The effects of the generalized use of iodized salt on occupational patterns in Switzerland

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Abstract

I examine the impact of the successful salt iodization campaign in Switzerland in the 1920s and 1930s on occupational patterns. Iodized salt eradicated mental retardation inflicted in utero by lack of iodine. By exploiting variation in pre-existing conditions and in the timing of the intervention I show that cohorts born in previously highly deficient areas after the introduction of iodized salt self-selected into higher-paying occupations. I also find that occupational characteristics in treated areas changed, and that cohorts born after the intervention engaged to a higher degree in occupations with higher cognitive demands.

JEL classification: I12, I18, J24, N34
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1 Introduction

Nutrition is inextricably linked to a population's health capital. Malnutrition, especially when it occurs early in life, can have serious detrimental effects on a person's lifetime productivity and economic prospects. Micronutrient deficiencies are a common source of malnutrition, caused by insufficient intake of necessary vitamins and minerals. Iodine is one such micronutrient.

Lack of iodine causes many disorders, the most common of which is an enlargement of the thyroid gland, when there is not enough iodine for the production of hormones which regulate metabolism. This enlargement is called a goiter. Other symptoms include short stature and deaf-mutism. However, the most catastrophic consequence of iodine deficiency is brain damage, which is irreversible and can go unnoticed in a population. Iodine deficiency results in various degrees of mental underdevelopment when it occurs in utero and the first three months of life. Cretinism, which is an acute form of mental retardation, often coupled with goiter and deaf-mutism, occurs when iodine deficiency in utero is most severe.

Iodine deficiency is the leading cause of preventable mental retardation in the world today. The WHO estimates that nearly 50 million people suffer some degree of mental impairment due to a lack of iodine in their diets[1]. According to WHO's Global Database on Iodine Deficiency, more than 285 million children receive inadequate amounts of iodine in their diet [2]. Despite efforts to decrease the prevalence of iodine deficiency in the 1990s, there are still 38 million children born annually at the risk of developing iodine deficiency disorders. The most vulnerable areas in the world are South Asia and Central and Eastern Europe (UNICEF 2008).

Although iodine deficiency is eradicated in developed countries today, the picture looked quite different in early 20th century. Many countries, for reasons related to their geography, had "pockets" of endemic iodine deficiency within their boundaries. For example, in the USA

[1]Source: WHO, http://www.who.int/features/qa/17/en/index.html.
[2]Source: de Benoist, Andersson, Egli, Takkouche and Allen, eds (2004).

the area around the Great Lakes, as well as some Northwestern states had rates of iodine deficiency that were only paralleled by its prevalence in the Swiss Alps. Indeed, Switzerland was the worst-afflicted country in the world, because its soil has been stripped of its iodine content in many localities during the last Ice Age.

This paper estimates the effects of iodine deficiency eradication on occupational patterns using data from the 1970 Swiss Census. Switzerland was the first country in the world to introduce iodized salt in 1922. It was the first major nutritional intervention ever recorded. Iodized salt proved a cost-effective measure to eradicate endemic goiter, which is an enlargement of the thyroid gland, occurring when there is not enough iodine in the body. The invisible effects of iodine deficiency on mental development and cognitive ability were not fully understood at the time, and public health authorities did not know that they were fighting against mental retardation as well as endemic goiter. As a result of the country-wide iodization campaign there were no more endemic cretins born after 1930, deaf-mutism rates dropped significantly, and goiter disappeared in children and young recruits (Bürgi, Supersaxo and Selz 1990). Salt iodization also had a significant impact on graduation rates of those born in highly-deficient areas (Politi 2009). In this paper I find that occupational patterns in previously-deficient areas changed too, reflecting a shift towards higher-paying occupations and occupations with a lower physical- and a higher cognitive-skills component.

I combine data from the comprehensive 1970 Swiss Census with data on occupational characteristics. I identify the effect of iodization on occupational patterns by exploiting variation in pre-existing prevalence of iodine deficiency, and also differences in the timing of adoption of iodized salt across localities. I also use a fuzzy regression discontinuity design, where I identify the effect of iodization by looking at sudden jumps in iodized salt sales, and then compare occupational outcomes for cohorts born right before and right after the jump. Overall, I find that iodine deficiency eradication pushed cohorts affected by it towards higher-paying occupations, and occupations with higher cognitive demands. My estimates imply that more than 60% of the shift towards higher-paying occupations that took place in high-goiter areas over the period of examination is due to the eradication of iodine deficiency.

The economics literature has made important contributions in the study of the "fetal origins hypothesis", the idea that conditions in utero matter for health outcomes later in life (see Almond and Currie (2011) for a very good review of that literature). These contributions consist not just of introducing methodological improvements, but also of expanding on the set of outcomes that have been shown to be affected by health investments in utero. The outcomes studied by economists have often centered on education (years of schooling, graduation rates, test scores, absenteeism). There are fewer studies which look at longer-term effects, stretching beyond schooling ages. This paper contributes to closing this gap, by looking at longer term outcomes such as occupational choice.

The rest of the paper is organized as follows: Section 2 provides some background on iodine deficiency disorders and briefly describes the campaign for salt iodization in Switzerland. Section 3 describes the data used to define the sources of variation for my identification. Section 4 describes the Swiss Census microdata, as well as the occupational variables used to identify the effect of iodization on occupations. Section 5 outlines my identification strategy, and empirical results are presented in sections 6 and 7. Section 8 concludes.

2 Background on Iodine Deficiency Disorders and the Swiss Iodization Campaign

Iodine, together with Iron and Vitamin A, is a necessary micronutrient, found in very small quantities in the human body. Most of the body's iodine is located in the thyroid gland. Iodine is essential in the synthesis of the two thyroid hormones which regulate metabolism and "play a determining part in early growth and development of most organs, especially of the brain" (Delange 2001).

When the thyroid does not receive sufficient amounts of iodine it adapts by enlarging in order to maximize the use of available iodine. This enlargement is called a goiter, and it is one of the many symptoms of iodine deficiency. Goiters can occur at any point in one's lifetime, whenever the iodine intake is not sufficient. Some goiters are reversible, especially in young individuals. Reversing goiter in adults is harder, especially when they have been subject to iodine deficiency for many years.

Goiter is a visible effect of iodine deficiency. Apart from goiter, however, iodine deficiency can have irreversible and harder to observe consequences if it occurs in utero and in the first three months of life. Iodine deficiency in utero results in various degrees of mental retardation and abnormal brain development, which might even go undetected in a population. Severe iodine deficiency can cause cretinism, an acute condition characterized by a combination of mental retardation, stunting and physical deformation. Bleichrodt and Born (1994) estimate that the average IQ of iodine-deficient groups is 13.5 points lower than that of non-deficient groups[3]. If this is true, then iodine deficiency should have sizable economic effects for any afflicted population. It is this intelligence-enhancing aspect of correcting iodine deficiency that is at the heart of this paper.

