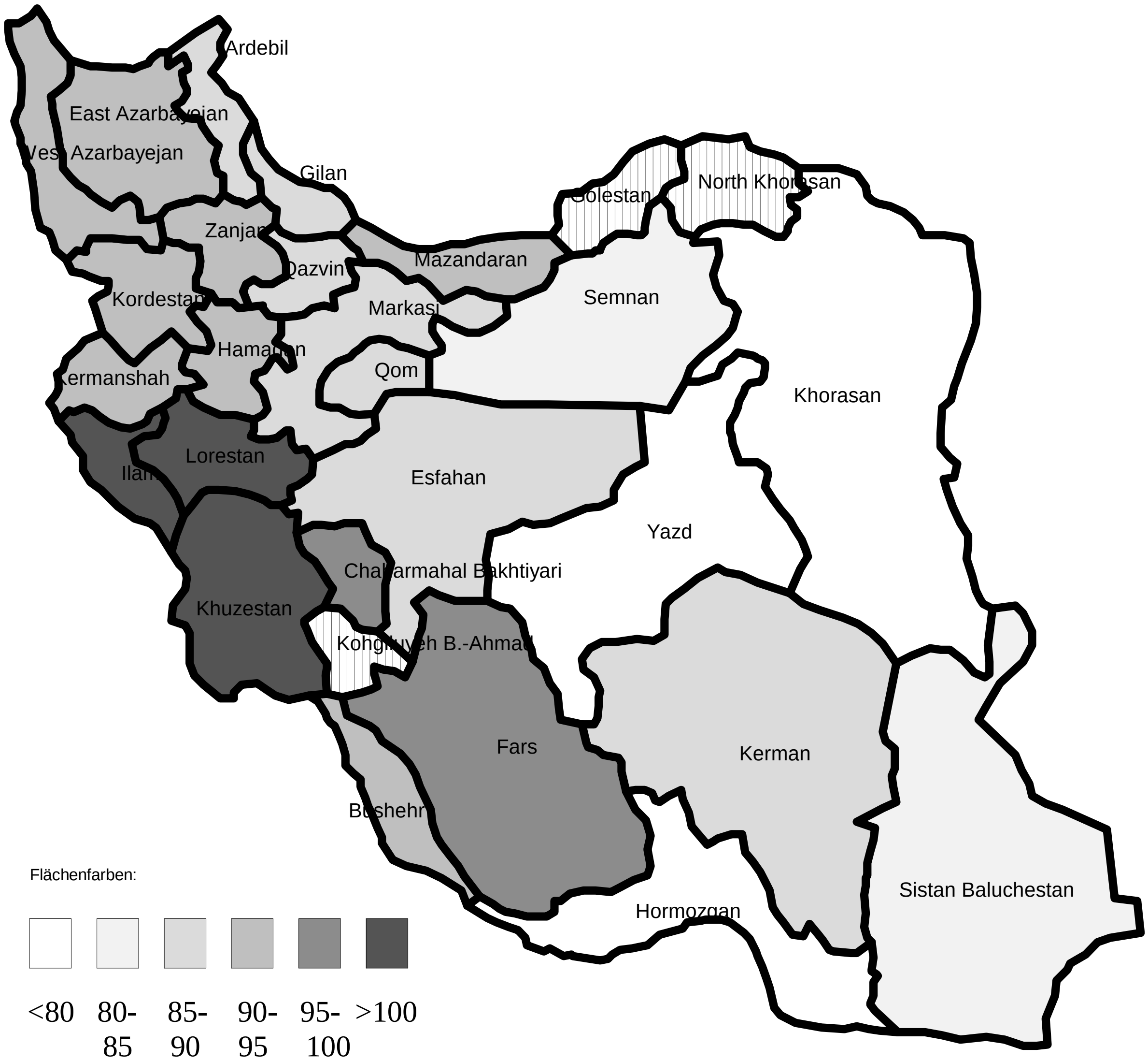
Sources: National Censuses of Population and Housing, Tehran (1976). The grey stripped lengthways provinces are not included as detailed data are missing.

Figure 4: Distribution of child-woman ratios in Iran and Iraq



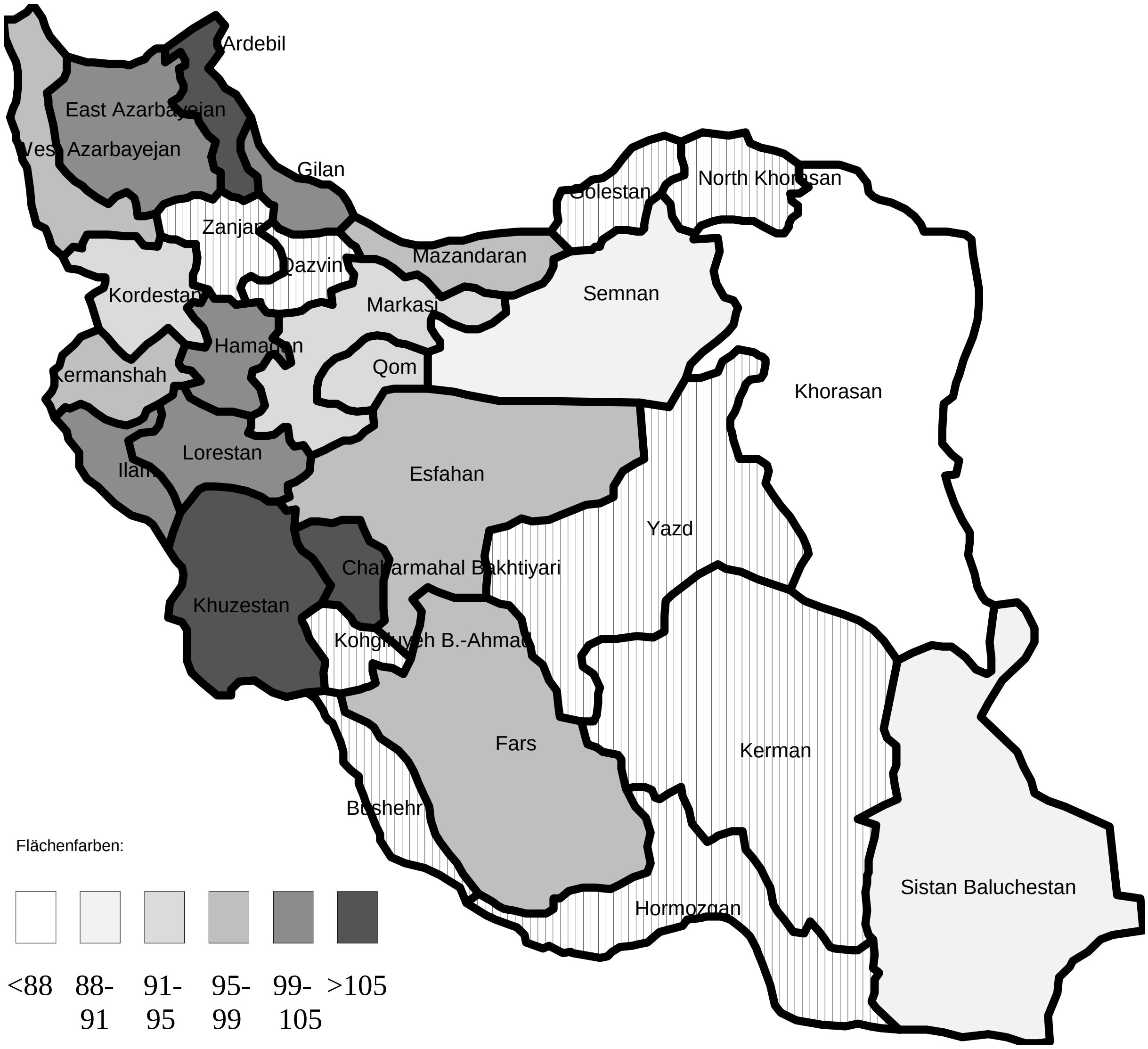
Sources: For Iran: National Censuses of Population and Housing 1956, 1966 and 1976 Tehran. For Iraq: Central Population Census of 1965 Baghdad.

