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Changes in Mortality in Switzerland, 1880–1910[1]

We look at mortality and longevity in Switzerland in the period 1880–1910, in the time of the so-called first demographic transition, analyzing the channels explaining the Preston curve relationship. After controlling for a number of channels through which GDP can affect demography, there is still weak evidence for a Preston curve for life expectancy at birth, while we cannot find such a relationship for infant mortality. Mortality Ginis decrease over time, mainly due to the reduction in infant mortality.

An important finding on the relationship between income and longevity is the Preston curve, which states that longevity increases with increasing income, but with decreasing rates.[2] Explanations for this phenomenon are improvements in nutrition,[3] public

1 We are grateful to two anonymous referees, Luigi Lorenzetti, and participants at the 2016 SGWSG Annual Conference in Berne and the 2016 EHB Conference in Tübingen for their helpful comments and suggestions.

2 Samuel H. Preston, The Changing Relation between Mortality and Level of Economic Development, in: Population Studies 29/2, 1975, pp. 231–248.

3 See for example: Robert William Fogel, The Escape from Hunger and Premature Death, 1700–2100. Europe, America, and the Third World, Cambridge 2004. For changes in quality and quantity of nutrition in Switzerland see: Berend Strahlmann, Erhebungen über den Lebensmittelverbrauch der schweizerischen Bevölkerung in historischer Sicht, in: Georg Brubacher and Günther Ritzel (ed.), Zur Ernährungssituation der schweizerischen Bevölkerung. Erster schweizerischer Ernährungsbericht, Bern 1975; Beatrix Mesmer, Rationelle Ernährung. Sozialmedizinische Reaktionen auf den Wandel der Ess- und Trinkgewohnheiten, in: Peter Saladin, Hans-Jürg Schaufelberger, Peter Schläppi et al. (ed.), «Medizin» für die Medizin. Arzt und Ärztin zwischen Wissenschaft und Praxis. Festschrift für Hannes G. Pauli, Basel 1989, pp. 329–343; Beatrix Mesmer, Die Verwissenschaftlichung des Alltags. Anweisungen zum richtigen Umgang mit dem Körper in der schweizerischen Populärpresse 1850–1900, Zürich 1997; Jakob Tanner, Fabrikmahlzeit. Ernährungswissenschaft, Industriearbeit und Volksernährung in der Schweiz 1890–1950, Zürich 1999; Jakob Tanner, Ernährung. Neuzeit, Historisches Lexikon der Schweiz, 2009; Martin R. Schärer, Ernährung und Essgewohnheiten, ed. by Paul Hugger, Handbuch der schweizerischen Volkskultur 1, Zürich 1992, pp. 253–288.

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infrastructure investment,[4] and health care, probably more relevant in the 20th than in the 19th century.[5] Another potential channel is institutional quality, simultaneously producing increasing longevity and increasing income.[6]

We analyze these aspects with a focus on Switzerland in the period 1880–1910, which is characterized by an accelerated modernization process, featuring the demographic transition[7] as well as fast economic growth, structural change and a strong urbanization rate, where the share of the population living in larger cities almost doubled from 13.3% in 1880 to 25.8% in 1910.[8] Swiss cantons have been affected to varying degrees by these changes. We exploit this variability to test the Preston curve relationship and the above-mentioned channels.

The pattern of declining mortality in Europe since the 18th century has been described several times. The factors that contributed to escaping the Malthusian trap are well known. However, the weighting of individual factors and the precise mechanisms contributing to the decline in mortality and increase in life expectancy in Europe over the last 200 to 300 years remain controversial to this day. One example is the debate about Thomas McKeown's thesis that population growth and the decline in mortality in Europe since the 18th century are due to better socio-economic conditions, rather than to public health measures or medical interventions;[9] the causal mechanism led from better nutrition to better protection against infectious diseases and thus to a reduction in mortality. Recent research distinguishes between nutrition and nutritional status. While nutrition refers to the quantity and quality of food consumed, nutritional status is the balance between consumed food and the energy requirements of the individual.[10] Whether a diet is adequate depends ultimately on the changing epidemiological and socio-economic environment. Urban redevel-

4 Preston (see note 2); Samuel H. Preston, Causes and Consequences of Mortality Declines in Less Developed Countries during the 20th Century, in: Richard A. Easterlin (ed.), Population and Economic Change in Developing Countries, Chicago 1980; Samuel H. Preston, American Longevity. Past, Present, and Future, Syracuse 1996.

5 David Cutler, Angus Deaton and Adriana Lleras-Muney, The Determinants of Mortality, in: Journal of Economic Perspectives 20/3, 2006, pp. 97–120.

6 Sudhir Anand and Martin Ravallion, Human Development in Poor Countries. On the Role of Private Incomes and Public Services, in: The Journal of Economic Perspectives 7/1, 1993, pp. 133–150; Partha Dasgupta and Martin Weale, On Measuring the Quality of Life, in: World Development 20/1, 1992, pp. 119–131.

7 Jean-Claude Chesnais, La transition démographique. Étapes, formes, implications économiques. Étude de séries temporelles (1720–1984), relatives à 67 pays, Paris 1986; Geoffrey McNicoll, Demographic Transition, in: Joel Mokyr (ed.), The Oxford Encyclopedia of Economic History, Oxford 2003.

8 Wilhelm Bickel, Bevölkerungsgeschichte und Bevölkerungspolitik der Schweiz seit dem Ausgang des Mittelalters, Zürich 1947.

9 Thomas McKeown, The Modern Rise of Population, London 1976; Thomas McKeown, The Role of Medicine. Dream, Mirage, or Nemesis?, London 1976.

10 Roderick Floud, Bernard Harris and Sok Chul Hong, The Changing Body. Health, Nutrition, and Human Development in the Western World since 1700, Cambridge 2012.

opment and sanitary intervention during the 19th century contributed to a positive change in the epidemiological environment, thus potentially increasing the impact of improvements in nutrition.[11]

The study of mortality in Switzerland is hampered by the absence of data before 1867.[12] It is therefore difficult to evaluate if Swiss mortality levels had already declined at the end of the 18th century, as was the case for several European countries, although a few local studies seem to confirm this.[13] However, the available data from 1867 show that Swiss mortality was still high in an international comparison around 1870, but decreased rapidly thereafter, so that by 1910, it had reached a level comparable to that of France and Britain, where the decline had started earlier.[14] As in most other countries, the decline in mortality was most pronounced among children below the age of five,[15] especially girls.[16] Moreover, this decline was mainly driven by exogenous mortality, which suggests that improved medico-sanitary conditions played an important role.[17] Indeed, the principal causes of child death during this period were infectious diseases, particularly enteritis.[18]

Several researchers have pointed to the considerable mortality differentials between Swiss regions, which persisted until the late 20th century.[19] A number of studies have investigated these regional differentials and their underlying causes.[20] Three conclusions emerge from this literature. First, Catholic cantons or districts exhibited significantly higher mortality levels. Second, elevated regions had a mortality advantage in the pre-transitional regime with the colder climate reducing the risk of contamination with infectious diseases. During the demographic transition, however, this advantage

11 Bernard Harris, Public Health, Nutrition, and the Decline of Mortality. The McKeown Thesis Revisited, in: Social History of Medicine 17/3, 2004, pp. 379–407.

12 Luigi Lorenzetti and Alfred Perrenoud, Infant and Child Mortality in Switzerland, 19th–20th Centuries, Genève 1999.

13 Alfred Perrenoud, La mortalité des enfants en Europe francophone. État de la question, in: Annales de démographie historique 1, 1994, pp. 79–96; Anselm Zurfluh, Une population alpine dans la Confédération. Uri aux XVII[e]–XVIII[e]–XIX[e] siècles, Paris 1988; Hans-Rudolf Burri, Die Bevölkerung Luzerns im 18. und frühen 19. Jahrhundert. Demographie und Schichtung einer Schweizer Stadt im Ancien Régime, Luzern 1975.

14 Alfred Perrenoud, Le recul de la mortalité «ordinaire», in: Jean Pierre Bardet and Jacques Dupâquier (ed.), Histoire des populations de l'Europe, vol. 2, Paris 1998, pp. 57–82.

15 Lorenzetti and Perrenoud (see note 12).

16 Luigi Lorenzetti, Mortalità e cause di morte in Svizzera. Differenze di genere durante la transizione demografica (1870–1930), in: Popolazione e storia 2, 2009, pp. 71–93.

17 Lorenzetti and Perrenoud (see note 12).

18 Luigi Lorenzetti and Véronique Meffre, La transition sanitaire dans les Alpes suisses. Les aspects démographiques du retard (1880–1920), in: Histoire des Alpes 10, 2005, pp. 233–250.

19 Lorenzetti and Perrenoud (see note 12); Reto Schumacher, Structures et comportements en transition. La reproduction démographique à Genève au 19[e] siècle, Bern 2010, pp. 17–19.