Endemic goiter and endemic cretinism are primarily due to the geographic location of a population. The main store of iodine is the ocean. As ocean water evaporates, iodine falls on the upper layers of soil through rainfall. Therefore, geographic areas close to the ocean are naturally rich in iodine. On the contrary, regions subject to heavy rain or intense glaciation in the past may be iodine-poor due to soil erosion. It takes thousands of years for rain water to replenish the superficial layers of soil with iodine, so the iodine content of the soil and water of those regions is extremely low. Regions naturally poor in iodine include mountainous areas such as the Andes, the Alps, the Pyrenees, and the Himalayas (Koutras, Matovinovic and Vought 1980).

Due to its geography and geological history, Switzerland was known for its high prevalence of goiter and cretinism since ancient times (Roman writers mentioned it in their works). During Napoleonic Wars, the low performance of Swiss recruits for the French Army troubled

[3]This estimate is based on a meta-analysis of 21 studies of the effect of iodine deficiency on cognitive ability.

Napoleon and the local authorities in today's canton of Valais. Under Napoleon's orders, a survey was conducted, which showed an extremely high prevalence of cretinism in the population (Bürgi et al. 1990). Further studies revealed that Switzerland had a much higher rate of goiter and cretinism than any of its neighboring countries (Italy, France, Germany).

As a result of all the studies showing the extent of the goiter problem, a Swiss Committee for the study of goiter was established in 1907. At that time, goiter was still attributed to some agent in the drinking water, even though experiments with iodine supplementation for the treatment of goiter were already taking place in France and, later, in the USA. Right before his death in 1917, Theodor Kocher, a prominent Professor of surgery in Bern and Nobel laureate for his work on the thyroid gland, advocated the treatment of goiter with small doses of iodine (Bürgi et al. 1990).

Iodine has been explicitly used in the treatment of goiter ever since Bernard Courtois isolated it as an element in 1811[4]. The idea that endemic goiter is due to iodine deficiency was first put forward in 1846, by Jean-Louis Prévost and A.C. Maffoni (Prévost and Maffoni 1846). Swiss data on goiter prevalence confirmed the link between iodine deficiency and goiter prevalence: the canton of Ticino ranked the lowest among cantons in goiter prevalence. Ticino, located in the southernmost part of Switzerland, bordered Italy and enjoyed a milder climate, proximity to the Mediterranean Sea and possibly more iodine-rich foods coming from Italy than the rest of the country. Another canton with unusually low goiter prevalence was Vaud. Historically, Vaud had an exclusive salt mine, which was rich in iodine (Bürgi et al. 1990, p.581). The naturally occurring high iodine content of the salt produced in Vaud would explain the low goiter prevalence in that canton.

Thus, by the time iodized salt became widely available, medical science had established a link between iodine deficiency and endemic goiter. However, the crucial role of iodine in mental development was not understood until more than a century later. When large-scale interventions of iodine supplementation took place around the 1920s and after, the objective

[4]However, iodine-rich foods and plants, such as seaweed, were used by ancient civilizations, such as the Chinese and the Greeks, to treat the swelling of the neck before the isolation of iodine as an element.

was goiter eradication. People did not know that they were also fighting against mental retardation.

Iodized salt started circulating in Switzerland in 1922. Almost simultaneously, fortification of salt with iodine began in the USA, where iodized salt first appeared in 1924. Both interventions eliminated endemic cretinism and goiter in children, and they decreased goiter prevalence in adults, even though they were followed by an initial spike in goiter-related surgeries and deaths, which then subsided[5]. In fact, after doctors started prescribing iodide to their patients in order to fight goiter, toxic side-effects resulting from over-dosing triggered opposition to the universal use of iodine. These large-scale nutritional interventions, the first of their kind on both sides of the Atlantic ocean, were not without controversy.

The first Swiss canton to provide iodized salt was Appenzell-Ausserrhoden. Iodization there started in February 1922, with the initiative of a local doctor, H. Eggenberger. In June 1922, the Swiss Goiter Committee recommended the addition of small amounts of iodine in salt and the additional weekly consumption of iodine tablets by schoolchildren. In November 1922, the Swiss salt monopoly [United Swiss Rhine Salt Works (USRSW)[6]] started adding iodine to salt and selling the new product at the same price as non-iodized salt. Even before that date, though, iodine prophylaxis had become popular by means of tablets or other supplements. After the recommendations of the Swiss Goiter Committee and the success of salt iodization in Appenzell-Ausserrhoden, the other cantons started allowing the sale of iodized salt in their markets.

Not all cantons introduced iodized salt simultaneously, though. For instance, Valais iodized in 1925, Zürich in 1932 and Bern in 1936[7]. On the other hand, Aargau and Basel-Land didn't iodize until 1952 and 1950 respectively. In 1925 fewer than one fourth of cantons

[5]This adverse consequence of iodine supplementation was due to the existence of nodular goiters in the population. Nodular goiters were caused by chronic iodine deficiency. Nodular goiters may become toxic following a sudden increase in iodine intake after a long period of deprivation. This side-effect of iodization is known as iodine-induced hyperthyroidism).

[6]USRSW was "the exclusive supplier of salt to 24 of the 25 cantons" of Switzerland, the exception being the canton of Vaud (Bürgi et al. 1990, p.582).

[7]This is the first year that the cantons' iodized sales exceeded 40% of total salt sales.

had iodized salt sales that exceeded 60% of total salt sales. By 1945 fewer than one fourth of cantons had salt sales that were below 20% of total salt sales. By 1955, iodized salt sales exceeded 60% of total salt sales in all cantons, and in many of them only iodized salt was sold and consumed (Wespi 1962).

The success of the iodization program was indisputable. According to Bürgi et al. (1990), "no new endemic cretins born after 1930 have been identified" (p.577). Deaf-mutism rates fell sharply for cohorts born after 1922. In Appenzell-Ausserrhoden, which was the first canton to provide iodized salt to its inhabitants, the prevalence of goiter in newborns fell from 20% to 6.4% within the first year after iodization. The prevalence dropped further when, in later years, the iodine content of salt was raised. In the city of Lausanne, 23.7% of young recruits had large goiters in 1924/1925, but the figure had dropped to 0.2% by 1983-1987 (Bürgi et al. 1990)[8].

3 Data Description: Bircher's monograph and Iodized Salt Sales

To identify the effect of iodization on occupational outcomes, I employ two sources of variation: the first is the naturally-occurring geographical variation in underlying iodine deficiency prior to the generalized use of iodized salt. The second source of variation arises because of differences in the timing of adoption of iodized salt across Swiss localities.

In 1883, Swiss physician Heinrich Bircher published a monograph with details on the geographic variation in goiter rates across Switzerland (Bircher 1883). Over the period 1875-1880, he toured every town and village in Switzerland and recorded goiter cases in recruits, which served as a proxy for goiter prevalence in the local population. Bircher's monograph was eye-opening to public health authorities at the time, because it showed the

[8]For more information on iodine deficiency disorders and their eradication in Switzerland, see Politi (2009).

extent of the problem across the country, and also the big variation in goiter prevalence, even among villages within a short distance from each other. The data correlates well with separate measurements of iodine content of the water and soil across Swiss localities, as well as other goiter studies that were done on the population of specific locations. It is superior to other sources of information on iodine content or goiter prevalence in Switzerland, because it is comprehensive and consistent, since all measurements were taken by the same individual in roughly the same period, and cover all of Switzerland.