Figure 5a: Child-woman ratios, 1956 census



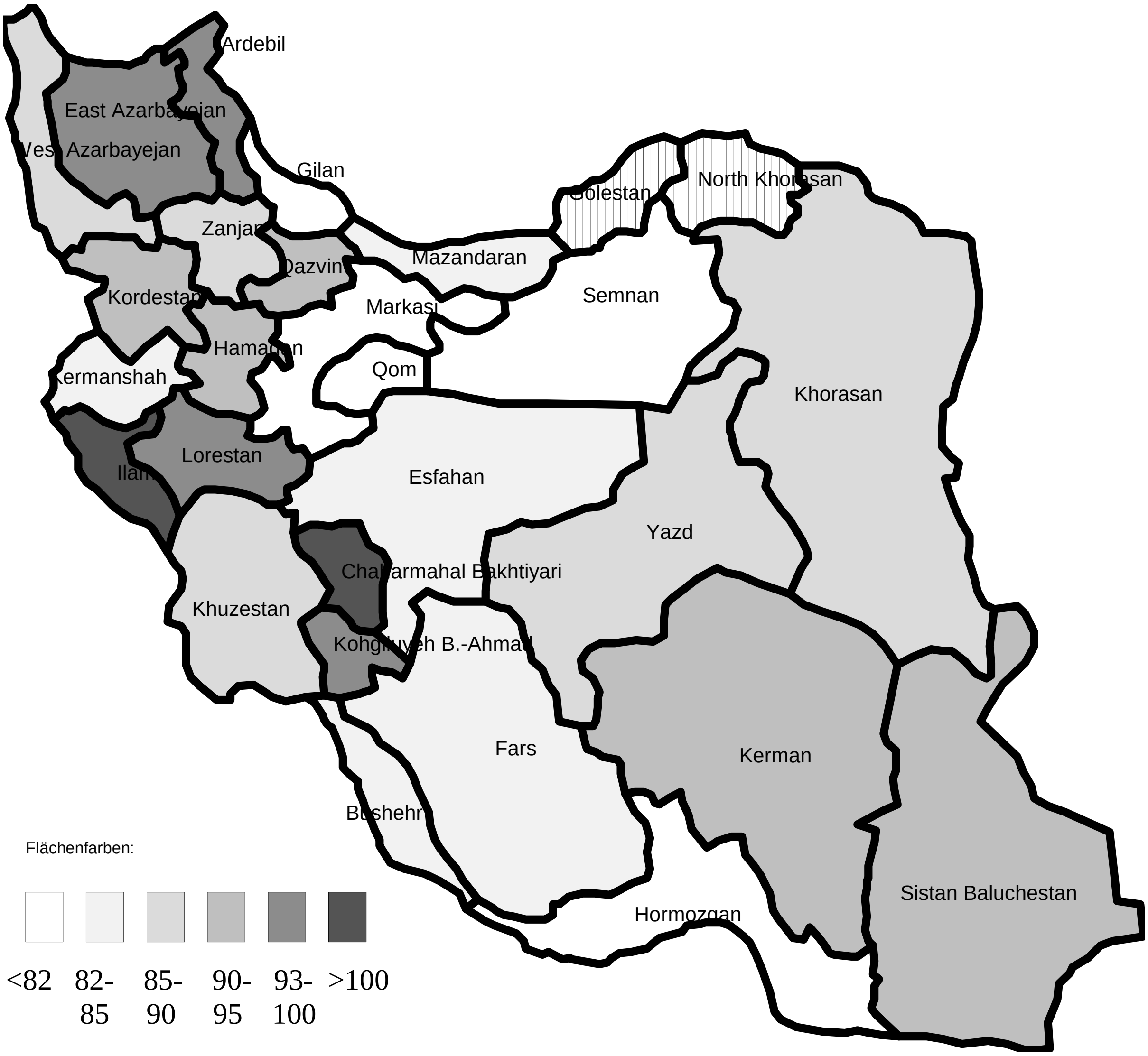
Sources: National Censuses of Population and Housing, Tehran (1956). The grey stripped lengthways provinces are not included as detailed data are missing.

Figure 5b: Child-woman ratios, 1966 census



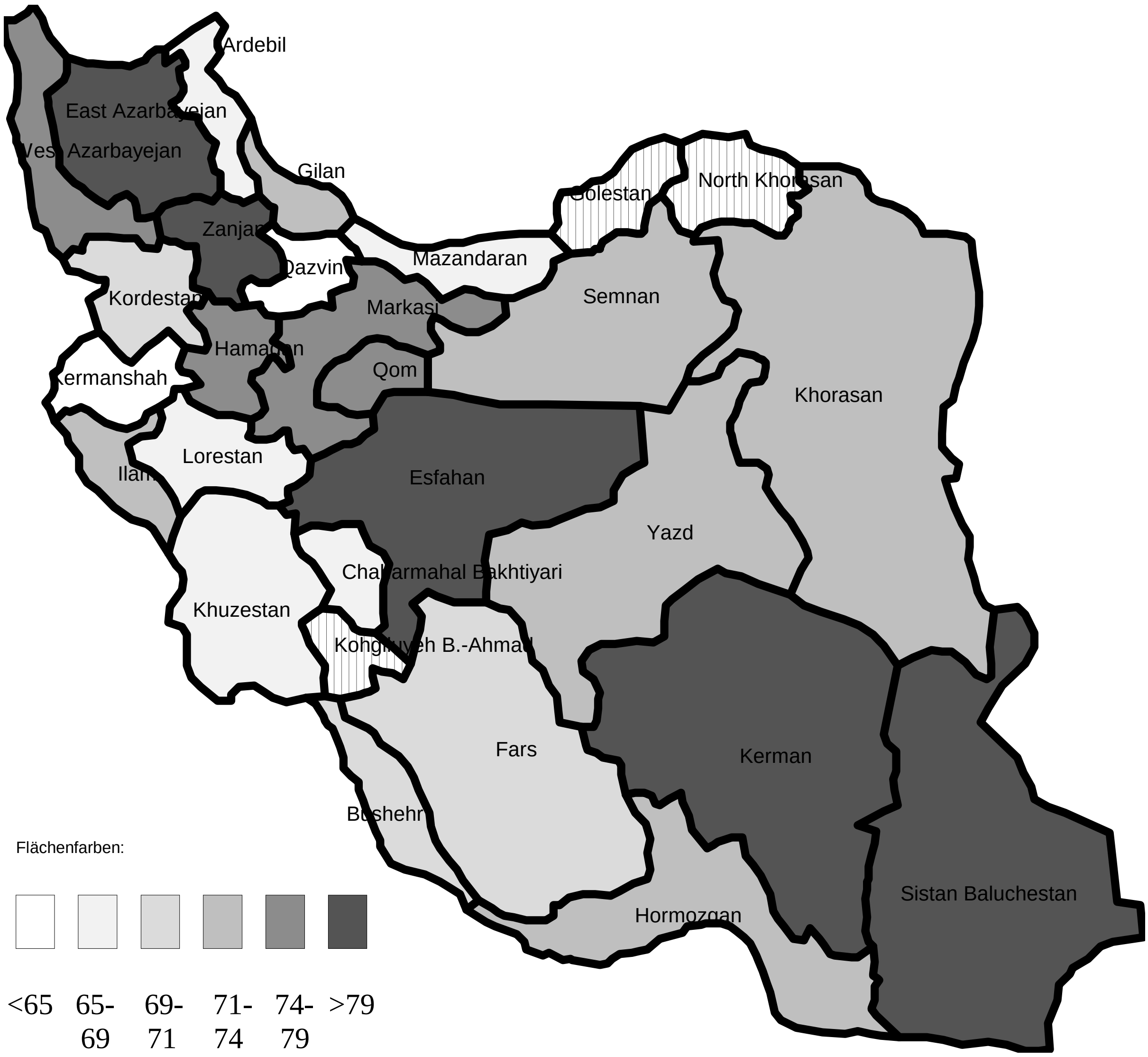
Sources: National Censuses of Population and Housing, Tehran (1966). The grey stripped lengthways provinces are not included as detailed data are missing.