20 Francine Van de Walle, One Hundred Years of Decline. The History of Swiss Fertility from 1860 to 1960. Philadelphia 1977, Chap. 4; Lorenzetti and Perrenoud (see note 12); Lorenzetti and Meffre (see note 18).

vanished because mortality levels decreased faster in the low-lying areas of the country, while medico-sanitary measures advanced more slowly in the mountainous regions. Third, urban and industrial regions suffered from higher infant mortality around 1870, whereas rural regions registered more child deaths in 1910.
Switzerland's fertility transition, too, was characterized by considerable regional disparities. The largest cities and some proto-industrial districts witnessed a very early decline in fertility rates, whereas in some rural alpine areas, the decline did not start until after 1930. Combined with significant differences in pre-transitional fertility levels and a variable pace of decline, these lags led to high fertility differentials among Swiss regions.[21]
The background to the demographic changes is Switzerland's economic modernization process, which occurred in the context of rapid market integration following the foundation of the federal state in 1848,[22] swift integration of international goods and capital markets,[23] acceleration of transportation between Swiss regions,[24] rapid electrification,[25] and the consolidation of the national banking system.[26]
Political and economic integration triggered fundamental structural change, including a comparatively fast decline in the agricultural employment share[27] and a high level of industrialization,[28] but also structural change within the agricultural sector toward meat and dairy products,[29] rapid growth of the industries of the Second Industrial Revolution,[30] and the emergence of Switzerland as an international financial center.[31]

21 Schumacher (see note 19), pp. 19–27.
22 Cédric Humair, Développement économique et Etat central (1815–1914). Un siècle de politique douanière suisse au service des élites, Bern 2004.
23 Guillaume Daudin, Mathias Morys, Kevin H. O'Rourke, Globalization, 1870–1914, in: Stephen N. Broadberry and Kevin H. O'Rourke (ed.), The Cambridge Economic History of Modern Europe, vol. 2, Cambridge 2010, pp. 5–29.
24 Thomas Frey, Die Beschleunigung des Schweizer Verkehrssystems 1850–1910, in: Schweizerische Zeitschrift für Geschichte 56/1, 2006, pp. 38–45.
25 Serge Paquier, Histoire de l'électricité en Suisse. La dynamique d'un petit pays européen 1875–1939, Genève 1998.
26 Malik Mazbouri, Kapitalmarkt. Der Kapitalmarkt nach 1850, Historisches Lexikon der Schweiz, 2008.
27 Stephen Broadberry, Giovanni Federico, Alexander Klein, Sectoral Developments, 1870–1914, in: Stephen N. Broadberry and Kevin H. O'Rourke (ed.): The Cambridge Economic History of Modern Europe, vol. 2, Cambridge 2010, p. 61.
28 Paul Bairoch, International Industrialization Levels from 1750 to 1980, in: Journal of European Economic History 11, 1982, pp. 269–333.
29 Bruno Fritzsche, Thomas Frey, Urs Rey et al., Historischer Strukturatlas der Schweiz. Die Entstehung der modernen Schweiz, Baden 2001; Max Lemmenmeier, Luzerns Landwirtschaft im Umbruch wirtschaftlicher, sozialer und politischer Wandel in der Agrargesellschaft des 19. Jahrhunderts, Luzern 1983.
30 Paquier (see note 25); Tobias Straumann, Die Schöpfung im Reagenzglas. Eine Geschichte der Basler Chemie (1850–1920), Basel 1995.
31 Malik Mazbouri, L'émergence de la place financière suisse (1890–1913). Itinéraire d'un grand banquier, Lausanne 2005.

As a result of this shift, growth rates of GDP per capita were comparatively high. Switzerland managed to make the transition from being below the Western European average in 1851 to becoming one of the wealthiest economies in terms of GDP per capita by around 1910.[32]
Alongside these national trends, regional specialization and urbanization rates increased significantly, allowing for the exploitation of comparative advantages and agglomeration economies.[33] This modernization process did not lead to a notable increase in regional inequality at higher geographical levels, however. Between 1860 and 1930, the alpine region's GDP per capita was only 15% to 30% lower than that of the more advanced lowlands. However, at lower geographical levels and even between cantons, inequality was considerable, so that the richest cantons' GDP per capita was between 1.8 and 2.4 times higher than that of the poorest cantons.[34]
Investment in infrastructure concerned not only railways and electrification. Several of the larger cities demolished the town walls around the mid-19th century and started to develop urban transportation networks, allowing for urban sprawl and reduced population density.[35] Investment in water provision and sewerage systems further improved sanitary conditions up to 1910, although in the early stages, centralized water provision also emerged as a vector of disease transmission.[36] Finally, the construction of several large hospital complexes[37] and the increasing professionalization of medical staff during the second half of the 19th century[38] led to improved public health services. However, even after the foundation of the federal state, public health care remained the responsibility of the cantons.
In sum, the historical literature on late 19th-century Switzerland highlights several features that are closely connected to the possible mechanisms linking GDP per capita and mortality, namely potentially improved nutrition through market integration and a transformation of agricultural production, investment in health-related infrastructure, and improved health care services. Moreover, many of these features are characterized

32 Christian Stohr, Trading Gains. New Estimates of Swiss GDP, 1851–2008, in: LSE Economic History Working Papers 245, 2016.
33 Christian Stohr, Growth Poles. Agglomeration Economies and Economic Growth in Switzerland from 1860 to 2008 (GSEM Working Paper Series), Genève 2014.
34 Christian Stohr, Multiple Core Regions. Regional Inequality in Switzerland, 1860 to 2008 (Research in Economic History 34), 2018, pp. 135–198.
35 François Walter, La Suisse urbaine, 1750–1950, Carouge 1994, pp. 190–230.
36 Martin Illi, Wasserversorgung, in: Historisches Lexikon der Schweiz, 2016.
37 Pierre-Yves Donzé, Bâtir, gérer, soigner. Histoire des établissements hospitaliers de Suisse romande, Chêne-Bourg 2003, pp. 65–171.
38 Erich Wyss, Heilen und herrschen. Medikalisierung, Krankenversicherung und ärztliche Professionalisierung 1870–1911, Zürich 1982; Rudolf Braun, Zur Professionalisierung des Ärztestandes in der Schweiz, in: Werner Conze (ed.), Bildungsbürgertum im 19. Jahrhundert, vol. 1, Stuttgart 1985.

by significant regional disparities, which allow us to effectively test the Preston curve relationship and possible underlying mechanisms.

The main building block of our analysis are cantonal life tables for the period 1880–1910 based on the federal census. The nature of the data determines the type of life table we can construct: a cohort or generation life table, which would be an ideal tool to study mortality trends, is not possible. Instead, we calculate life expectancy from period or current life tables, which are based on mortality rates in a short time period.[39] This has to be kept in mind with respect to the interpretation of the results, because for a period with falling mortality rates, a current life table will underestimate life expectancy. Therefore, our results have to be seen as lower bounds.[40]

From these life tables, we use life expectancy together with measures for regional economic activity to shed light on the relative importance of the channels mentioned above. Among these are measures for institutional quality along the lines of Putnam,[41] measures for human capital,[42] and newly constructed regional GDP estimates.[43] As in Peltzman,[44] we use the hypothetical number of survivors at each age to compute mortality Gini coefficients, analyzing the change of social inequality in this sphere.

Data

Our main data source is census data for 1880, 1888, 1900, and 1910, which provide cantonal population size by age. The number of deaths per year, in age classes 0, 1–4, 5–14, 15–19, 20–29, 30–39, 40–49, 50–59, 60–69, and >69 years (1880–1900) and 0, 1–4, 5–14, 15–19, 20–29, 30–39, 40–49, 50–59, and >59 years (1910) comes from the population movement statistics of the Federal Statistical Office.[45]

We also use the total cantonal population for the census years.[46] As is usual for Switzerland, a central problem of the historical-quantitative analysis of mortality

39 Hallie J. Kintner, The Life Table, in: Jacob P. Siegel and David A. Swanson (ed.), The Methods and Materials of Demography, Amsterdam 2004, p. 301.

40 We are grateful to an anonymous referee for pointing this out.

41 Robert D. Putnam, Making Democracy Work. Civic Traditions in Modern Italy, Princeton 1994.

42 Timo Boppart, Josef Falkinger, Volker Grossmann et al., Under which Conditions does Religion affect Educational Outcomes?, in: Explorations in Economic History 50/2, 2013, pp. 242–266; Timo Boppart, Josef Falkinger, Volker Grossmann, Protestantism and Education. Reading (the Bible) and Other Skills, in: Economic Inquiry 52/2, 2014, pp. 874–895.

43 Stohr (see note 34).

44 Sam Peltzman, Mortality Inequality, in: Journal of Economic Perspectives 23/4, 2009, pp. 175–190.

45 Statistisches Bureau des eidgenössischen Departements des Innern, Die Bewegung der Bevölkerung in der Schweiz im Jahre 1880. Bern 1882. We use the same publication for the years: 1881, 1887, 1888, 1889, 1899, 1900, 1901, 1909, 1910, and 1911. In order to smooth idiosyncrasies, we take age group averages of 3 years around the census date. For 1880, we decided to take the average over 1880 and 1881 only, because the statistics for 1879 do not report the age class 0.

46 Historische Statistik der Schweiz HSSO, 2012. Tab. B.4. hsso.ch/2012/b/4.

rates is the cantonal responsibility for collecting data. In extreme cases, this led to 25 (now 26) different reporting qualities, a potential source of inter-observer error. This was probably partly the case for the compilations of data on marriages, births, and deaths used in this study. It certainly contributed to the difficulty for the Federal Statistical Office to present accurate figures of death by age group at cantonal level in the early days.[47] However, the statistics on population movement also show that the quality of data increases over time: the number of deaths that cannot be assigned to any age decreases over time and is very small from 1880 onwards, with just 70 cases for the entire of Switzerland.