I use the data collected by Bircher to group Swiss districts according to their goiter prevalence. Goiter prevalence serves as a proxy for underlying iodine deficiency in the population. I classify a district as being "high-goiter" if it belongs to the top 25% of the population-weighted goiter distribution. This corresponds to districts where goiter prevalence was 11.7% or higher. Correspondingly, a district is "low-goiter" if its goiter prevalence is within the lowest 25% of the goiter distribution in the population, corresponding to goiter rates lower than 3.5%. High-goiter districts are where I expect to observe the treatment effect of iodization. On the contrary, I expect the treatment effect to be much lower in low-goiter districts.

After iodized salt became available in 1922, it was not adopted at the same time or speed by all cantons. Some cantons, such as Nidwalden and Schaffhausen, were early adopters, whereas other cantons, such as Aargau, Basel-Stadt, and Basel-Land were much slower. The sale of iodized salt had to be approved and allowed by each canton's constitution. In 1962 H. J. Wespi, M.D. and Chief Doctor of Women's Clinic in Aarau, published a paper containing data on yearly iodized salt sales as a percentage of total salt sales per canton, from 1922 to 1961 (Wespi 1962). These data, part of which are displayed in Table 1A-1, show how widespread the use of the "new salt" was at any point in time.

Some cantons, such as Schwyz and Luzern made a very fast transition to iodized salt, whereas for other cantons, such as Thurgau and Graubünden, the transition was much more gradual. It appears that low-goiter cantons were the ones that adopted iodized salt earlier than highly-affected cantons. This reluctance from the part of those most likely to benefit from the intervention is puzzling at first. However, one needs to take into account that this was the first major nutritional intervention to ever take place, and it was not without controversy, especially in light of many thyroid-related deaths resulting from iodine overdoses to people who had been severely deficient throughout their lives. Cantons where the stakes were higher are likely to be the ones where the transition took the longer to finally occur, since public debate on the issue would have been more heated.

I use the data contained in Wespi's paper as a measure of treatment. In addition, based on Wespi's data I construct a variable corresponding to one's age relative to iodization in their canton of birth. In particular, I identify jumps in the sales of iodized salt, and I look at individuals' occupational choice outcomes, comparing those born right before and right after the jump in sales. Most cantons had a steep transition to iodized salt[9] In Table 1A-1, the years that correspond to a jump in sales of iodized salt are highlighted for most cantons. There are a few cantons, namely Aargau, Basel-Land and Basel-Stadt, where sales of iodized salt did not jump within the period of examination.

4 Data Description: The 1970 Swiss Census and Dictionary of Occupational Titles

I identify the effect of iodization on occupational choice using microdata from the 1970 Swiss Census (Federal Statistical Office 1970), which includes detailed information on a person's year and location of birth. Switzerland is a federation made up of 26 cantons, 184 districts and 2896 municipalities. The 1970 Swiss Census records an individual's municipality of birth. This low level of aggregation is particularly important, because endemic iodine deficiency was a very localized phenomenon, and it depended on the iodine content of a population's local sources of food and water. Municipalities within a short distance of each other might have

[9] For more information on Bircher's monograph and on the geographic variation of goiter prevalence, as well as on the iodized salt sales data, and how iodized salt adoption coincides with a drop in deaf-mutism rates, see Politi (2009).

Table 1: Actively employed individuals in 1970 Swiss Census, cohorts born 1905-1945

	Employed	**Unemployed**	**Non-active**	**Total**
Males	1,141,642	1,742	51,084	1,194,468
Females	477,039	923	749,163	1,227,125
Total	1,618,681	2,665	800,247	2,421,593

Source: 1970 Swiss Census

had very different exposure to iodine before iodized salt was introduced, so it is important to know in as much detail as possible the location of one's birth.

I look at all individuals born in Switzerland from 1905 to 1945 (inclusive) whose occupation is recorded in the Swiss Census. Unfortunately, occupation is only recorded for people actively employed (both part- and full-time) at the time of the Census. This excludes most women in my sample, which is why the results which follow focus on males. Table 1 shows that less than 39% of females were active in the labor force in 1970. On the contrary, out of 1,194,468 males born in the period 1905-1945, 95.5% were active in 1970.

The 1970 Swiss Census contains detailed information on each individual's occupation, using 4-digit codes according to the International Standard Classification of Occupations (ISCO). Using these data, I group individuals into 9 broad occupation categories, according to the first digit of their ISCO code. The distribution of each occupational category in the population according to the 1970 Census (for people born in Switzerland in the period 1905-1945) can be seen in Table 2. I then divide observations among three broad occupational groups, and run a multinomial logit model of occupational choice based on one's location and year of birth. The first group corresponds to the top three occupational categories, the second group to the next four, and the third group to the last two. The occupational categories in the first group include individuals employed in executive and managerial positions, senior officials and legislators, professionals such as physicians, engineers and lawyers, as well as technicians and associate professionals such as police inspectors, trade brokers, and health

Table 2: Broad occupational categories in 1970 Swiss Census, cohorts born 1905-1945

	Occupational Category	**Males**	**Females**	**Total**
High-paying occupations	1: Legislators, senior officials, managers	83,833	19,816	103,649
	2: Professionals	78,508	19,242	97,750
	3: Technicians and Associate Professionals	171,644	56,848	228,492
	4: Clerks	158,118	123,304	281,422
	5: Service, shop and market sales workers	48,612	104,641	153,253
	6: Skilled agricultural and fishery workers	115,300	40,282	155,582
	7: Craft and related trades workers	312,020	52,485	364,505
	8: Plant/machine operators and assemblers	123,306	18,407	141,713
	9: Elementary Occupations	50,301	42,014	92,315
	Total	1,141,642	477,039	1,618,681

Source: 1970 Swiss Census

associates. These occupational categories have earned higher wages historically, compared to the other categories of occupations in the data. For example, in the second trimester of 2007, the annualized median income of full-time workers in these top categories was over 84,000 Swiss Franks or more, whereas the corresponding number for all other occupation categories was less than 65,000 Swiss Franks (Communication from the Swiss Federal Statistical Office). Occupational categories in the second group include clerks, service and shop sales workers, skilled agricultural workers, as well as craft and related trades workers. The third group includes low-status, low-earnings and low-skill occupations such as machine operators and elementary occupations such as street vendors, cleaners, and unskilled laborers. According to Table 2, 26.5% of individuals (29.3% of males) are employed in the first group of occupations, which corresponds to the three higher-paying occupational categories.