Figure 5c: Child-woman ratios, 1976 census



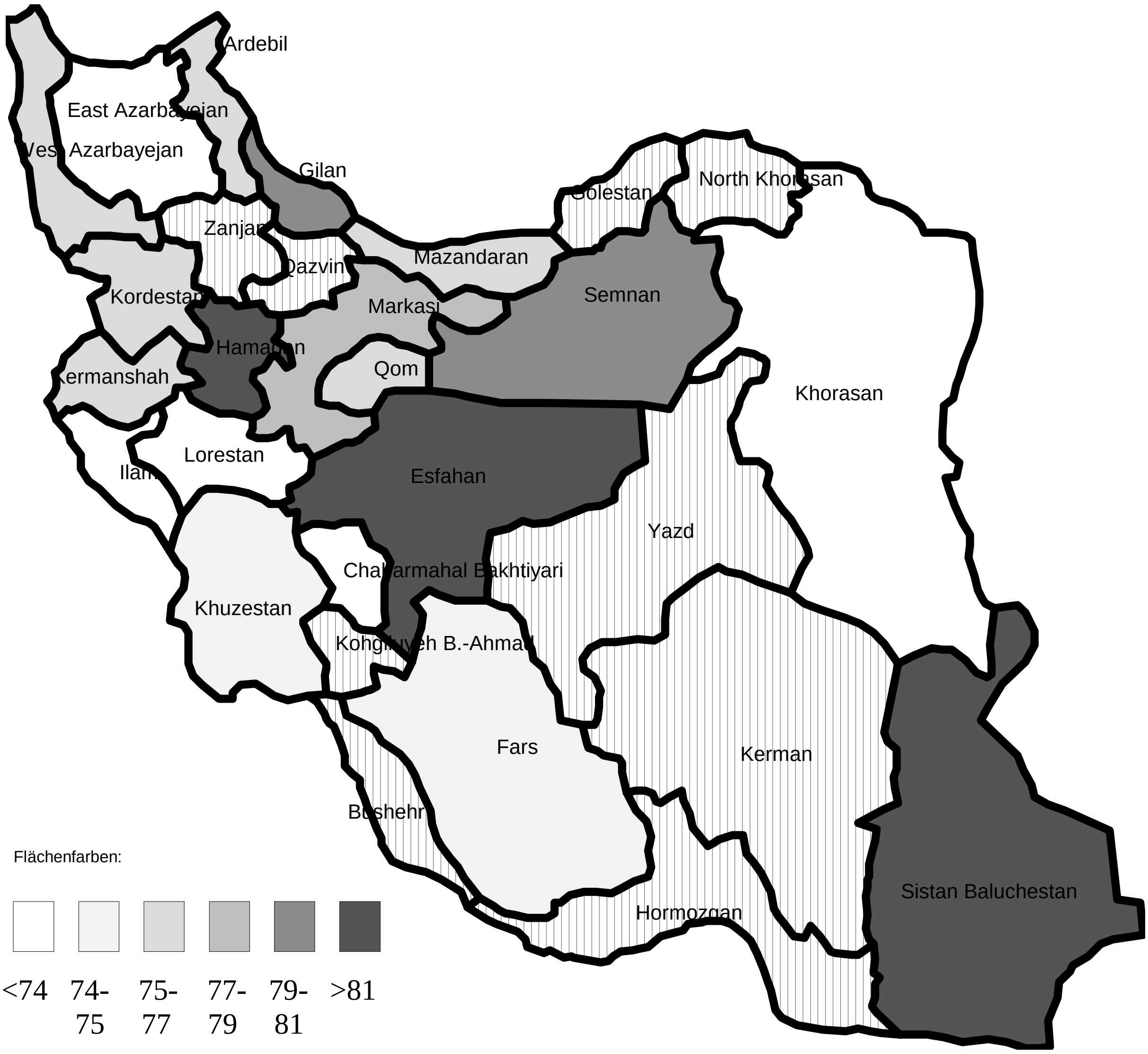
Sources: National Censuses of Population and Housing, Tehran (1976). The grey stripped lengthways provinces are not included as detailed data are missing.

Figure 6a: Gini-Index, 1956 census



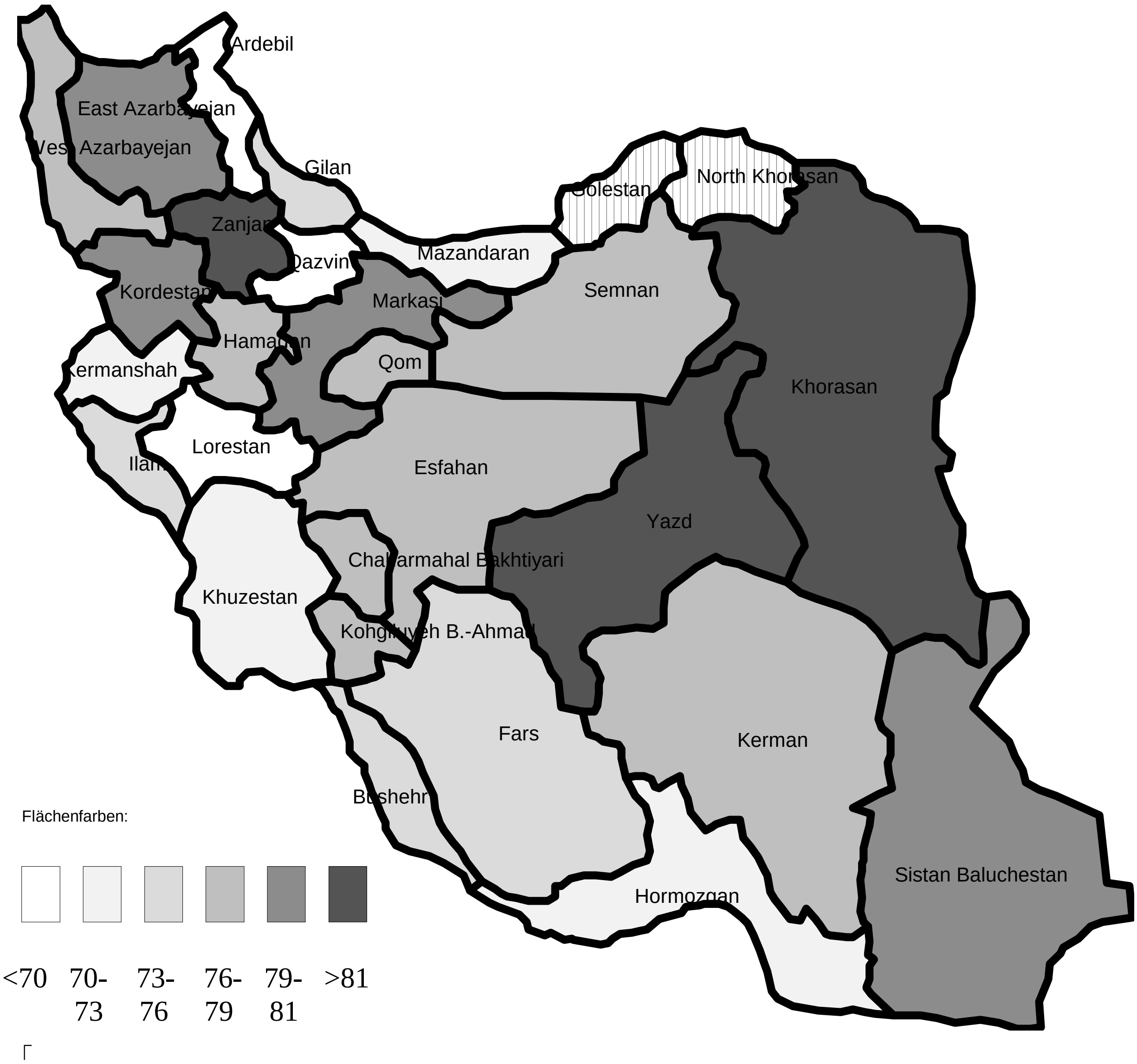
Sources: National Censuses of Population and Housing, Tehran (1956). The grey stripped lengthways provinces are not included as detailed data are missing.