Statistics inevitably evolve in form and content over the decades. They always emerge in a historical and social context and are therefore never merely descriptive, but are also an indication of how the world is perceived.[48] In the available data, the age groups in which deaths were recorded changed between 1880 and 1911, but only with respect to the oldest age group, which was over 60, over 70 or over 80, depending on the survey year. In addition to the fact that any statistical class formation is ultimately at the discretion of the researcher, it is evident that through class formation, especially at the respective class boundaries, a distinction is made between the objects of the survey which does not always reflect reality. In other words, the real difference between a 29-year-old and a 30-year-old is widened if one is in the 20–29-year-old group and the other belongs to the next group. Of course, age groups should not be seen as homogeneous groups; the quantitative analysis of deaths is ultimately an attempt to discern any structural peculiarities that do not have to apply to the individual case.

A measure representing the economic characteristics of a canton is the share of agricultural employment.[49] We also use cantonal urbanization rates, which we calculated from the municipal population data in Schuler et al.,[50] using the threshold of 2000 inhabitants as the urban definition. To measure the development of the health sector, we have data on health-related occupation,[51] births per midwife,[52] and inhabitants (i.e. potential patients) per doctor.[53] We do not have a direct measure representing health-related public infrastructure investment, but use employment related to pub-

47 Hansjörg Siegenthaler and Heiner Ritzmann-Blickenstorfer (ed.): Historische Statistik der Schweiz, Zürich 1996, p. 176.

48 Jakob Tanner, Der Tatsachenblick auf die «reale Wirklichkeit». Zur Entwicklung der Sozial- und Konsumstatistik in der Schweiz, in: Schweizerische Zeitschrift für Geschichte 45, 1995, pp. 94–108.

49 Historische Statistik der Schweiz HSSO, 2012. Tab. F.10. hsso.ch/2012/f/10.

50 Martin Schuler, Dominik Ullmann, Werner Haug, Eidgenössische Volkszählung 2000. Bevölkerungsentwicklung der Gemeinden 1850–2000, Neuchâtel 2002.

51 Historische Statistik der Schweiz HSSO, 2012. Tab. B.4. hsso.ch/2012/f/10.

52 Historische Statistik der Schweiz HSSO, 2012. Tab. B.4. hsso.ch/2012/d/22.

53 Historische Statistik der Schweiz HSSO, 2012. Tab. B.4. hsso.ch/2012/d/20 and Historische Statistik der Schweiz HSSO, 2012. Tab. B.4. hsso.ch/2012/d/23. Midwives: 1880 and 1888: births per midwife 1887/1891; 1900: birth per midwife 1896/1900; 1910: births per midwife 1908/1912. Doctors: 1880: inhabitants per doctor 1875; 1888: inhabitants per doctor 1890.

lic water supply as a proxy.[54] Public attitude towards health issues is measured by participation and yes-shares in the referenda on the epidemics law in 1882, on the regulation of alcohol consumption in 1885, on food safety in 1906, and on the ban of absinth production in 1908.[55]

In addition, we use regional GDP estimates from Stohr,[56] which allows an analysis of the relationship between GDP per capita and mortality at cantonal level. These estimates were constructed using very fine-grained data on agricultural inputs, employment in manufacturing and services, as well as value added at national level. This data represents a significant improvement over earlier vintages[57] as it relies on far more statistical evidence concerning the agricultural production structure and employment in the non-agricultural sectors. It also depends on fewer assumptions than the estimates of Ritzmann and David,[58] which cover the period after 1890.

The estimates from Stohr are only in nominal terms. In order to make them comparable over time, we deflate the nominal values with the price index of single-deflated value added from Stohr.[59] This deflator is more appropriate for our analysis than the standard GDP deflator, which is based on double deflation. Contrary to double-deflated GDP, single-deflated GDP includes terms of trade gains, which have a real impact on welfare.[60]

Another broad indicator for the standard of living in a given year is average human stature of the cohort born in said year.[61] As is usual in a historical context, this indicator is not available for the entire population, but Switzerland has the advantage that since the Federal Constitution of 1848, military service is compulsory. In consequence, every male Swiss citizen (not abroad), as a rule at the age of 19 years, was conscripted and examined to determine the individual fitness-for-service status, a practice still in place today.[62] In 1875, the conscription procedure was standardized on federal level. On district level, the Federal Statistical Office published data

54 Historische Statistik der Schweiz HSSO, 2012. Tab. B.4. hsso.ch/2012/f/10.
55 Historische Statistik der Schweiz HSSO, 2012. Tab. B.4. hsso.ch/2012/x/10.
56 Stohr (see note 34).
57 Christian Stohr, Spatial Dynamics of Economic Growth in Switzerland from 1860 to 2000, Thesis in Economic and Social Sciences, Genève 2014.
58 Heiner Ritzmann and Thomas David, Schätzungen des Bruttoinlandprodukts nach Branchen und Kantonen 1890–1960, in: Patrick Halbeisen, Margrit Müller, Béatrice Veyrassat (ed.), Wirtschaftsgeschichte der Schweiz im 20. Jahrhundert, Basel 2012, pp. 1185–1214.
59 Stohr (see note 32).
60 W. Erwin Diewert and Catherine J. Morrison, Adjusting Output and Productivity Indexes for Changes in the Terms of Trade, in: The Economic Journal 96/383, 1986, pp. 659–679; Stohr (see note 32).
61 Richard H. Steckel, Stature and the Standard of Living, in: Journal of Economic Literature 33/4, 1995, pp. 1903–1940; John Komlos, Anthropometric History, in: Steven N. Durlauf et al. (ed.), The New Palgrave Dictionary of Economics, Basingstoke 2008.
62 This feature rules out the possibility of selection bias, as put forward by Howard Bodenhorn, Timothy W. Guinnane, Thomas A. Mroz, Sample-Selection Biases and the Industrialization Puzzle, in: The Journal of Economic History 77/1, 2017, pp. 171–207. On this point see also the reaction of John

for conscripts with birth years 1865–1872, corresponding to conscription years 1884–1891.[63] We use the data collected by Marti[64] and added the years 1908–1912.[65] For the year 1880, we take the conscripts measured in 1884. For 1900, there are no data available, so we take the average of the heights measured in 1891 and in 1908. Since we want to analyze the impact on life expectancy at birth in 1880, 1888, 1900, and 1910, this measure can be interpreted as approximately reflecting the biological standard of living of the parental generation.

As a measure for human capital, we use the outcomes of the pedagogical examinations in 1880, 1890, 1900, and 1910.[66] These examinations were introduced as part of the conscription process with the purpose of monitoring primary school performance in Switzerland. Since military service was compulsory, the results provide a detailed picture of the effects of regional differences in schooling quality on the abilities of 19-year-old males. With few exceptions, recruits had to undergo a standardized test in four subjects: reading, essay writing, mathematics (written and oral) as well as knowledge of Swiss history and constitution.[67] From 1875 to 1879, the grade categories ranged from 1 (very good) to 4 (poor), and thereafter from 1 to 5.[68]

Finally, we look at the influence of social capital on mortality and life expectancy, as a proxy for institutional quality. As Putnam[69] shows in his study for Italy, social capital and institutional quality are highly correlated. Social capital is very difficult to measure, but for Switzerland, Putnam's proxies are available: We have cantonal data on voter turnout at referenda and national council elections,[70] on the existence of local newspapers,[71] and on membership in associations.[72]

Komlos and Brian A'Hearn, The Decline in the Nutritional Status of the U.S. Antebellum Population at the Onset of Modern Economic Growth (NBER Working Paper Series 21845), Cambridge 2016.

63 Statistisches Bureau des eidgenössischen Departements des Innern. Statistische Lieferungen 62, 65, 68, 72, 77, 81, 85, 96.

64 Simon Marti, Die Verteilung der Körperhöhen auf Bezirksebene in der Schweiz, 1884–1891 und 1908–1912, Zürich 2012.

65 Data source: Swiss Federal Archives, E3321#13–04 Sanitarische Rekrutenprüfung, 1864–1915.

66 For a detailed description see: Boppart et al., Under which Conditions (see note 42); Boppart et al., Protestantism and Education (see note 42).

67 Oliver Zimmer, A Contested Nation. History, Memory and Nationalism in Switzerland, 1761–1891, Cambridge 2003, p. 181.

68 Source: Statistisches Bureau des eidgenössischen Departements des Innern, Pädagogische Prüfung bei der Rekrutierung, Statistische Lieferungen 47, 82, 129, 175.

69 Putnam (see note 41).

70 Historische Statistik der Schweiz HSSO, 2012. Tab. B.4. hsso.ch/2012/x/10 and Historische Statistik der Schweiz HSSO, 2012. Tab. B.4. hsso.ch/2012/x/20.