Table 3: Job characteristics for occupational categories in 1970 Swiss Census

ISCO category	**Manual Dexterity**	**Motor Coordination**	**Physical Demands**	**Strength**	**Spatial Aptitude**	**Numerical Aptitude**	**Verbal Aptitude**	**Intelligence**
1	2.2052	2.1933	0.7502	1.7039	2.3255	3.1489	3.7353	2.8395
	(0.0680)	(0.0557)	(0.2306)	(0.1341)	(0.1013)	(0.0665)	(0.0779)	(0.0881)
2	2.5256	2.4086	1.0425	1.7536	3.1514	3.7347	4.3509	3.4330
	(0.5371)	(0.3076)	(0.6282)	(0.3077)	(0.6944)	(0.4738)	(0.2069)	(0.2345)
3	2.5544	2.5896	1.3572	1.8623	2.6859	3.1512	3.5000	2.6139
	(0.4548)	(0.3985)	(0.7021)	(0.3315)	(0.5859)	(0.3687)	(0.3124)	(0.2569)
4	2.6782	3.0950	1.7675	1.5043	2.2449	2.6962	3.1454	2.1783
	(0.0961)	(0.4348)	(0.2062)	(0.4200)	(0.129)	(0.1324)	(0.0909)	(0.0719)
5	2.5622	2.5112	1.4389	2.2582	2.3215	2.6254	2.8821	1.9442
	(0.1734)	(0.2752)	(0.3600)	(0.2722)	(0.2453)	(0.3455)	(0.2330)	(0.2058)
6	2.5081	2.2774	3.0692	3.4742	3.0425	2.6244	2.7457	2.2911
	(0.0653)	(0.0633)	(0.1572)	(0.0812)	(0.1222)	(0.1009)	(0.0624)	(0.1289)
7	3.2093	2.8661	2.6782	2.8385	3.1094	2.6329	2.7408	1.9864
	(0.2143)	(0.0818)	(0.5528)	(0.3927)	(0.3124)	(0.1953)	(0.1531)	(0.0980)
8	2.8371	2.7467	2.0387	2.6882	2.6209	2.3042	2.5312	1.7804
	(0.0898)	(0.1407)	(0.1684)	(0.2429)	(0.1900)	(0.2146)	(0.2015)	(0.2091)
9	2.9034	2.4706	2.3261	3.1635	2.4313	2.1324	2.3319	1.5312
	(0.0554)	(0.1305)	(0.2928)	(0.2992)	(0.0934)	(0.1665)	(0.1096)	(0.1009)
Total	2.7578	2.6830	2.0061	2.3790	2.7014	2.7381	3.0214	2.2071
	(0.3795)	(0.8017)	(0.7382)	(0.7382)	(0.4879)	(0.4460)	(0.5258)	(0.4714)

Source: 1970 Swiss Census and England and Kilbourne (1988)

I combine the occupational data of the 1970 Swiss Census with data on occupational characteristics compiled by Paula England and Barbara Kilbourne from the Dictionary of Occupational Titles for 1980 US Census Detailed Occupations (England and Kilbourne 1988)[10]. These data contain scores on a variety of characteristics for all occupational codes used in the 1980 US Census. For example, occupations get scores according to verbal, numerical, spatial, and other aptitudes needed to perform the job, as well as the physical demands of the job.

In order to match occupational characteristics to occupations listed in the 1970 Census, I first match occupational codes from the 1980 US Census with ISCO codes, which are used in the coding of occupations in the Swiss Census. For many four-digit ISCO categories there were either no entries or no direct correspondence with US Occupational codes, so I aggregate ISCO codes to three-digit categories, and compute the average value of each characteristic in each category. I end up with 108 distinct occupations, and there are eight characteristics matched to each occupation.

I look into occupational characteristics which broadly correspond to various physical and cognitive demands of occupations (following the methodology of Case and Paxson (2006).). The variables corresponding to physical requirements are manual dexterity, motor coordination, physical demands (such as climbing, kneeling, and reaching), and strength. The variables related to the cognitive requirements of a given occupation are spatial, verbal, and numerical aptitude, as well as intelligence. As in Case and Paxson (2006), in some cases I reverse-coded some of these variables, in a way that a higher value corresponds to higher requirements for a given characteristic in an occupation. Values for each characteristic typically range from 1 to 5, except in the case of physical demands, which ranges from 0 to 4, and motor coordination and intelligence, which range from 1 to 4.

As expected, cognitive requirements such as verbal and numerical aptitude tend to have higher values for occupations in upper ISCO categories (1, 2, 3), whereas the opposite is

[10] The dataset is available in electronic format and freely distributed by the Inter-university Consortium for Political and Social Research (ICPSR).

true for physical requirements such as manual dexterity and strength. This is shown in table 3, which lists average scores and standard deviations for each job characteristic for each broad ISCO category in the Swiss Census. For example, legal professionals (a sub-category of ISCO category 2, which includes lawyers and judges) have really high scores for numerical and verbal aptitude (4.2 and 4.4 respectively). On the contrary, this occupational category only has a score of 0.4 for physical demands, and 1.2 for strength. On the other hand, agricultural laborers (part of ISCO category 9) have scores of 2 and 2.2 for numerical and verbal aptitude, whereas they have scores of 2.9 and 3.5 for physical demands and strength.

These occupational characteristics are, as one would expect, highly correlated with each other, so it is advisable to get a smaller set of variables or indices which aptly describe the cognitive and physical demands of each occupation. For this reason I conduct factor analysis on all eight occupational characteristics, in order to capture the main underlying dimensions over which occupations differ from each other. This exercise delivers two factors with eigenvalues higher than 1[11]. These first two principal components resulting from factor analysis correspond to two indices for each occupation, and they correspond to linear combinations of the occupational characteristics listed above. These two indices summarize the cognitive and physical demands for each occupation. I use these two indices instead of using all eight characteristics listed above.

Tables 4 and 5 show the results of the factor analysis. I use principal components factoring and rotate the factor loadings so that, by construction, the two factors are not correlated with each other. The two factors together capture 81.6% of the total variance observed across 108 occupational categories in eight occupational characteristics. Table 4 shows the correlation of each characteristic with each of the two factors, as well as the idiosyncratic variance of each characteristic, which is not shared with the other variables (uniqueness). Factor 1 is defined by characteristics such as intelligence and verbal aptitude, whereas it is negatively correlated with characteristics such as strength and physical demands. Hence,

[11] According to the Kaiser criterion in factor analysis, factors with eigenvalues equal or higher to 1 should be retained.

Table 4: Factor Analysis on Occupational Characteristics: Factor Loadings

Characteristic	Factor 1: Cognitive Demands	Factor 2: Physical Demands	Uniqueness
Intelligence	0.9561	-0.0646	0.0816
Verbal Aptitude	0.9541	-0.1672	0.0617
Numerical Aptitude	0.9431	0.0400	0.1090
Spatial Aptitude	0.4227	0.8067	0.1706
Strength	-0.7662	0.3412	0.2966
Physical Demands	-0.5658	0.7050	0.1829
Motor Coordination	-0.1063	0.7664	0.4014
Manual Dexterity	-0.4334	0.8027	0.1678

Source: 1970 Swiss Census and England and Kilbourne (1988)

Table 5: Factor Analysis on Occupational Characteristics: Scoring Coefficients

Characteristic	Cognitive Demands	Physical Demands
Intelligence	0.25506	0.06846
Verbal Aptitude	0.24417	0.02389
Numerical Aptitude	0.26202	0.11235
Spatial Aptitude	0.19697	0.39150
Strength	−0.17521	0.07031
Physical Demands	−0.08371	0.24785
Motor coordination	0.04819	0.32073
Manual Dexterity	−0.03764	0.30347