Figure 6b: Gini-Index, 1966 census



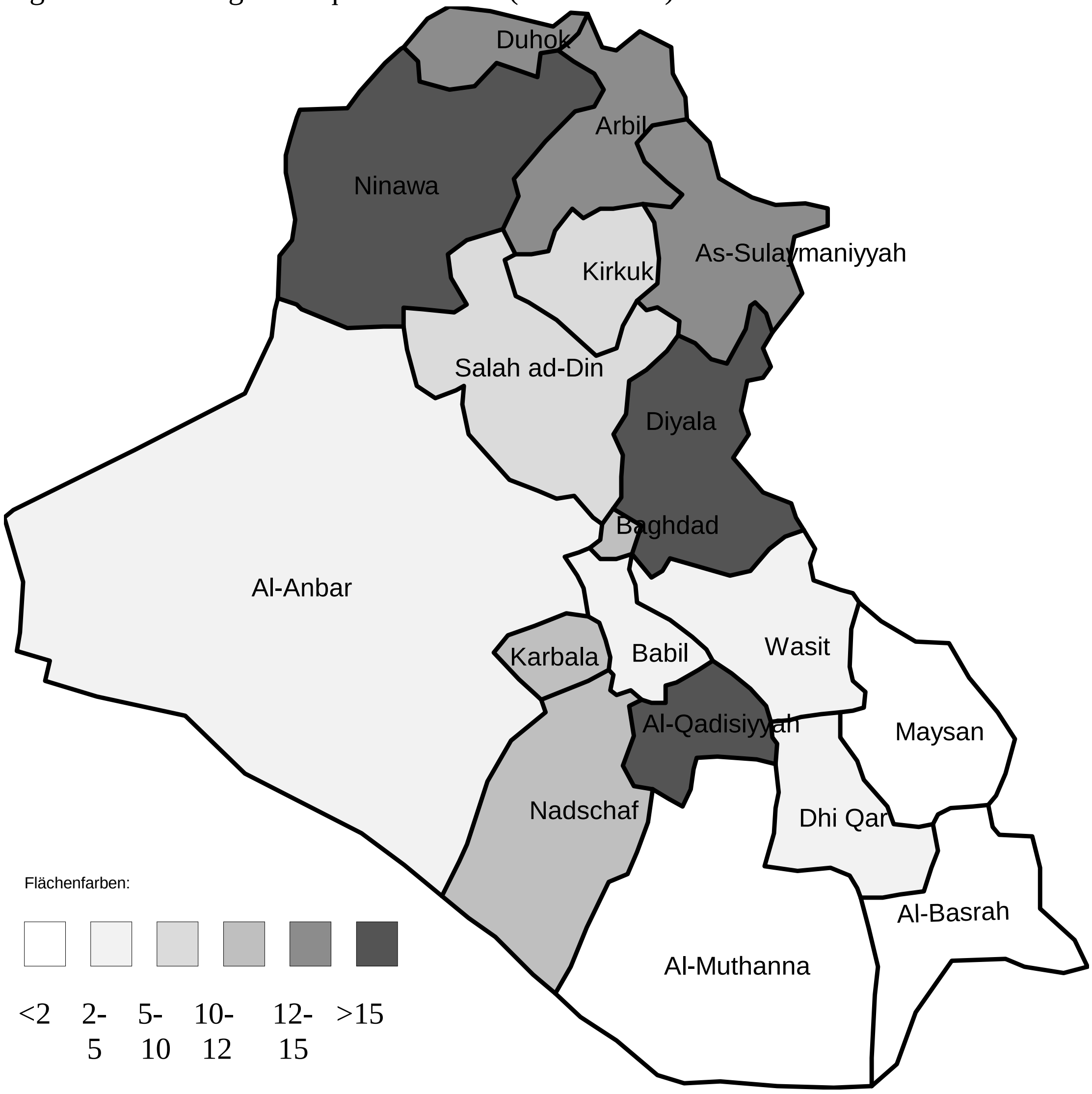
Sources: National Censuses of Population and Housing, Tehran (1966). The grey stripped lengthways provinces are not included as detailed data are missing.

Figure 6c: Gini-Index, 1976 census



Sources: National Censuses of Population and Housing, Tehran (1976). The grey stripped lengthways provinces are not included as detailed data are missing.

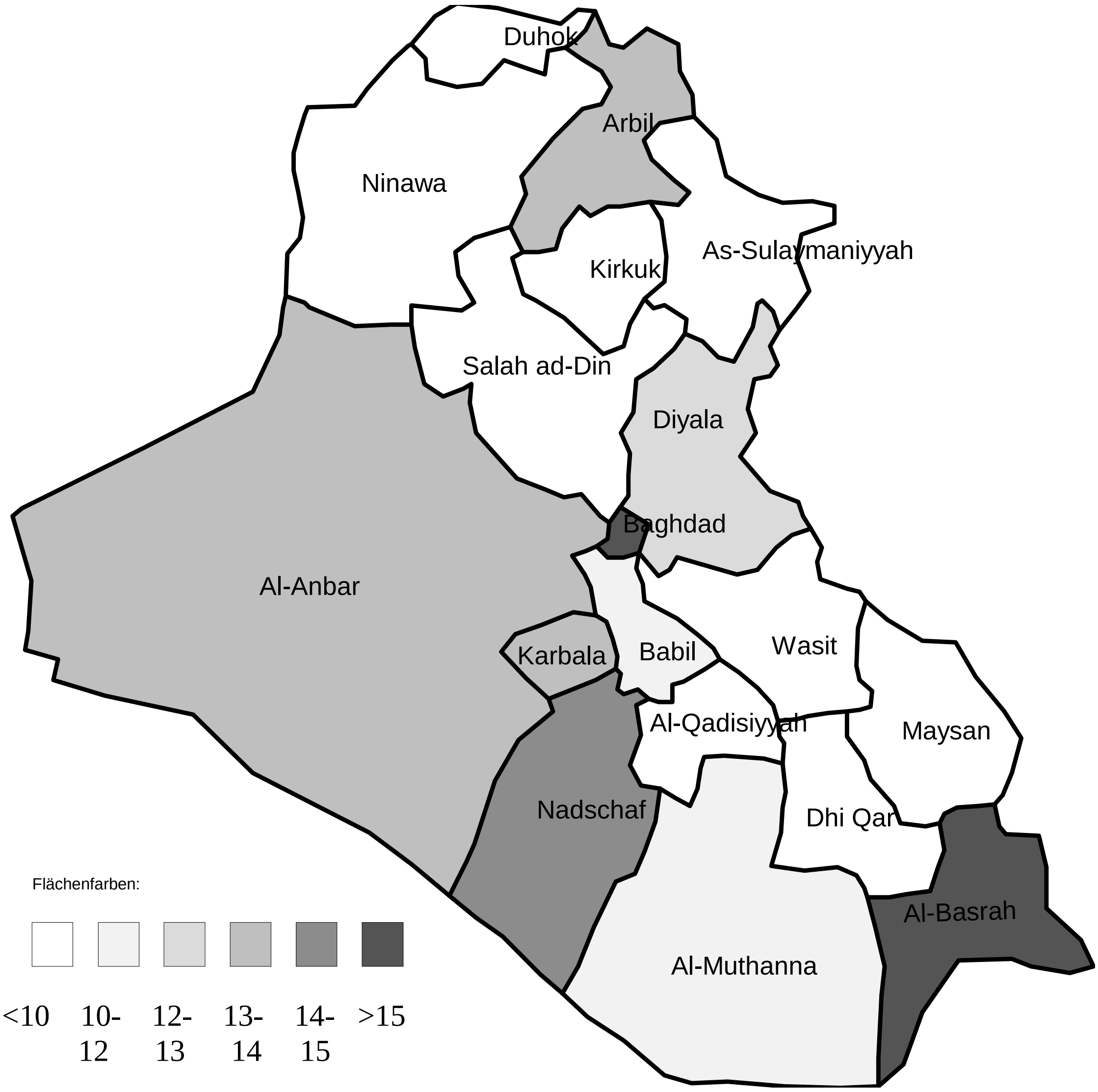
Figure 7: Percentage of sequestered land (of total area)



Source: Central Population Census, Baghdad (1965).