71 Kurt Bürgin, Statistische Untersuchungen über das schweizerische Zeitungswesen. 1896–1930, Leipzig 1939.

72 Eduard Keller, Wilhelm Niedermann, Die schweizerischen Vereine für Bildungszwecke im Jahre 1871, Basel 1877.

Results

Since death statistics are only available for age groups, we construct abridged life tables.[73] Let ${}_nD_x$ be the number of deaths in the age interval x to $x + n$, where $x = 0, 1, 5, 15, 20, 30, 40, 50, 60, 70$, and $n = 1, 4, 10, 5, 10, 10, 10, 10, 10, \infty$.[74] The age-specific raw mortality rates can be obtained from

$$ {}_nM_x = {}_nD_x \,/\, {}_nP_x \,, $$

where ${}_nP_x$ is the population in the age interval x to $x + n$. We convert mortality rates to probabilities of dying ${}_nq_x$ using[75]

$$ {}_nq_x = \frac{2n\, {}_nM_x}{2 + n\, {}_nM_x}. $$

From the probabilities of dying, the survival probabilities can be calculated as

$$ {}_np_x = 1 - {}_nq_x. $$

For the final age group, we have

$$ {}_\infty p_{70} = 0 \Leftrightarrow {}_\infty q_{70} = 1. $$

Starting with a cohort of 100,000 live births, we calculate the number surviving to a certain age $x + n$ as

$$ l_{x+n} = l_x\, {}_np_x $$

and the number dying in an age group as

$$ {}_nd_x = l_x\, {}_nq_x \,. $$

Person years between ages x to $x + n$ are given as

$$ {}_nL_x = \frac{n}{2}(l_x + l_{x+n}). $$

To take excess child mortality into account, we calculate person years for the first age group as

$$ L_0 = 0.3 l_0 + 0.7 l_1. $$

Person years lived above age x, T_x, are the cumulated person years above age x. Finally, average remaining lifetime for age x is

$$ e_x = \frac{T_x}{l_x}. $$

Table 1 contains example output for this procedure (Zurich, males, 1880).

73 Donald Trevor Rowland, Demographic Methods and Concepts, New York 2003. Note that this procedure is based on the assumption of stationarity. However, we impose the same distortion on all cantons, which should reduce the error. Moreover, net migration was close to zero because our period of analysis covers the time Switzerland changed from an emigration to an immigration country.

74 For 1910, the definitions have to be adjusted to $x = 0, 1, 5, 15, 20, 30, 40, 50, 60$, and $n = 1, 4, 10, 5, 10, 10, 10, 10, \infty$.

75 The census takes place at the end of December in the census year. To adjust for the fact that the number of deaths is a float variable measured for the entire year, while population size is a stock measured at the end of the year, we assume uniformly distributed deaths and calculate the relevant population for the denominator as ${}_nP_x + 0.5\, {}_nD_x$.

Table 1: Life Table for Zurich (Males, 1880)

Age	${}_nM_x$	${}_np_x$	${}_nq_x$	l_x	${}_nd_x$	${}_nL_x$	T_x	e_x
0	0.28	0.75	0.25	100.000	24.857	82.600	3.872.673	39
1–4	0.02	0.91	0.09	75.143	6.617	287.338	3.790.073	50
5–14	0.01	0.95	0.05	68.526	3.727	666.622	3.502.735	51
15–19	0.00	0.98	0.02	64.799	1.550	320.117	2.836.113	44
20–29	0.01	0.93	0.07	63.248	4.131	611.828	2.515.996	40
30–39	0.01	0.90	0.10	59.117	5.720	562.576	1.904.167	32
40–49	0.01	0.87	0.13	53.398	7.144	498.259	1.341.592	25
50–59	0.03	0.77	0.23	46.254	10.818	408.451	843.333	18
60–69	0.05	0.58	0.42	35.436	14.936	279.683	434.882	12
> 69	0.13	0.00	1.00	20.500	20.500	155.198	155.198	8

Life expectancy at birth for the years 1880 and 1910 is displayed in Figure 1. With very few exceptions, life expectancy for women is higher than for men. Moreover, there is a significant increase between 1880 and 1910. Interestingly, in the canton of Obwalden, life expectancy in 1880 was already at a level that the other cantons did not reach until 1910. Lorenzetti and Perrenoud (1999) caution against taking the official statistics on infant mortality at face value, and introduce correction factors for regional mortality rates which we use for Obwalden and Nidwalden. As can be seen from the lower part of Figure 1, the correction does not change the picture dramatically. Nevertheless, we use the corrected figures for further analysis.

While it is true that terminal height is the consequence of the interaction of genetic factors with the environment during infancy, childhood, and adolescence, the literature shows that it is especially the first years of life when children are susceptible to adverse living conditions.[76] Therefore, Figure 2 is based on average height of conscripts measured in 1910/1900/1890/1880, which we compare with GDP per capita in the approximate birth year, i.e. 1888/1880/1870/1860. The trend in average human stature from the 19th to the 20th century described elsewhere[77] is obvious: In the period of

76 See for example James M. Tanner, Foetus into Man. Physical Growth from Conception to Maturity. Cambridge 1990, p. 131. This is related to the early life hypothesis about the importance of early life conditions on educational achievement, labor market outcomes, morbidity, or mortality later in life. See for example: David J. P. Barker, Fetal and Infant Origins of Adult Disease. Papers Written by The Medical Research Council Environmental Epidemiology Unit, London 2002; David J. P. Barker, Mothers, Babies and Health in Later Life, Edinburgh 1998; Douglas Almond, Janet Currie, Killing Me Softly. The Fetal Origins Hypothesis, in: Journal of Economic Perspectives 25/3, 2011, pp. 153–172.

77 Kaspar Staub, Der biologische Lebensstandard in der Schweiz seit 1800. Historisch-anthropometrische Untersuchung der Körperhöhe (und des Körpergewichts) in der Schweiz seit 1800, differenziert nach Geschlecht, sozioökonomischem und regionalem Hintergrund, Bern 2010; Kaspar

about 30 years, median height increases by 2–3 cm. There is also a positive correlation at a first glance between per capita GDP and height on cantonal level.
We use the share of agricultural employment to proxy the sectoral specialization of a canton. Looking at the distribution of life expectancy at birth and infant mortality conditional on our specialization measure (Figures 3 and 4), we see that for 1910, life expectancy is higher and infant mortality lower for cantons with a low agricultural share. At the start of our observation period, it was better to live in a more rural canton in terms of life expectancy and mortality, but this changed at the beginning of the 20th century.[78] What is also obvious is the significant drop in infant mortality at the turn of the century. Similar interpretations can be drawn from the relation between urbanization and life expectancy or infant mortality (Figures 5 and 6), although the negative correlation in 1880 is very weak.

We estimate two models

$$Y_{tji} = \alpha_0 + \alpha_t + \alpha_i + \alpha_1 GDP_{tj} + \alpha_2 HC_{tj} + \alpha_3 SC_{tj} + \alpha_5 HS_{tj} + \alpha_6 H_{tj} + \alpha_7 A_{tj} + \alpha_8 U_{tj} + \epsilon_{tji},$$

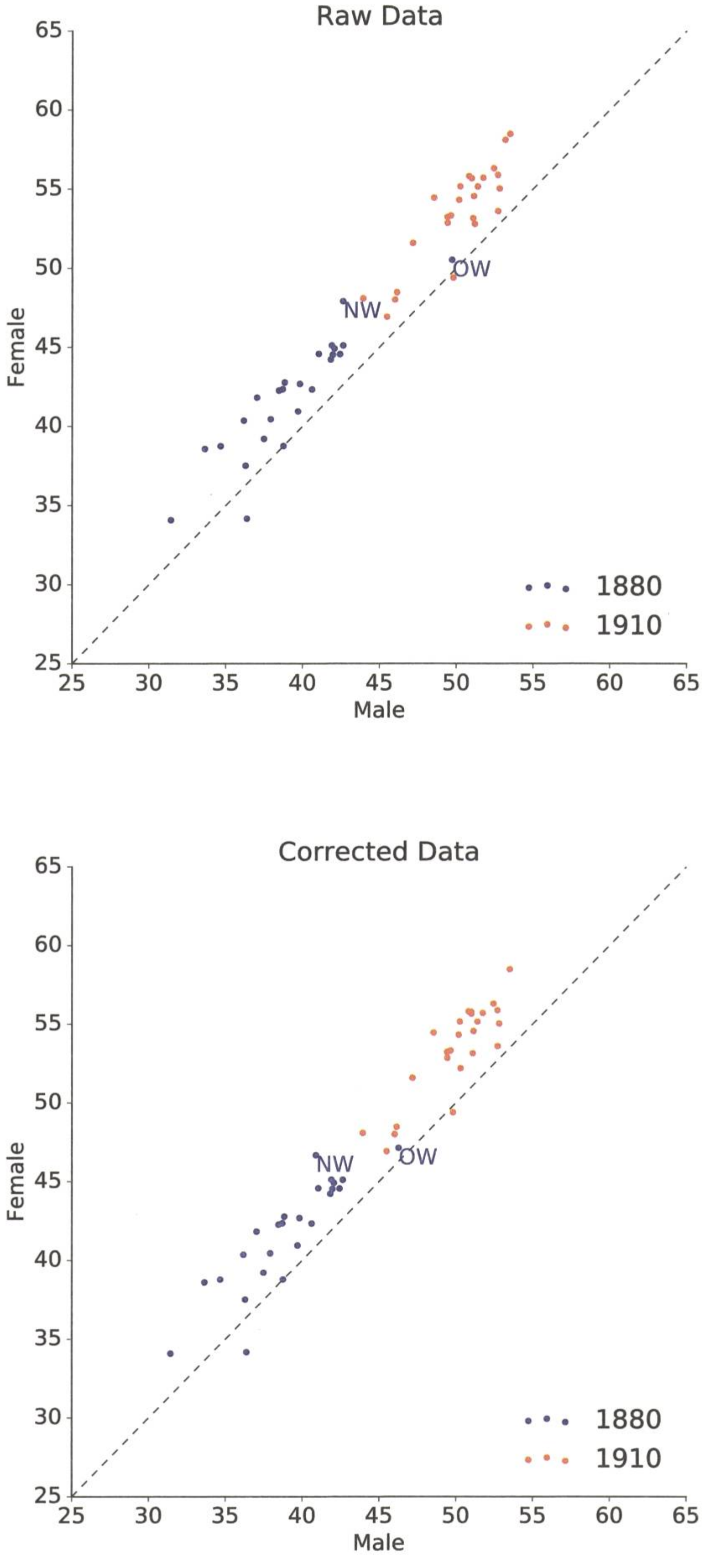
where the indices are t = 1880, 1888, 1900, 1910 (time), j = 1, …, 25 (cantons), $i = M, F$ (sex). The variable Y on the left is either life expectancy at birth (e_0) or infant mortality (${}_1M_0$). We include time fixed effects (α_t) and control for sex (α_i). GDP enters as second-degree polynomial, because we want to see whether a Preston curve relationship exists after including other relevant cantonal characteristics. Given the results in Figures 3 to 6, we allow for interaction with time for the employment share in agriculture ($A_{t,j}$) and the urbanization rate (U_{tj}).
The variable $HC_{t,j}$ represents human capital, in this version the cantonal average mathematics mark in the pedagogical examinations.[79] Social capital $SC_{t,j}$ is measured by the number of local newspapers per head. Average height of 19-year-old conscripts $H_{t,j}$ reflects socio-economic conditions during childhood and adolescence. Finally, the conditions of the health sector HS in canton j and time t are measured by the share of employment in the health sector, the number of patients per doctor, and the