Source: 1970 Swiss Census and England and Kilbourne (1988)

Table 6: Cognitive and Physical Demands Indices by Occupational Category in the 1970 Swiss Census

ISCO category	**Cognitive Demands**	**Physical Demands**
1	0.8000	-1.2448
	(0.1104)	(0.2855)
2	1.8331	0.2608
	(0.4169)	(1.5166)
3	0.8009	0.0000
	(0.3247)	(1.4090)
4	0.0893	-0.0185
	(0.1954)	(0.5601)
5	-0.2681	-0.3399
	(0.3878)	(0.5827)
6	-0.4313	0.4060
	(0.1487)	(0.1130)
7	-0.3214	1.4322
	(0.2937)	(0.5050)
8	-0.6242	0.3037
	(0.2382)	(0.3160)
9	-1.2139	-0.0268
	(0.2581)	(0.2090)
Total	0.0172	0.4382
	(0.7780)	(1.0518)

Source: 1970 Swiss Census and England and Kilbourne (1988)

it captures the cognitive demands of an occupation. On the contrary, Factor 2 is more heavily defined by characteristics pertaining to physical demands and is negatively correlated with intelligence and verbal aptitude. Note that spatial aptitude, although introduces as a "cognitive characteristic", also plays a significant role for Factor 2. I will henceforward refer to Factor 1 as "Cognitive Demands", whereas I will refer to Factor 2 as "Physical Demands".

Table 5 shows how each characteristic is used to create the two indices, one for the cognitive and one for the physical demands of each occupation. Each occupation gets a "score" for each factor, which is a linear combination of the occupational characteristics, each multiplied by the coefficients shown in Table 5. The cognitive index, as expected, places a big weight on cognitive characteristics, while it weighs physical demands negatively. The physical index, on the contrary, gives bigger emphasis on characteristics focusing on physical demands, although cognitive demands are also weighed positively, albeit with much smaller weights (with the exception of spatial aptitude). After I construct the two indices, I combine the data with the Swiss Census, so that each individual who is active in the labor force is matched with an index measuring the cognitive demands of his occupation, and another index measuring the physical demands. Table 6 shows summary statistics for the two occupational indices in the Swiss male population born in the period 1905-1975 and recorded in the 1970 Census. The two indices vary quite a bit within each singe-digit occupational categy, taking values ranging from -2.4 to 2.7.

5 Identification using geographical and temporal variation

The main idea behind the identification strategy is to use two sources of variation in order to identify the effect of iodization on occupational outcomes. The first source of variation is geographical; not all areas in Switzerland were affected by iodine deficiency to the same extent. What defined the prevalence of iodine deficiency in a locality was the iodine content of soil and drinking water, which in turn was determined by geological developments in that locality, which took place thousands of years before the period of study. Using Bircher's rich dataset, I am able to identify districts where the prevalence of goiter among recruits prior to iodization was very high, implying a high prevalence of underlying iodine deficiency in the population. I treat all districts where goiter rates are at the top 25% of the population-weighted goiter distribution as being high-goiter. These are the districts where goiter prevalence is 11% or higher.

I expect iodization to have a greater impact on the cognitive ability of those populations born in high-goiter districts compared to any effects measured for people born in low-goiter districts. Thus, people born in high-goiter districts constitute my treatment group, whereas people born in low-goiter districts make up the control group.

The second source of variation is temporal; once the salt monopoly started producing iodized salt, each canton had to authorize its sale by amending its constitution. As a result, the "new product" did not become available across all cantons at the same time. Therefore, people born after iodized salt was introduced constitute the treated population, whereas people born before iodization are a control group.

As discussed in section 3, a glance at the data shows that high-goiter cantons allowed the sale of iodized salt later, compared to low-goiter cantons. This might reflect reluctance from the part of the authorities in those cantons to introduce such a far-reaching public health measure, in light of the debate ignited by the spike in thyroid-related deaths following iodine overdose in some chronically deficient populations. The identifying assumption here is that the timing of iodization in each canton is not correlated with factors which might have affected an individual's occupational choice, other than cognitive ability.

The non-random nature of the difference in the timing of adoption is problematic for my identification strategy to the extent that it reflects time-variant unobserved differences between high- and low-goiter cantons, which affected the timing of adoption of iodized salt in the 1920s and 1930s, and also affected occupational patterns many years later, when the treated population entered the labor market. Although it seems unlikely that a common unobserved factor would affect both these outcomes, I do introduce a linear, canton-specific time trend in all specifications.

Combining the geographical and temporal sources of variation, the treatment group includes **people born in high-goiter districts after iodized salt was introduced**. On the contrary, people born in low-goiter districts, and people born before iodization form the control group.

5.1 Iodized salt sales and birth location

I introduce iodized salt sales in one's canton of birth one year prior to one's birth directly as a regressor, in a multinomial logit model of occupational choice. As outlined in section 4, the outcome is an occupation indicator variable taking three values: 1 for managerial, professional and technical professions (ISCO one-digit categories 1-3), 2 for clerical, sales, and skilled agricultural and fisheries positions (ISCO categories 4-7), and 3 for plant operators and assemblers, as well as elementary occupations such as street cleaners. The regressor of interest is the percentage of iodized salt sales in total salt sales one year prior to birth in one's canton of birth. I also control for canton and cohort fixed effects, to remove the effect of any omitted variables that are canton- or cohort-specific. In addition, I introduce a canton-specific time trend, to control for any other gradual changes that occurred at the canton level and might have affected one's occupational outcomes. I cluster standard errors at the canton of birth - year of birth level.

I also regress the two occupational characteristics indices outlined in section 4 on the same regressor and controls. In particular, I run the following regression for an individual i born in canton c in year y:

$index_{icy} = \alpha + \beta \cdot$ *Iodized salt 1 year prior to birth*$_{cy}$

$+$ *Canton of birth Fixed Effects*$_c$

$+$ *Canton of birth time trend*$_c$

$+$ *Cohort of Birth Fixed Effects*$_y$ $+\epsilon_{icy}$,

where standard errors are clustered at the canton-cohort level.

I estimate the above regression focusing on males, since, as noted above, the majority of females were not active in the labor force in this sample. My sample includes all males born in Switzerland between 1905 and 1945 (inclusive), for whom occupational data were recorded during the 1970 Census. This means that my results are conditional on being active in the labor market. As seen in Table 1, 96% of Swiss-born males born in that period are recorded as active in the labor market in my sample, so selection into employment does not seem important in this particular context. In any case, selection into employment would most likely introduce downwards bias to my estimates, if I assume that prior to the intervention severely deficient individuals might have opted out of the labor force, thus making the control group artificially healthier.

5.2 Jumps in iodized salt sales; a Fuzzy Regression Discontinuity Approach

I use Wespi's data on the percentage of iodized salt sales to get information on the timing and speed of iodization in each canton. Most cantons experienced a big jump in iodized salt sales within a period of 1 to 2 years, so that the timing of the intervention is easy to identify in the majority of cases. Appendix 1A-1 shows Wespi's data, and the years that are identified as "jump years" are highlighted. The probability of someone being treated with adequate iodine in utero changes discontinuously depending on whether they were born before or after the jump in sales. I use these jumps in a "fuzzy regression discontinuity" (FRD) framework (for a description of FRD see, for example, Imbens and Lemieux (2008)).