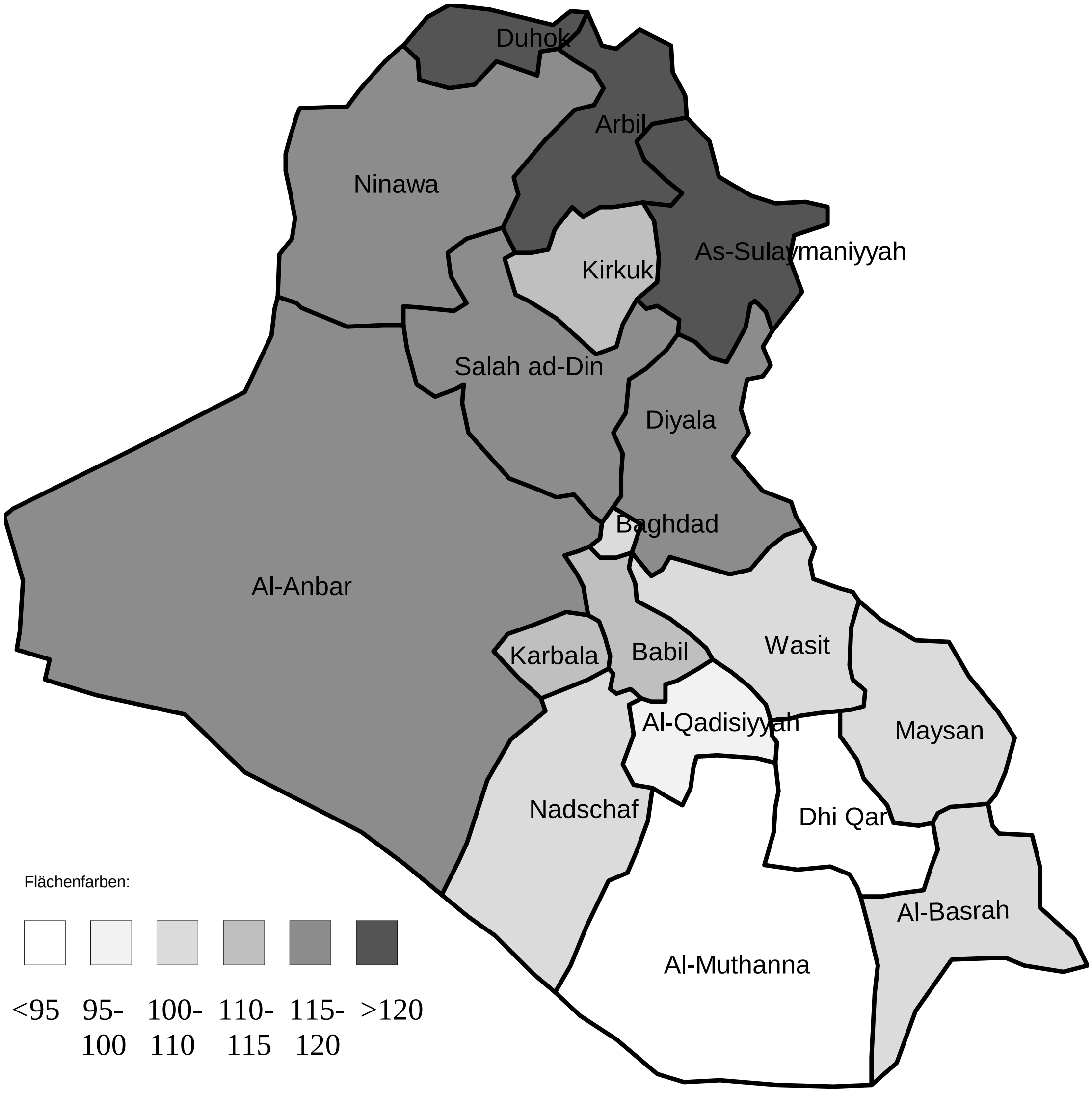
Note: including government lands not cultivated in 3 years

Figure 8: School enrolment rate, 1965 census



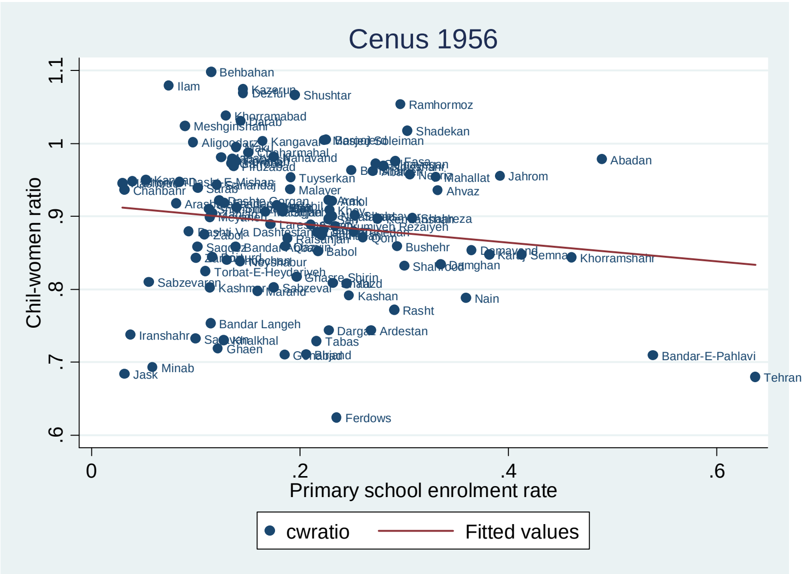
Source: Central Population Census, Baghdad (1965).

Figure 9: Child-woman ratios, 1965 census



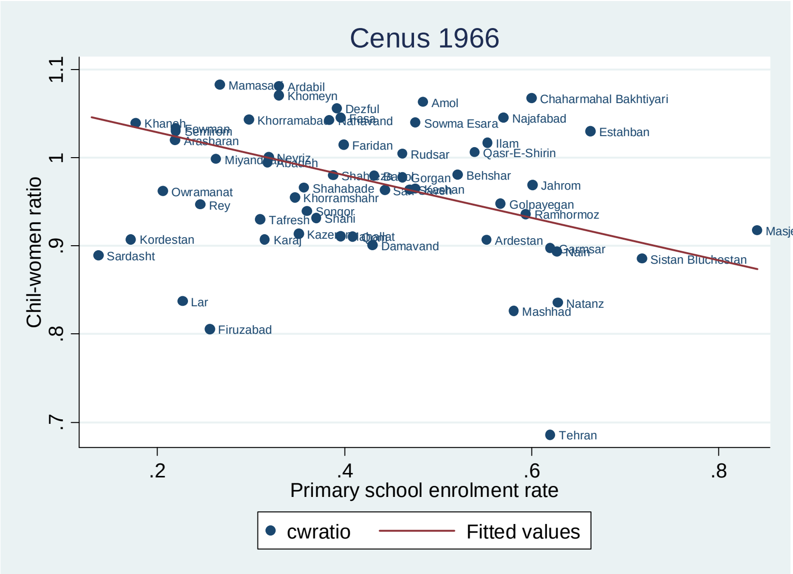
Source: Central Population Census, Baghdad (1965).

Figure10a: Relationship between child-woman ratio and school enrolment rate, 1956 census



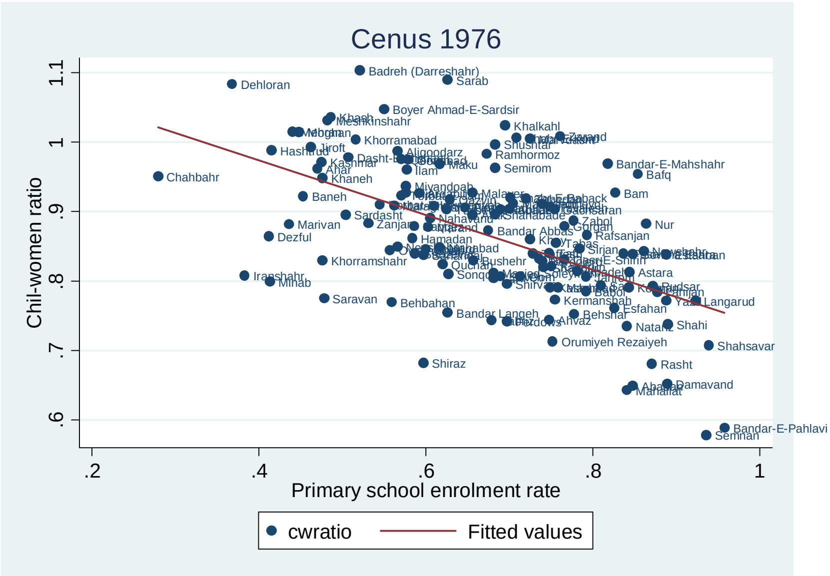
Sources: For Iran: National Censuses of Population and Housing, Tehran (1956).

Figure10b: Relationship between child-woman ratio and school enrolment rate, 1966 census



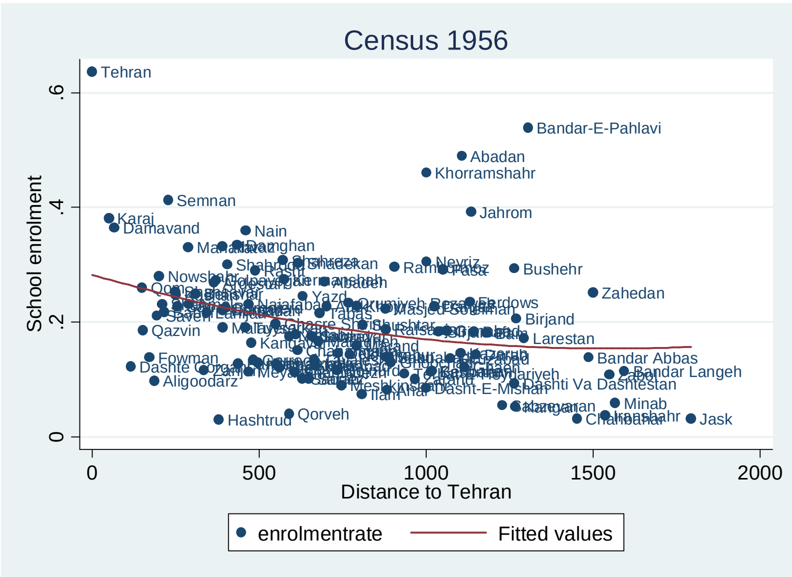
Sources: For Iran: National Censuses of Population and Housing, Tehran (1966).