Staub, Frank Rühli, Ulrich Woitek et al.: The Average Height of 18- and 19-Year-Old Conscripts (N = 458 322) in Switzerland from 1992 to 2009, and Secular Height Trend since 1878, in: Swiss Medical Weekly, 2011; Kaspar Staub, Ulrich Woitek, Christian Pfister et al., Überblick über zehn Jahre historisch-anthropometrische Forschung in der Schweiz. Säkularer Trend, soziale und regionale Unterschiede in der mittleren Körperhöhe und -form seit Beginn des 19. Jahrhunderts, in: Bulletin der Schweizerischen Gesellschaft für Anthropologie 18/2, 2012, pp. 37–50; Joël Floris, Körpergrösse, Body-Mass-Index und Geburtsgewichte. Lebensstandard und Anthropometrie in Zürich und Basel 1904–1951, Zürich 2016.

78 For the purpose of this descriptive plot, we define a low share to be less than 40%. The reason is that we wanted to have enough cantons in both groups for both years. In the later analysis, we will not apply this grouping.

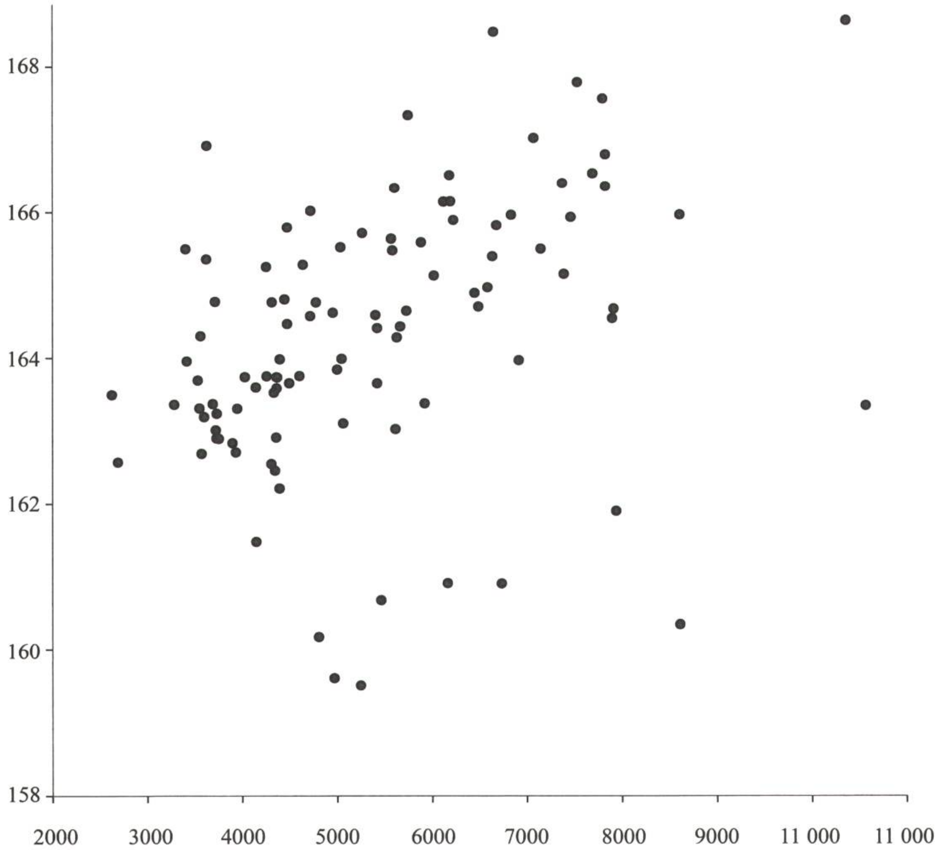
79 Results with the average mark from the other tests can be found in the appendix (Tables 4 and 5).

Figure 1: Life Expectancy at Birth, 1880 and 1910



The data for Obwalden and Nidwalden in the lower graph are corrected using the factors suggested by Lorenzetti and Perrenoud (see note 16). Despite the correction, Obwalden and Nidwalden have the highest life expectancy in 1880.

Figure 2: Cantonal GDP per capita and Average Height, 1880–1910



Average height: male conscripts (19 years); cantonal GDP: approximate birth years (1880, 1888, 1900, 1910). The data are stacked.

number of births per midwife. We transform the continuous variables by either subtracting the minimum or the maximum. In this way, the intercept can be interpreted as life expectancy or infant mortality in 1880 for a canton with minimum agricultural share, urbanization rate, GDP and local newspaper per capita, worst average mark in mathematics, minimum average height, minimum employment share in the health sector, and worst supply of health services as reflected by maximum number of births per midwife and maximum number of patients per doctor. The results are displayed in Table 3.

Both for life expectancy and infant mortality, we see a significant trend between 1880 and 1910, with life expectancy increasing and infant mortality decreasing. Per capita GDP has a Preston curve effect for life expectancy even after controlling the channels mentioned in the introduction: the first parameter of the polynomial is positive, and

Table 2: Cantonal Height Distributions

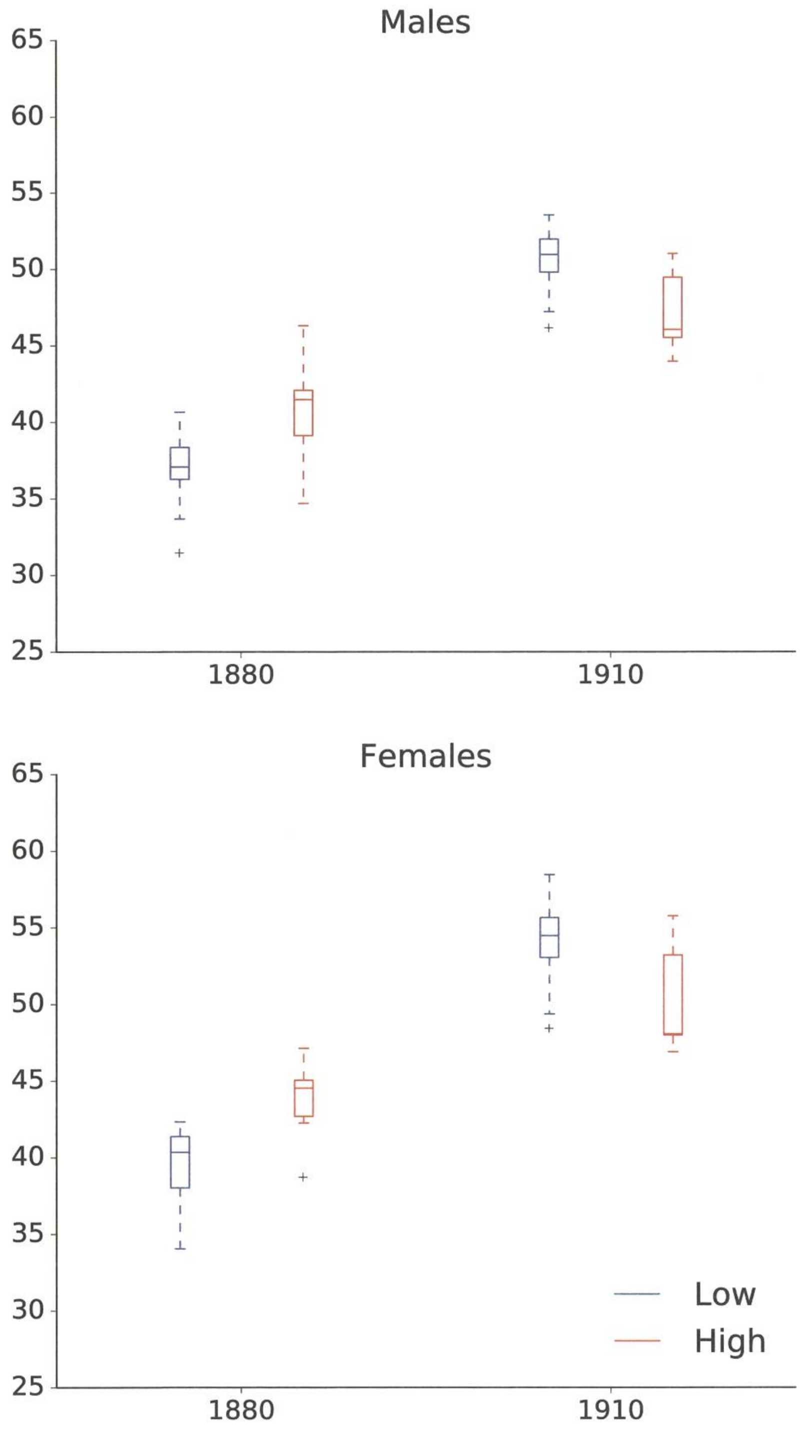
Percentile	1880/1888	1900/1910
5%	160.49	161.90
25%	163.03	164.62
50%	163.63	165.23
75%	164.18	165.97
95%	166.08	167.07

Average height (cm): male conscripts (19 years).