Based on the year of the jump in iodized salt sales, which is particular to each canton, I construct a new variable, age relative to iodization, which will be common across all people born in the same canton in the same year, but will generally be different across individuals born in the same year, but in different cantons. An individual born in a "jump year" has a relative age of 0. An individual is treated if their relative age is higher than 0.

Because of the difference in the timing of adoption, I can control for unobserved, time-invariant canton characteristics, as well as unobserved, space-invariant cohort characteristics, and a cantons-specific trend. Since these jumps all occurred in a small window of time, this method is "cleaner" than a simple regression of outcomes on iodized salt sales, as there are fewer possible confounding effects taking place within the same small time frame in a particular canton.

I check for some preliminary evidence of how being born in a high-goiter district right after a jump in iodized salt sales affects one's occupational outcomes in a linear probability model, after controlling for district and cohort of birth fixed effects, as well as a district-specific time trend.

I run the following regression for an individual i born in district d in year y:

$outcome_{idy} = \alpha + \beta \cdot$ *(Born in high-goiter district) X (Born after jump in sales of iodized salt)*$_{dy}$

+ *District of birth Fixed Effects*$_d$

+ *District of birth time trend*$_d$

+ *Cohort of birth Fixed Effects*$_{dy}$ $+\epsilon_{idy}$,

where outcomes are an indicator variable for being employed in a high-paying occupation (top 3 out of the 9 ISCO occupational categories), as well as the occupational indices described in section 4. Standard errors are clustered at the district-cohort of birth level. I first use all males born in Switzerland in the period 1905-1945, and then I focus on the sub-sample of those males born within ten years of the jump in iodized salt sales in their canton of birth. In some specifications I allow cohort fixed effects to vary across high- and low-goiter districts.

Next, I follow the FRD approach, and regress the above outcomes on the percentage of iodized salt sales (at the canton-level) one year prior to birth (and additional controls), but I instrument iodized salt sales with an indicator variable equal to 1 if someone is born after the big jump in sales which marked each canton's decisive transition to iodized salt.

I run the following regression for an individual i born in canton c in year y:

$outcome_{icy} = \alpha + \beta\cdot$ *Iodized salt 1 year prior to birth*$_{cy}$

+ *Trend before jump in iodized salt sales*$_{cy}$

+ *Trend after jump in iodized salt sales*$_{cy}$

+ *Canton of birth Fixed Effects*$_{c}$

+ *Canton of birth time trend*$_{c}$

+ *Cohort of Birth Fixed Effects*$_{y}$ $+\epsilon_{icy}$,

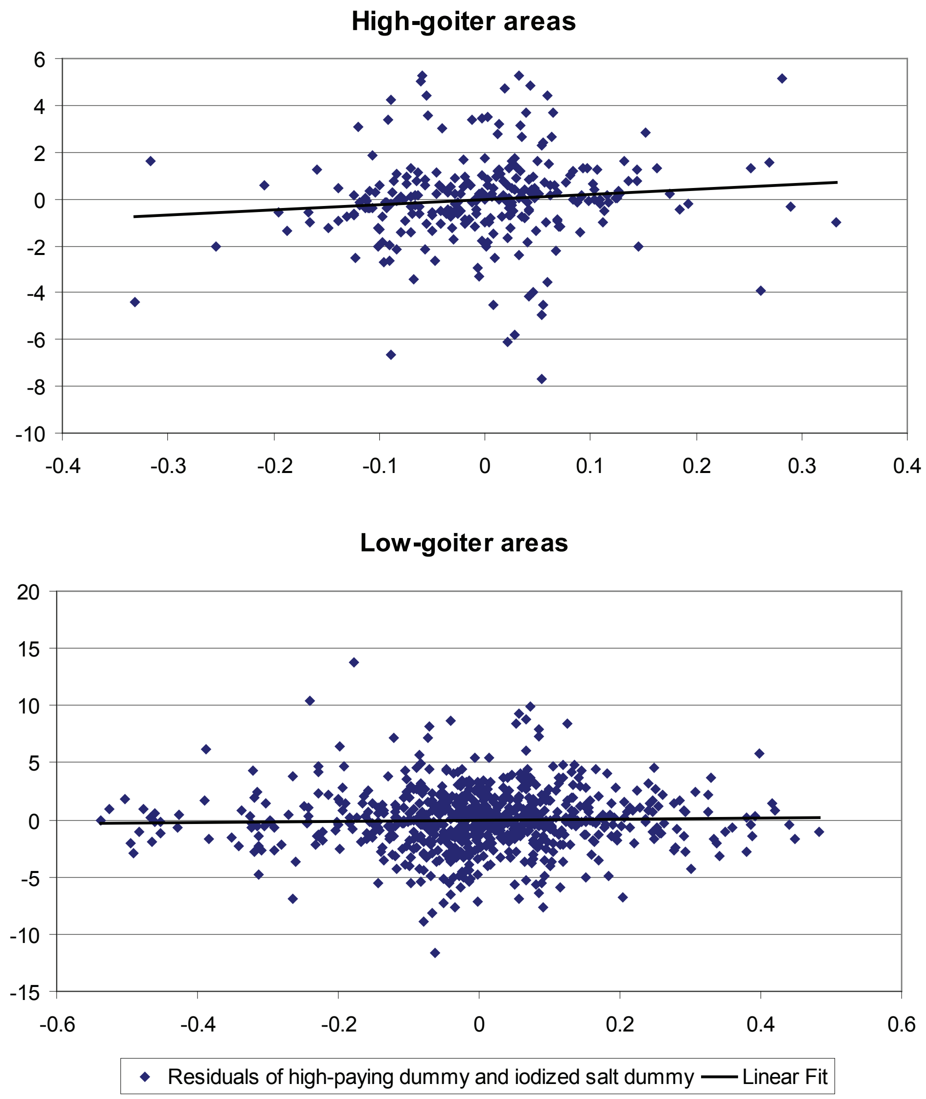
where $outcome_{icy}$ is either an indicator variable for being employed in a high-paying occupation (top 3 catogories in ISCO classification system), or one of the occupational indices described in section 4. Standard errors are clustered at the canton-cohort of birth level. I include both a linear canton-specific time trend, but also linear nationwide trends which are allowed to differ before and after the jump in iodized salt sales.

I estimate the treatment effect for males only. After estimating the effect for Switzerland as a whole, I use only those observations corresponding to high- and low-goiter districts, and estimate the effects of iodization separately by area.

6 The effect of Iodization on Occupational Choice

Figure 1 is a graphical representation of the regression results outlined later in this section. Figure 1 includes two scatterplots of average residuals (at the canton - year of birth level) from regressing a high-paying occupation dummy and iodized salt sales one year prior to birth on canton and cohort fixed effects, as well as a canton-specific linear trend. The first scatterplot comes from including only those individuals born in high-goiter districts, whereas the second one only includes people born in low-goiter districts. There are fewer observations in the first scatterplot because iodine deficiency was localized in certain parts of the country, so high-goiter districts are found in fewer cantons than low-goiter districts. As a result, when residuals are averaged at the canton - year of birth level, there are fewer observations.