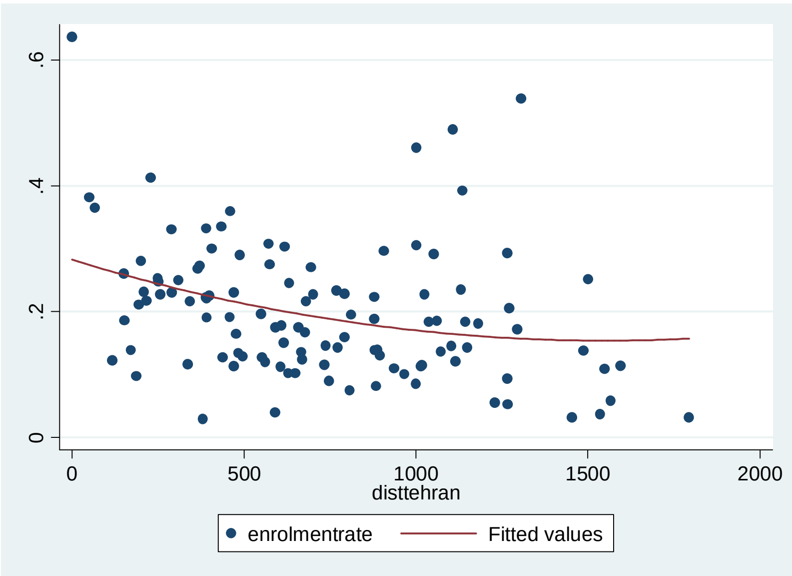
Figure10c: Relationship between child-woman ratio and school enrolment rate, 1976 census



Sources: For Iran: National Censuses of Population and Housing, Tehran (1976).

Figure 11a: Non-linear relationship between school enrolment and distance to Tehran, 1956

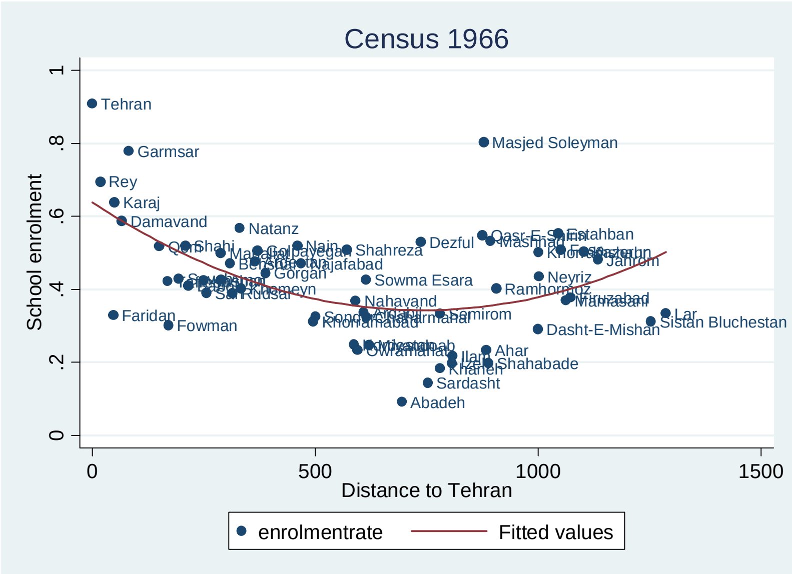


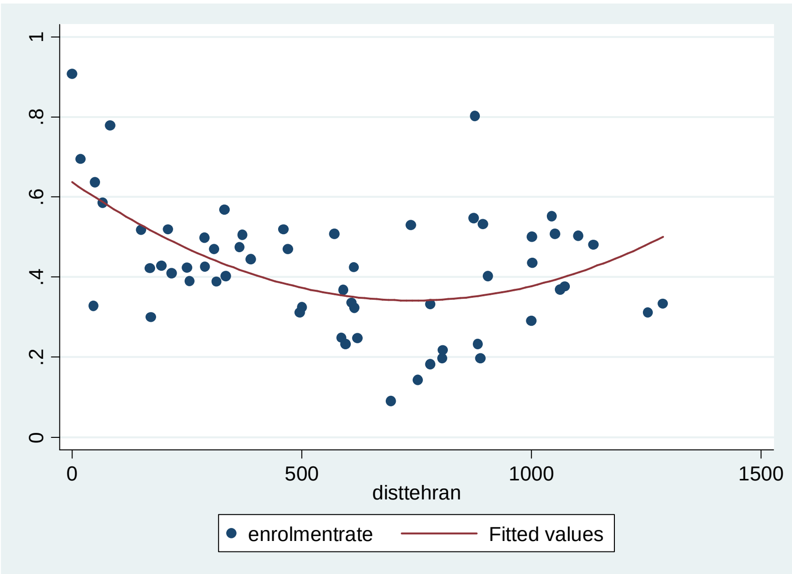


Note: Both figures reveal the same non linear relationship; the top figure reveals supplemental the county notations.

Sources: National Censuses of Population and Housing, Tehran (1956).

Figure 11b: Non-linear relationship between school enrolment and distance to Tehran, 1966

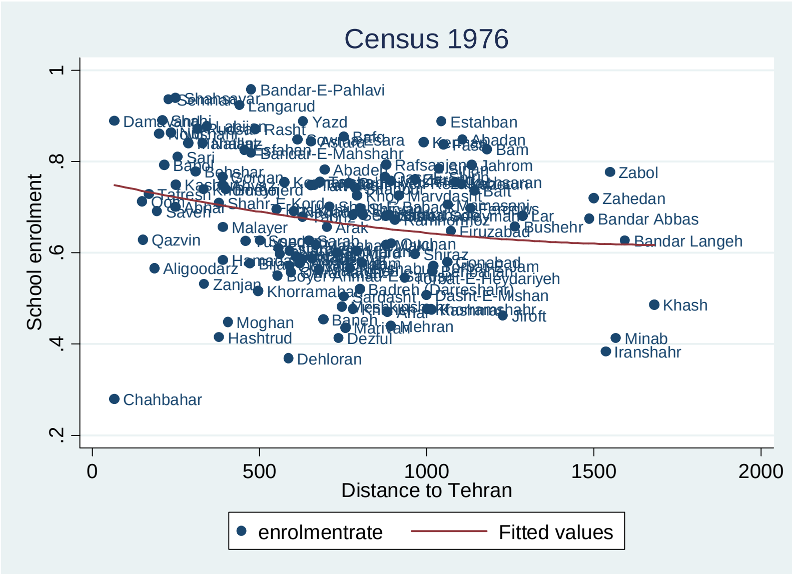


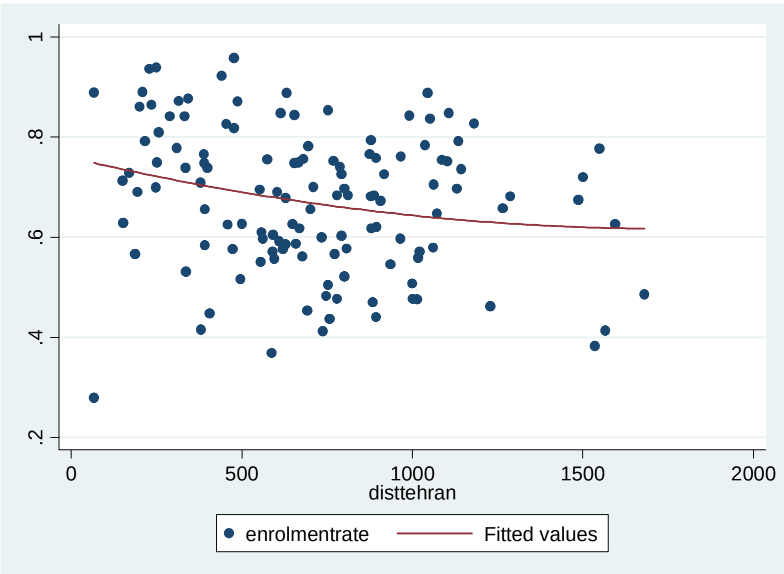


Note: Both figures reveal the same non linear relationship; the top figure reveals supplemental the county notations.

Sources: National Censuses of Population and Housing, Tehran (1966).