Table 3: Regression Results, Life Expectancy at Birth (e_0) and Infant Mortality ($_1M_0$)

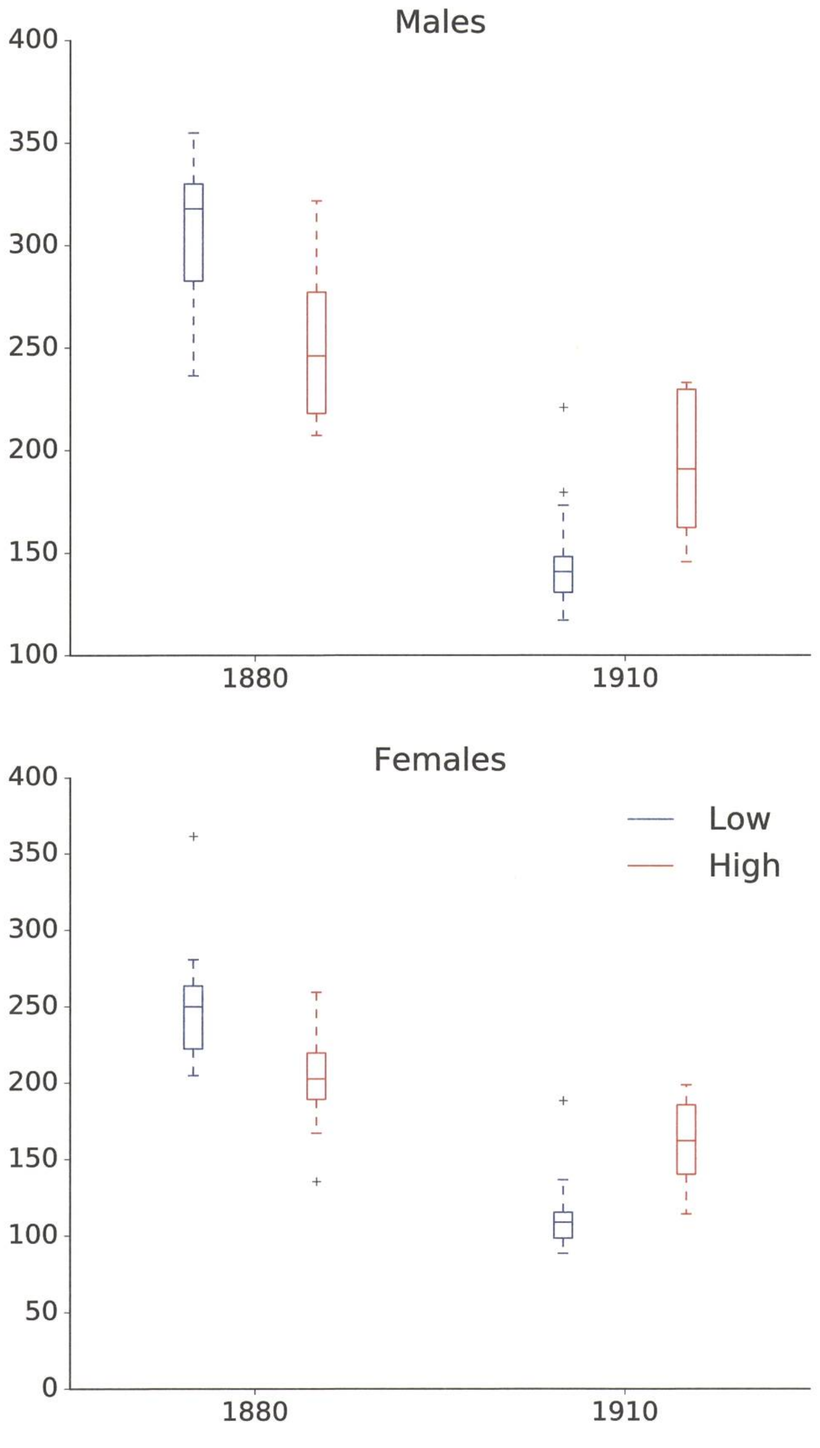
	e_0		$_1M_0$	
Variable	Est.	p-value	Est.	p-value
Female	2.8273	(0.0000)	-43.8795	(0.0000)
GDP	0.0440	(0.3542)	0.5932	(0.4297)
GDP × GDP	-0.0014	(0.0182)	-0.0011	(0.9066)
Agriculture	8.3755	(0.0010)	-69.4837	(0.0810)
1888	6.2005	(0.0062)	-67.8547	(0.0569)
1900	10.1915	(0.0000)	-115.7687	(0.0021)
1910	13.3271	(0.0000)	-143.4706	(0.0004)
1888 × Agriculture	-6.4649	(0.0503)	69.7802	(0.1802)
1900 × Agriculture	-14.7603	(0.0000)	155.6752	(0.0061)
1910 × Agriculture	-21.5721	(0.0000)	210.8456	(0.0011)
Urbanization	-0.0221	(0.2279)	0.3136	(0.2792)
1888 × Urbanization	0.0012	(0.9624)	-0.2249	(0.5664)
1900 × Urbanization	0.0206	(0.4313)	-0.1554	(0.7071)
1910 × Urbanization	0.0624	(0.0202)	-0.5732	(0.1753)
Height	0.3320	(0.0020)	-5.1821	(0.0023)
Newspapers	0.5088	(0.7990)	18.5853	(0.5567)
Health sector	0.0582	(0.0001)	-0.0539	(0.8167)
Doctors	-0.0006	(0.0017)	0.0123	(0.0001)
Midwives	-0.0331	(0.0079)	0.7974	(0.0001)
Mathematics	-2.7862	(0.0000)	25.1325	(0.0046)
Constant	26.2917	(0.0000)	421.2927	(0.0000)
Observations		200		200
R^2		0.896		0.809

Figure 3: Agricultural Share and Life Expectancy, 1880 and 1910



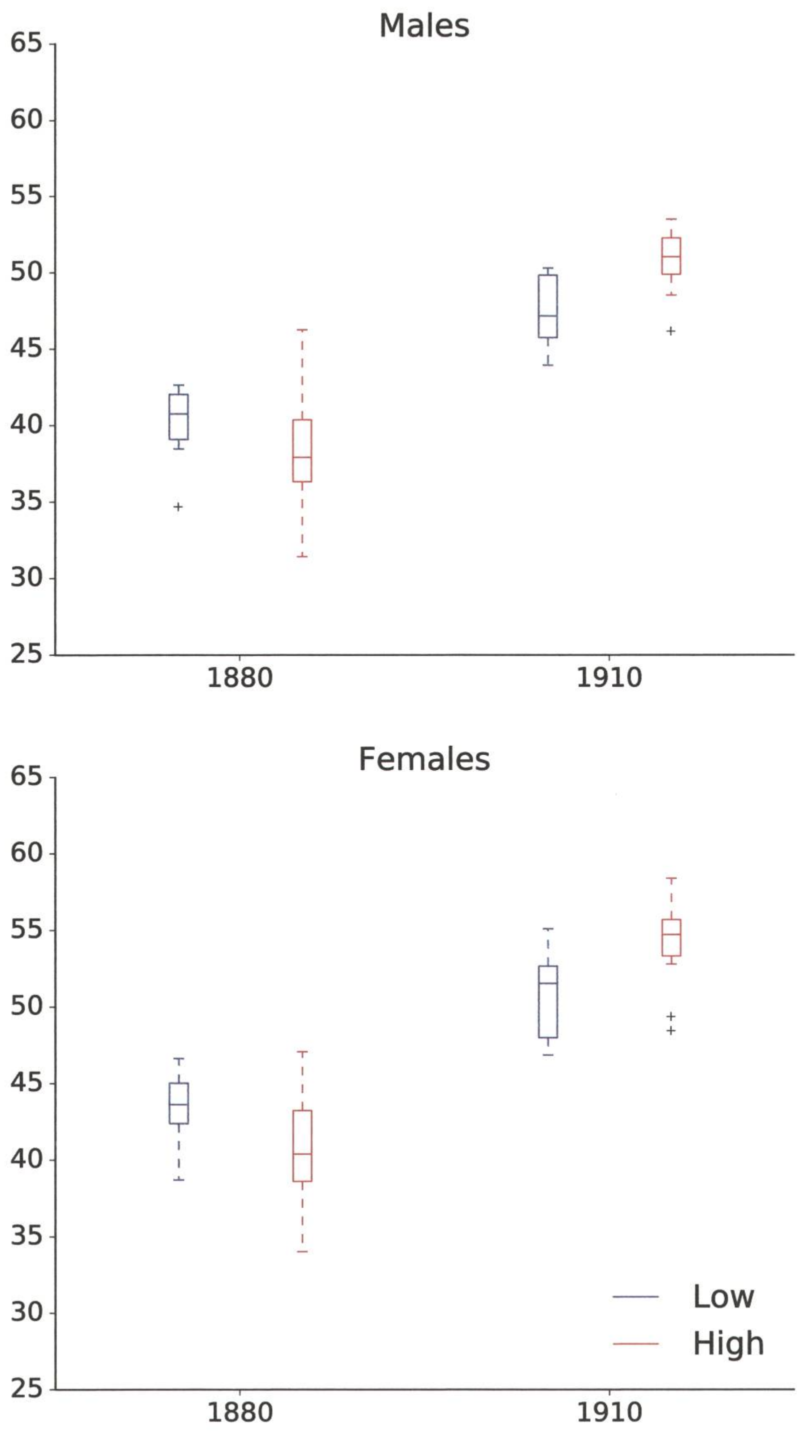
the second is negative and significant at the 5% level. For infant mortality, there is no such effect. A potential explanation for this result is the following: GDP does not influence mortality or life expectancy directly, but through the aforementioned channels. It could be that we found the channels through which GDP reduces infant mortality, but a relevant one is missing for life expectancy.