Figure 1: Regression-adjusted residuals graph of high-paying dummy and iodized salt



(Source: 1970 Swiss Census and England and Kilbourne (1988))

What Figure 1 shows is that whereas regression-adjusted higher sales of iodized salt around one's time of birth are associated with a regression-adjusted higher probability of being employed in a high-paying occupation in the future, such a relationship does not exist for people born in low-goiter areas, where I expect the treatment effect to have been lower.

Table 7 displays results of a multinomial logit model of occupational choice, as outlined in sections 4 and 5.1. Such an empirical specification is consistent with Roy's model of

Table 7: Multinomial Logit model of occupational choice

	ALL AREAS	**HIGH-GOITER**	**LOW-GOITER**
High-income occupations	1.0474	1.2289***	1.0448
	(1.60)	(3.95)	(1.05)
Middle-income occupations	1.0173	1.1161***	1.0565
	(0.68)	(2.20)	(1.31)
Canton Fixed Effects	YES	YES	YES
Cohort Fixed Effects	YES	YES	YES
Canton trends	YES	YES	YES
Observations	1137706	286051	278590
Pseudo R^2	0.0147	0.0105	0.0166

Notes: * significant at 10% level; ** significant at 5% level; *** significant at 1% level; The table shows odds ratios of the coefficient on iodized salt in canton of birth 1 year prior to birth.; High-income category includes managers, professionals, technicians and associate professionals. Middle-income category includes clerks, service, shop and market sales workers, skilled agricultural and fishery workers, and craft and related trades workers. The reference category is low-income occupations, which includes plant and machine operators and assemblers, and elementary occupations.; The regression includes all Swiss-born males born in period 1905-1945 and recorded in 1970 Swiss Census.; High-goiter districts are those belonging to the top 25% of the population-weighted goiter distribution.; Low-goiter districts are those belonging to the bottom 25% of the population-weighted goiter distribution.; z-statistics in parentheses, standard errors clustered at the canton-year of birth level.

occupational choice (Roy 1951, Heckman and Honor 1990), where individuals self-select into occupations according to their comparative advantage. As seen in Table 7, if we look at Switzerland as a whole, there is little evidence that iodization affected occupational choice. However, as soon as we focus on those areas that were highly iodine deficient, hence treated by iodized salt, the results suggest that being born after iodized salt sales went from 0 to 100% of total salt sales increases one's odds of selecting into the top occupational group by almost 23%, and into the middle occupational group by 11.6%, relative to the bottom occupational group. No such effects are observed for those born in low-goiter districts, as expected, since those individuals would not have been affected by iodized salt.

Table 8 shows results from a differences in differences approach at the district level: A high-paying occupation indicator variable, corresponding to the top three ISCO occupational categories, is regressed on an indicator variable for being in the treatment group (which is the interaction of two indicator variables: being born in a high-goiter district, and being

Table 8: Occupational choice if born after jump in canton-level iodized salt sales in high-goiter district

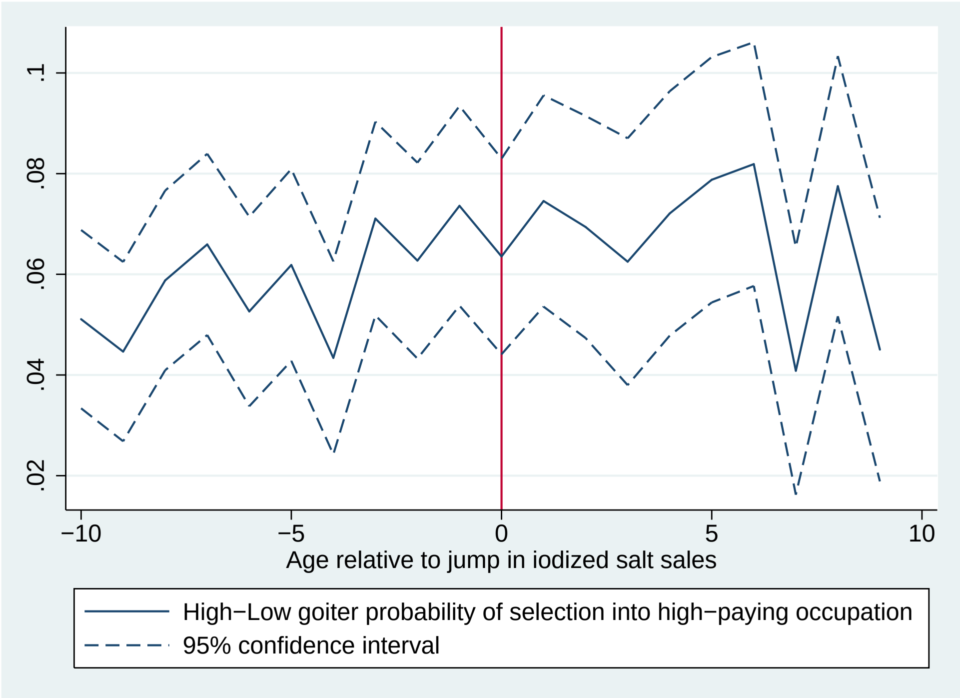
	All cohorts		**Born +/- 10 years from jump**	
	(1)	**(2)**	**(3)**	**(4)**
High-paying occupation dummy	1.5245***	1.2399***	1.2393**	1.3524**
	(0.3847)	(0.4722)	(0.5001)	(0.6042)
District-specific trend	YES	YES	YES	YES
Number of Observations	1141642	1141642	508566	508566
R^2	0.0422	0.0423	0.0416	0.0416
High-paying occupation dummy	1.2366***	0.9286**	1.3864***	0.9102*
	(0.3521)	(0.4358)	(0.3718)	(0.5479)
District-specific trend	NO	NO	NO	NO
Number of Observations	1141642	1141642	508566	508566
R^2	0.0419	0.0419	0.0411	0.0412

Notes: * significant at 10% level; ** significant at 5% level; *** significant at 1% level; Coefficients correspond to changes in percentage points in the probability of being employed in the top three occupational categories if one was born in a high-goiter canton after a jump in iodized salt sales.; Columns (1) and (3) assume common cohort fixed effects for high- and non-high-goiter districts.; Columns (2) and (4) assume different cohort fixed effects for high- and non-high-goiter districts.; All regressions include district and cohort of birth fixed effects.; Standard errors in parentheses, clustered at the district-year of birth level.

born after a jump in iodized salt sales). The regression also includes district fixed effects, a district-specific time trend (in some specifications), as well as year of birth fixed effects, which in columns (1) and (3) are the same for high-goiter districts and the rest of the country, but which are allowed to be different for high-goiter districts in columns (2) and (4). Standard errors are clustered at the district-year of birth level. Columns (1) and (2) include the whole sample, whereas columns (3) and (4) only include people born within 10 years of the jump in iodized salt sales. As shown on table 8, the gain in percentage points for males here is of the order of 1.2 to 1.5 percentage points if we include a district-specific trend, whereas is it slightly smaller if we do not include a trend. Given that not quite 30% of the population is employed in the top occupational group in our period of examination, this increase is economically significant.