Figure 11c: Non-linear relationship between school enrolment and distance to Tehran, 1976

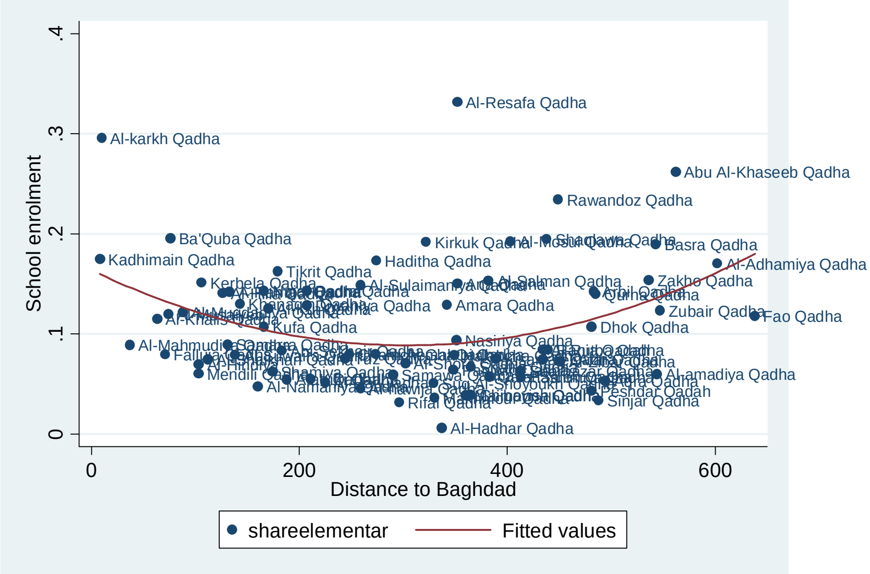


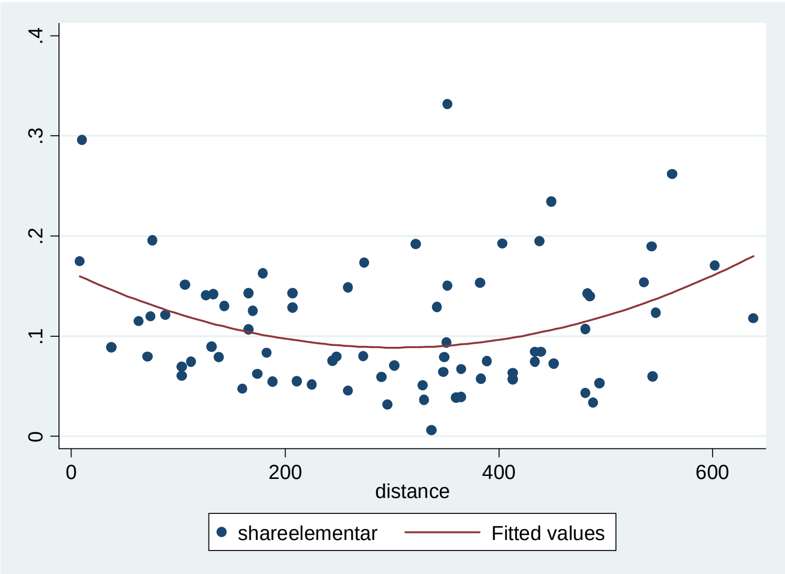


Note: Both figures reveal the same non linear relationship; the top figure reveals supplemental the county notations.

Sources: National Censuses of Population and Housing, Tehran (1976).

Figure 11d: Non-linear relationship between school enrolment and distance to Baghdad





Note: Both figures reveal the same non linear relationship; the top figure reveals supplemental the county notations.

Source: Central Population Census, Baghdad (1965).

Appendix A

Table A1: The association between education and fertility in Iran - Estimation with the same variable as for the Iraq

	(1) 1956	(2) 1966	(3) 1976
Dependent variable		Child women ratio	
School enrolment rate	-0.15	-0.24**	-0.04
	[-1.72]	[-2.13]	[-0.64]
Share Moslem	0	-0.02	-0.01
	[0.04]	[-1.62]	[-0.97]
Infant mortality	0	0.05	-0.01
	[0.19]	[1.05]	[-0.40]
Share urban population	0	-0.02	-0.05***
	[0.05]	[-0.83]	[-3.86]
Share married women	-0.02	0.56	0.74***
	[-0.50]	[1.36]	[6.60]
Constant	0.90***	1.15***	1.31***
	[10.20]	[15.77]	[16.82]
Observations	112	58	128
R-squared	0.03	0.28	0.54

OLS regression. Child women ratio is the number of children aged 0-5 over the number of women aged 15-45. School enrolment rate is the share of children aged 6-14 for census year 1966 and 1976 and enrolled in public primary schools. For census 1956 the School enrolment rate is the share of children aged 10-14 enrolled in public primary school. *** p<0.01, ** p<0.05, * p<0.1 t statistics in brackets.

Sources: Data for 113 districts from the first Iranian Census (1956); Data for 59 districts from the second Iranian Census (1966) covering 89 percent of the total population; Data for 129 districts from the third Iranian Census (1976).

Table A2 The association between education and fertility in Iran - Estimation with the same variable as for the Iraq

	IV first stage			*IV second stage*		
	(1)	(2)	(3)	(4)	(5)	(6)
	1956	1966	1976	1956	1966	1976
Dependent variable	School enrolment rate			Child women ratio		
Share Moslem	0.03**	0	0	-0.01	-0.01	-0.01
	[2.15]	[-0.24]	[-0.30]	[-0.33]	[-1.36]	[-0.93]
Infant mortality	0	0.04**	-0.03*	0	0.06	-0.03*
	[-0.03]	[2.38]	[-2.00]	[0.19]	[1.33]	[-1.85]
Share urban population	0.10***	0.13***	0.06***	-0.02	0.01	0
	[6.41]	[6.35]	[3.32]	[-0.27]	[0.40]	[-0.10]
Share married women	-0.02*	-0.51	-1.28***	-0.01	0.4	-0.18
	[-1.85]	[-1.54]	[-8.33]	[-0.39]	[1.20]	[-0.38]
Distance to Tehran	-0.02**	-0.07***	-0.02**			
	[-2.16]	[-3.88]	[-2.26]			
(Distance to Tehran)^2	0	0.00***	0.00*			
	[1.46]	[3.33]	[2.01]			
School enrolment rate				0.06	-0.50***	-0.74**
				[0.09]	[-2.94]	[-2.36]
Constant	-0.02	-0.04	0.19	0.92***	1.09***	1.37***
	[-0.36]	[-0.27]	[1.47]	[7.49]	[14.72]	[15.22]
Observations	112	58	128	112	58	128
R-squared	0.54	0.58	0.63			
F test						
p value						

2 SLS regression. Second-stage estimates results are in columns (4), (5), and (6). The corresponding first-stages results are in the columns (1), (2), and (3). Wu-Hausman F-test. Robust t statistics in brackets *** p<0.01, ** p<0.05, * p<0.1.

Sources: Data for 113 districts from the first Iranian Census (1956); Data for 59 districts from the second Iranian Census (1966) covering 89 percent of the total population; Data for 129 districts from the third Iranian Census (1976).

Appendix B

Table B1: Instrumental Variable Estimation for Iran with two instruments

	(1)	(2)	(3)	(4)	(5)	(6)
	1956	1966	1976	1956	1966	1976
	IV first stage			IV second stage		
Dependent Variable	School enrolment			Child woman ratio		
Share Moslem	0.02*	0	0	-0.01	-0.02*	-0.01
	[1.95]	[-0.01]	[-0.18]	[-0.49]	[-1.82]	[-0.88]
Infant mortality	0	0.03*	-0.03**	-0.01	0.06	-0.03*
	[0.12]	[1.79]	[-2.40]	[-0.41]	[1.49]	[-1.91]
Share urban population	0.09***	0.13***	0.06**	-0.01	-0.01	-0.01
	[4.86]	[6.17]	[2.40]	[-0.15]	[-0.45]	[-0.27]
Share married women	-0.02**	-0.78	-1.23***	0.04**	1.12***	0.47
	[-2.28]	[-1.69]	[-8.56]	[2.31]	[2.66]	[0.62]
Share of working women	0.01	-0.01	0.02	-0.03*	-0.01	0.01
	[1.25]	[-0.29]	[1.70]	[-1.83]	[-0.75]	[0.99]
Non-mover	0.03***	0.03**	0	0.02	0.01	0.01
	[4.34]	[2.66]	[0.34]	[1.57]	[0.43]	[0.82]
Population density	0	-0.02	0	0.02*	0.02*	0.01
	[-0.11]	[-0.59]	[0.37]	[1.87]	[1.65]	[0.45]
Distance to Tehran	-0.02**	-0.07***	-0.02**			
	[-2.52]	[-3.63]	[-2.21]			
(Distance to Tehran)^2	0.00*	0.00**	0.00**			
	[1.86]	[2.68]	[2.14]			
Proxy Landownership inequality	1.22	-7.01	-1.5			
	[1.36]	[-1.30]	[-0.88]			
(Proxy Landownership inequality)^2	-0.87	4.68	1.03			
	[-1.27]	[1.29]	[0.89]	-0.22	-0.40***	-0.90**
School enrolment				[-0.50]	[-2.73]	[-2.26]
Constant	-0.4	2.5	0.79	0.84***	-0.03	1.92**
	[-1.61]	[1.26]	[1.24]	[10.08]	[-0.06]	[2.51]
Observations	112	57	125	112	57	125
R-squared	0.6	0.64	0.64			
Partial F-statistic 1st stage	7.5	6.84	8.65			
Sargan Hansen p-value	0.11	0.13	0.08			

2 SLS regression. Second-stage estimates results are in columns (4), (5), and (6). The corresponding first-stages results are in the columns (1), (2), and (3). Wu-Hausman F-test. Robust t statistics in brackets *** p<0.01, ** p<0.05, * p<0.1.