Figure 4: Agricultural Share and Infant Mortality, 1880 and 1910



An increase in the agricultural employment share increases life expectancy and decreases infant mortality, but this effect vanishes or even gets reversed over time, as could be expected from the results in Figures 3 and 4. In line with Figures 5 and 6, urbanization has no significant effect until 1910, where it is positively related with life expectancy and negatively related with infant mortality. Average height has a sig-

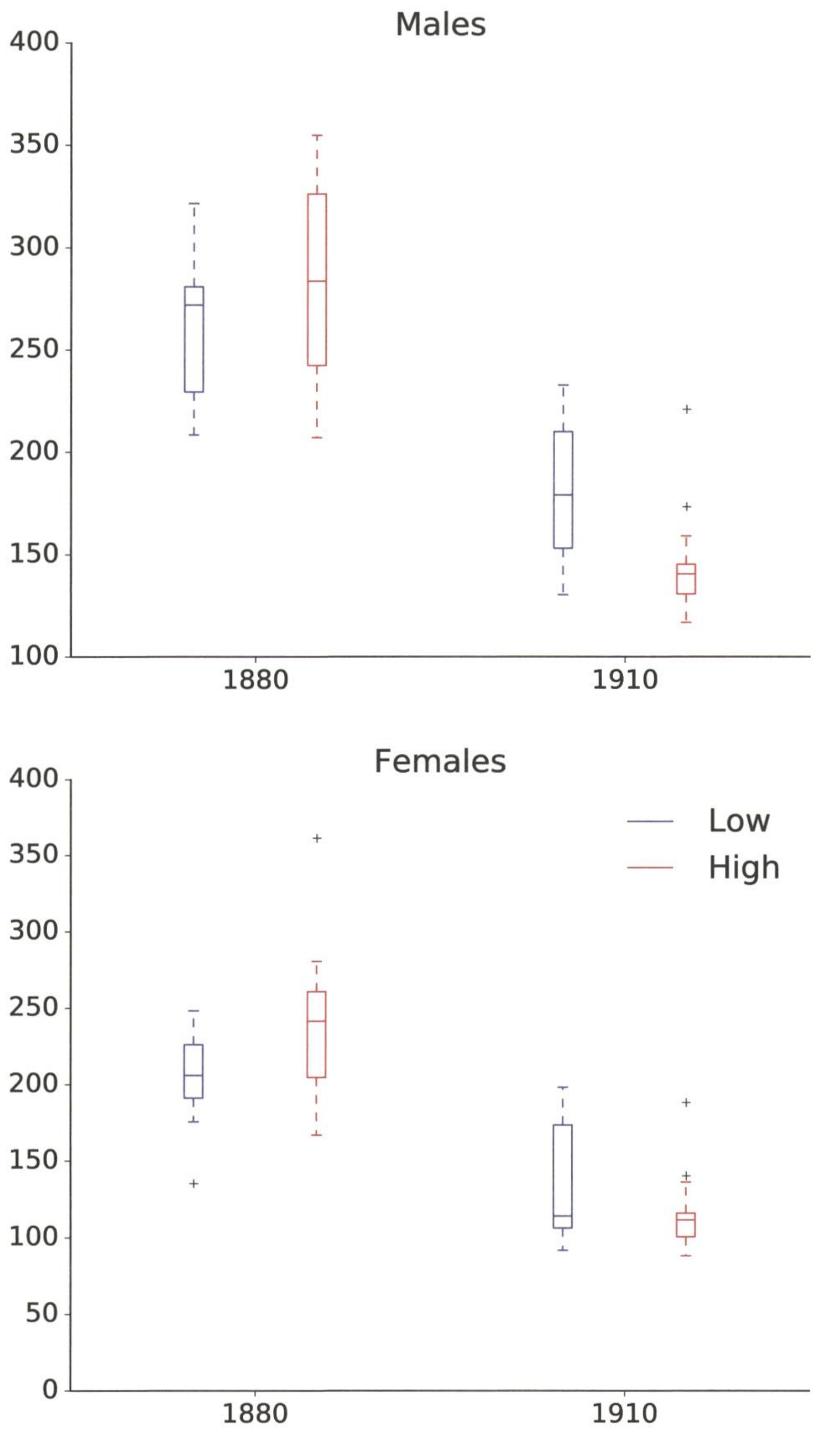
Figure 5: Urbanization Rate and Life Expectancy, 1880 and 1910



nificant effect, with the expected sign on both our outcome measures. Human capital represented by the performance in the mathematics test of the pedagogical examination has a positive effect on life expectancy and a negative one on infant mortality.[80]

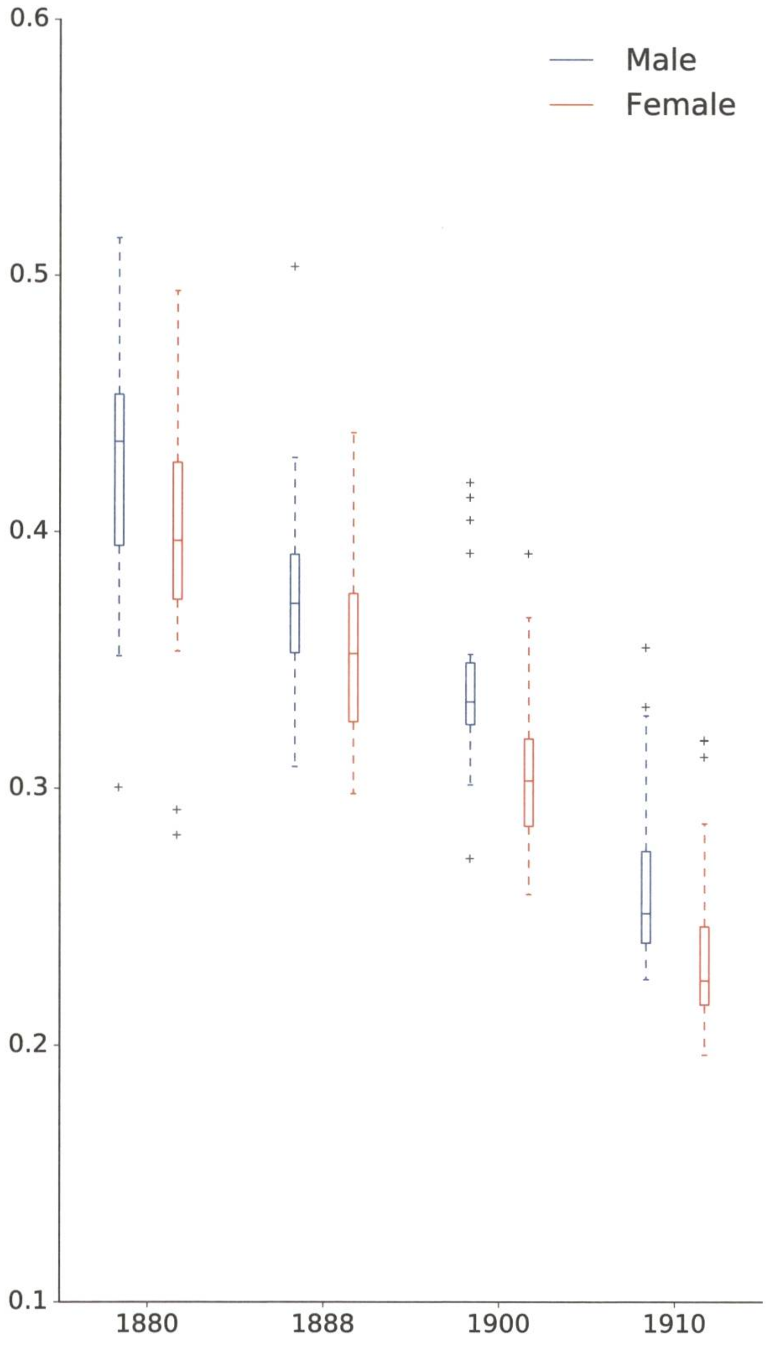
80 Note that higher average marks mean lower performance.