Sources: Data for 113 districts from the first Iranian Census (1956); Data for 59 districts from the second Iranian Census (1966) covering 89 percent of the total population; Data for 129 districts from the third Iranian Census (1976).

Table B2: The effect of education on fertility in Iraq with two instruments

	(1) IV first stage	(2) IV second stage
Dependent Variable	School enrolment	Child woman ratio
Share Moslem	0.371*	-0.213***
	[1.904]	[-3.929]
Infant mortality	-0.063	-0.025
	[-0.719]	[-0.841]
Share urban population	0.587***	-0.218**
	[4.593]	[-2.386]
Share married women	-0.088	0.018
	[-0.881]	[0.359]
Distance to Baghdad	-0.310**	
	[-2.955]	
(Distance to Baghdad)^2	0.052**	
	[2.803]	
Share of expropriated land	0	
	[-0.882]	
School enrolment		0.303***
		[2.720]
Constant	-0.815	0.734***
	[-1.125]	[2.803]
Observations	71	71
Sargan Hansen p-value	0.09	
R-squared	0.544	
Partial F-statistic 1st stage	16.73	
Robust t statistics in brackets		
*** p<0.01, ** p<0.05, * p<0.1		

2 SLS regression. t statistics in brackets *** p<0.01, ** p<0.05, * p<0.1
Source: District-level data from Iraq Census 1966 see main text and appendix for details.

Sources: Data for 113 districts from the first Iranian Census (1956); Data for 59 districts from the second Iranian Census (1966) covering 89 percent of the total population; Data for 129 districts from the third Iranian Census (1976).

6. Concluding remarks

This thesis employed height trends in several Islamic countries as a proxy for the development of standards of living. The first section improves our understanding of the Middle Eastern biological standard of living in the nineteenth and early twentieth centuries. Anthropometric data on approximately 48, 000 observations were used in the first section of the thesis to analyze eight countries in the Middle East for the period from 1850-1910. The data were extracted from a variety of previously published studies by anthropologists and provide estimates of anthropometric trends in the Middle East. This data may contain more measurement errors than height studies from industrializing countries, as we had to rely in part on anthropological surveys that reported aggregated height data. Using these estimates, regional differences are identified within the Middle East and between the Middle East and industrialized nations. This section also examines how these differences changed over time and compares the findings obtained from these data with previous estimates of alternative measures for standard of living such as wages and per capita GDP.

In general, Middle Eastern height values were higher than those of industrializing countries in the mid-nineteenth century. During these periods, Middle Eastern regions enjoyed some of the well-known “advantages of proximity” to animal husbandry. Substantial numbers of the population lived as Bedouins, who initially benefited from such advantages. However, after the late nineteenth century, European populations benefited from improvements in epidemiological and nutritional conditions. Therefore, in the late nineteenth century, the industrialized countries began to surpass the Middle East in terms of net nutritional status. In subsequent years, a strong divergence was observable. This is the first study to identify the point in time when the Middle East fell behind the industrialized countries with regard to net nutritional status.

In the second section, four anthropometric data sets are used to construct time series of average human height in Indonesia since the 1770s. The research question in this section was primarily how the Biological Standard of Living developed during colonial times. Our earliest data set provided the greatest challenges. The slave register was compiled in 1816 for tax collection purposes. The second data set contains information on contracted laborers who migrated from Indonesia to the Dutch colony of Surinam in South America. The third data set was constructed using of height data reported in anthropological and medical studies. This data set served primarily as a robustness check for the migrant data. Finally, we used three waves of the Indonesian Family and Life survey, 1993, 2000 and 2007, to asses the mean height development for the birth decades in the twentieth century. The paper finds a significant decline in average heights in the 1870s, followed by a modest recovery during the next three decades. These changes in height are related to a sequence of disasters. Specifically, we attribute the decline to four disasters: droughts, massive eruption of the Krakatau volcano, cholera and cattle plague. Average heights increased in the 1900s, accelerating after World War II. The Great Depression, Japanese occupation and the War of Independence in the 1930s and 1940s had negative effects on height. After Indonesia became independent in the 1940s, the continued increases in average height were related to a gradual improvement in economic conditions and more specifically to improvements in nutrition, the epidemiological environment and hygiene and medical care.

The third section addressed the critical review of studies by Sachs et al. 1995, 1997, Gelb 1988 and Gylfason 2001 on the curse of natural resources. These studies argued that the negative effects of natural resources on income growth are empirical facts. High resource intensity tends to correlate with a low rate of per capita income growth (Sachs et al. 2001). This section aims to establish a link between mean height (as a measure for the biological standard of living) and oil production data for several countries from across the world. We classified the oil producing countries into two categories. The oil producing Middle Eastern countries are considered separately because they produce, per capita, substantial amounts of oil relative to other producers in the world. In this section, oil production data and height information for 24 oil producing countries from 1925-1995 are used to run pooled cross-sectional regressions; combined with data for fifteen time periods for each country, these data amounted to 211 observations. Based on a review of the literature on the curse of natural resources, we hypothesize that height development in the Muslim world is affected by oil production per capita, income levels, milk production per capita, population density and the level of democratization.

In sum, increased oil production leads to higher nutritional statuses for both country categories. The Middle Eastern countries grow more slowly with each additional unit of oil production per capita. This statement holds if periods with output quotas are not considered. Moreover, an instrumental variable model allowed us to rule out the most obvious source of endogeneity in the crude oil production data. Nevertheless, the general finding remains in the IV-estimation. In sum, although the contributions of oil production in the Middle East were considerable, the results clearly show that an increase in petroleum production leads to a lower growth rate in mean height in Middle Eastern countries.

The fourth section of our analysis discusses human capital development in Iran and Iraq in the early 20th century and argues that an inverse relationship between fertility rates and school enrolment rates is evident for Iran but not for Iraq. Data from the Iranian national censuses of 1956, 1966 and 1976 and the 1965 Iraqi census are used to examine the relationship between child quantity and quality. Using the micro-regional data sets of Iranian (Shahrestans) and Iraqi (Qadha) districts, education and fertility data were obtained. Only by using census waves at this disaggregated level is it possible to investigate cross-country variations among fertility and education rates.

Educational level is represented by the primary school enrolment rate among individuals aged 7 and 14. To construct a Gini coefficient as a proxy for landownership inequality, we use the distribution of construction types of the housing units for Iran. For Iraq, the distributions of expropriated land obtained from the census of 1965 are used as a proxy for land inequality. The composition of the samples was primarily dictated by the availability of data for the model variables. A complete data set was obtained for 112 counties for 1956, 58 counties for 1966 and 128 counties for 1976 for Iran. For Iraq, the compiled data set yielded 71 observations.

The sharp decline in fertility in Iran since 1980 was remarkable, particularly after the Islamic Revolution. In particular after the Revolution family planning policies were not enacted. Quite the contrary was the case. The Iranian government implemented a number of increasing population policies during the Iran Iraq war. Hence the changes in fertility can partly be attributed to improvements in the educational characteristics of the population. A key issue is that a trade-off between child quantity and quality might have been operative in Iran since the 1960s, and the country has experienced a major decline in fertility in recent years.

To sum up, in general the contributions of thesis are the long term development for several Muslim countries and the combination of socioeconomic and anthropometric data sources, which has been compiled for the first time. Although some explanations are evident, particular areas and questions should be the subject of further research.