Figure 6: Urbanization Rate and Infant Mortality, 1880 and 1910



Social capital as measured by local newspapers per head has a significant positive effect on life expectancy. The effect on infant mortality has the expected direction; however, it is imprecisely estimated and insignificant on conventional levels.
Finally, turning to the size of the health sector, it is positively related not only to life expectancy, but also to infant mortality. The effect is not very precisely estimated;

Figure 7: Cantonal Mortality Ginis, 1880 to 1910



however, one can speculate that this result could be due to reverse causality, an issue we wish to address in the future: the size of the health sector might be a reaction to the level of infant mortality, which would lead to a positive correlation. The results on the impact of the quality of the health service as measured by patients per doctor and births per midwife are as expected, but not significant for the midwives.

As mentioned in the introduction, we follow Peltzman[81] and also look at mortality Gini coefficients, given by

$$G = 1 - \sum_{x=0}^{N} f(d_x)\big(F(T_{x-1}) + F(T_x)\big),$$

where N is the highest age, d_x the number of deaths at age x, and T_x the person years at age x. The share of deaths at age x is denoted by $f(d_x)$, and $F(T_x)$ is the cumulative share of person years up to age x, with $F(T{-}1) = 0$.

Mortality Ginis measure the concentration of mortality in specific age groups. Figure 5 shows that there is a significant decrease in mortality inequality between 1880 and 1910 in Switzerland, mirroring the results in Peltzman.[82] As Peltzman describes,[83] an increase in longevity will first lead to increasing mortality inequality, and then to a decrease, causing a pattern similar to a Kuznets curve for the relationship between average income and income inequality. This pattern cannot be observed in his data, and we do not see it for Switzerland either. The explanation offered by Peltzman is that it is the reduction in difference in longevity between those dying prematurely and those reaching old age driving the decrease in mortality inequality, due especially to the reduction of infant and early childhood mortality, a fact we also observe in the Swiss data.

Conclusion

We look at mortality and longevity in Switzerland in the period 1880–1910, in the time of the so-called first demographic transition, analyzing the channels explaining the Preston curve relationship. We find that there is a Preston curve for life expectancy at birth, albeit imprecisely estimated. We cannot find such a relationship for infant mortality, however. There is a change with respect to the consequences of living in a rural region: At the beginning of our observation period, life expectancy is higher and infant mortality is lower, the higher the share of agricultural employment in a canton. This advantage decreases over time and, in 1910, it is better to live in a canton with a low share of agricultural employment. The mortality Ginis reflecting concentration of mortality in specific age groups decrease over our observation period. Following Peltzman,[84] this finding can be explained by the reduction in the difference in longevity between people dying prematurely and dying at old age, driven by the reduction of infant and early childhood mortality.

81 Peltzman (see note 44).
82 Ibid., p. 180. Fig. 2.
83 Ibid., pp. 183 et seq.
84 Peltzman (see note 44).

Appendix A : Pedagogical Examinations

Table 4: Life Expectancy

	Mathematics		Reading		Essay		History	
	Est.	p-value	Est.	p-value	Est.	p-value	Est.	p-value
Female	2.8273	(0.0000)	2.8273	(0.0000)	2.8273	(0.0000)	2.8273	(0.0000)
GDP	0.0440	(0.3542)	0.0204	(0.6705)	0.0184	(0.7034)	0.0394	(0.4030)
GDP × GDP	-0.0014	(0.0182)	-0.0012	(0.0372)	-0.0012	(0.0371)	-0.0014	(0.0152)
Agric.	8.3755	(0.0010)	6.2233	(0.0118)	6.5864	(0.0090)	7.3135	(0.0030)
1888	6.2005	(0.0062)	3.9269	(0.0955)	5.1965	(0.0260)	5.3029	(0.0190)
1900	10.1915	(0.0000)	9.0822	(0.0002)	9.5888	(0.0001)	8.9400	(0.0002)
1910	13.3271	(0.0000)	12.1075	(0.0000)	12.3714	(0.0000)	11.9109	(0.0000)
1888 × Agric.	-6.4649	(0.0503)	-3.0227	(0.3776)	-4.9552	(0.1444)	-6.2746	(0.0561)
1900 × Agric.	-14.7603	(0.0000)	-13.6984	(0.0002)	-13.7272	(0.0002)	-14.5850	(0.0001)
1910 × Agric.	-21.5721	(0.0000)	-19.7394	(0.0000)	-19.6583	(0.0000)	-21.2832	(0.0000)
Urbaniz.	-0.0221	(0.2279)	-0.0302	(0.1091)	-0.0241	(0.2017)	-0.0356	(0.0567)
1888 × Urbaniz.	0.0012	(0.9624)	0.0156	(0.5423)	0.0046	(0.8570)	0.0058	(0.8150)
1900 × Urbaniz.	0.0206	(0.4313)	0.0263	(0.3246)	0.0232	(0.3876)	0.0340	(0.1967)
1910 × Urbaniz.	0.0624	(0.0202)	0.0689	(0.0117)	0.0677	(0.0141)	0.0788	(0.0036)
Height	0.3320	(0.0020)	0.3740	(0.0005)	0.3351	(0.0029)	0.2547	(0.0226)
Newspapers	0.5088	(0.7990)	1.3470	(0.5099)	1.9518	(0.3520)	0.1726	(0.9308)
Health Sector	0.0582	(0.0001)	0.0643	(0.0000)	0.0632	(0.0000)	0.0565	(0.0002)
Doctors	-0.0006	(0.0017)	-0.0004	(0.0260)	-0.0005	(0.0125)	-0.0007	(0.0003)
Midwives	-0.0331	(0.0079)	-0.0390	(0.0019)	-0.0432	(0.0006)	-0.0339	(0.0061)
Mathematics	-2.7862	(0.0000)						
Reading			-2.7787	(0.0000)				
Essay					-2.4657	(0.0001)		
History							-2.8039	(0.0000)
Constant	26.2917	(0.0000)	27.9562	(0.0000)	26.8419	(0.0000)	26.8996	(0.0000)
Observations		200		200		200		200
R^2		0.896		0.893		0.891		0.897

Table 5: Infant Mortality

	Mathematics		Reading		Essay		History	
	Est.	p-value	Est.	p-value	Est.	p-value	Est.	p-value
Female	-43.8795	(0.0000)	-43.8795	(0.0000)	-43.8795	(0.0000)	-43.8795	(0.0000)
GDP	0.5932	(0.4297)	0.8058	(0.2806)	0.8264	(0.2699)	0.6442	(0.3907)
GDP × GDP	-0.0011	(0.9066)	-0.0024	(0.7971)	-0.0022	(0.8118)	-0.0009	(0.9221)
Agric.	-69.4837	(0.0810)	-52.2065	(0.1725)	-56.6706	(0.1437)	-58.5262	(0.1320)
1888	-67.8547	(0.0569)	-44.0300	(0.2296)	-56.5876	(0.1161)	-60.3833	(0.0919)
1900	-115.7687	(0.0021)	-104.2105	(0.0057)	-109.1571	(0.0038)	-105.1597	(0.0054)
1910	-143.4706	(0.0004)	-131.4756	(0.0011)	-133.9995	(0.0009)	-131.1832	(0.0012)
1888 × Agric.	69.7802	(0.1802)	34.2674	(0.5209)	53.5475	(0.3075)	68.2138	(0.1906)
1900 × Agric.	155.6752	(0.0061)	147.7407	(0.0087)	148.5110	(0.0086)	153.0107	(0.0069)
1910 × Agric.	210.8456	(0.0011)	196.6726	(0.0021)	196.4771	(0.0022)	206.5506	(0.0014)
Urbaniz.	0.3136	(0.2792)	0.4065	(0.1666)	0.3464	(0.2350)	0.4248	(0.1519)
1888 × Urbaniz.	-0.2249	(0.5664)	-0.3826	(0.3375)	-0.2736	(0.4879)	-0.2604	(0.5083)
1900 × Urbaniz.	-0.1554	(0.7071)	-0.2221	(0.5925)	-0.1940	(0.6404)	-0.2663	(0.5243)
1910 × Urbaniz.	-0.5732	(0.1753)	-0.6409	(0.1301)	-0.6310	(0.1371)	-0.7125	(0.0953)
Height	-5.1821	(0.0023)	-5.3812	(0.0013)	-4.9172	(0.0048)	-4.6134	(0.0096)
Newspapers	18.5853	(0.5567)	9.4453	(0.7668)	2.5699	(0.9368)	21.6600	(0.4934)
Health sector	-0.0539	(0.8167)	-0.0855	(0.7081)	-0.0660	(0.7764)	-0.0523	(0.8229)
Doctors	0.0123	(0.0001)	0.0106	(0.0007)	0.0111	(0.0004)	0.0131	(0.0000)
Midwives	0.7974	(0.0001)	0.8461	(0.0000)	0.8897	(0.0000)	0.8090	(0.0000)
Mathematics	25.1325	(0.0046)						
Reading			28.5513	(0.0036)				
Essay					26.2085	(0.0063)		
History							23.9100	(0.0056)
Constant	421.2927	(0.0000)	406.7812	(0.0000)	418.7685	(0.0000)	415.0895	(0.0000)
Observations		200		200		200		200
R^2		0.809		0.809		0.808		0.808