Figure 2 is a plot of the regression-adjusted difference in probabilities of being employed in

Figure 2: Regression-adjusted probability of being employed in a highly-paid occupation by age relative to iodization; difference between high- and low-goiter districts



(Source: 1970 Swiss Census and England and Kilbourne (1988))

a high-paying occupation for people born in high- and low-goiter districts against age relative to iodization. The line represents the difference in coefficients on relative age indicator variables between those born in high- and low-goiter areas, after factoring out canton and cohort fixed effects, as well as a canton-specific trend. It is the regression equivalent of the "Fuzzy Regression Discontinuity" approach, the results of which are shown on Table 9 (A short description of the FRD method can be found in section 5.2). Contrary to Table 9, the results of which are largely in accordance with those of Tables 7 and 8, Figure 2 is subtle and does not show a clear-cut "jump" in the probability of selecting into a high-paying occupation at exactly year 0. It is, however, useful to keep in mind that the transition to iodized salt happened at the same time as a countrywide health campaign in favour of iodine supplementation, and it is possible that pregnant women had access to iodine tablets even before iodized salt became widely consumed in their canton of residence. In other words, it is possible the the jump in the probability that one was treated with iodine in utero happened before the jump in iodized salt sales. This would explain the jump that seems to occur a few years before the jump in iodized salt sales in Figure 2.

Table 9 presents the fuzzy regression discontinuity results. According to table 9, when looking at the country as a whole, iodization seems to not have had much of an effect on people's occupational choice. But the intra-region difference becomes clear when one looks separately at males born in high- and low-goiter districts. Those born in high-goiter districts after a jump in iodized salt sales had a higher and significant probability of being employed in a high-paying occupation. The increase in the probability is of the order of 2.8 to 3.1 percentage points, which is economically significant, given the baseline probability of being employed in the top occupational categories (less than 30%).

These estimates in Table 9 are double in magnitude compared to the results of Table 8. The reason for this discrepancy might be that the differences in differences results of Table 8 are estimated at the district level, instead of the canton level, which is more demanding of the data in terms of fixed effects variables. Another reason might be that the specification estimated in Table 8 uses a much "coarser" source of variation, which comes from the interaction of two indicator variables, whereas the regression results presented in Table 9 use the level of iodized salt sales 1 year prior to birth (instrumented by a pre-post jump indicator variable), which naturally displays greater variation in the sample.

In high-goiter areas, the percentage of males employed in a high-paying occupation rises from 25.8% for those males born prior to the jump in iodized salt sales to 30.8% for those born after iodization (see Table 10). If iodization increases one's chances of belonging to that category by 3.1 percentage points, as indicated by Table 9, then my estimates imply that iodization accounts for 62% of the rise in the percentage of males employed in high-paying occupations over that period. Therefore, iodization accounts for a significant part of the shift towards higher-paying occupations observed in high-goiter areas over the period of examination.

Table 9: Occupational Choice: Fuzzy Regression Discontinuity

	ALL AREAS	**HIGH-GOITER**	**LOW-GOITER**
High-paying occupation dummy	0.18287	3.04414***	−0.2031
	(0.45487)	(1.00704)	(0.49165)
Canton-specific trend	YES	YES	YES
Number of Observations	1137706	286051	278590
R^2	0.0253	0.0172	0.0275
High-paying occupation dummy	0.38926	2.82739***	−0.96432*
	(0.47304)	(1.06678)	(0.50778)
Canton-specific trend	NO	NO	NO
Number of Observations	1137706	286051	278590
R^2	0.0252	0.017	0.0273

Notes: * significant at 10% level; ** significant at 5% level; *** significant at 1% level; Coefficients correspond to changes in percentage points in the probability of being employed in the top three occupational categories, as the percentage of iodized salt sales goes from 0% to 100%.; The regression includes all Swiss-born males born in period 1905-1945 and recorded in 1970 Swiss Census.; High-goiter districts are those belonging to the top 25% of the population-weighted goiter distribution.; Low-goiter districts are those belonging to the bottom 25% of the population-weighted goiter distribution.; Standard errors in parentheses, clustered at the canton-year of birth level.

Table 10: Change in occupational choice and characteristics after iodization

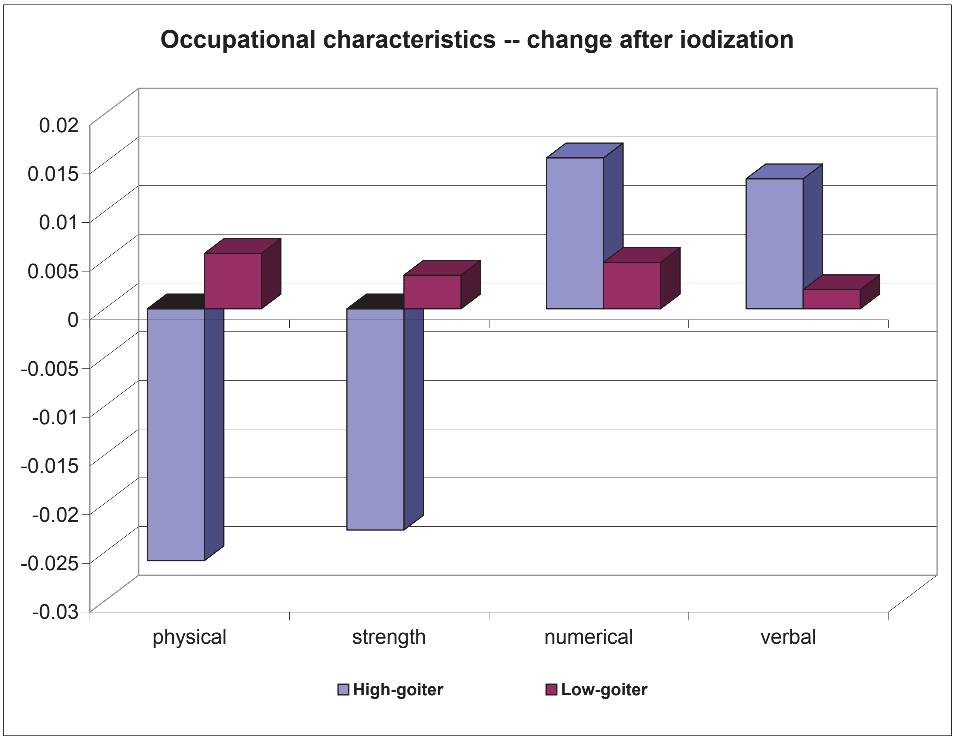
	High goiter areas		**Low-goiter areas**	
	Born before iodization	**Born after iodization**	**Born before iodization**	**Born after iodization**
Proportion going into	0.2586	0.3081	0.2728	0.3229
high-paying occupations	(0.4379)	(0.4617)	(0.4454)	(0.4676)
Cognitive Demands	-0.0623	0.0926	-0.0364	0.1054
	(0.7572)	(0.7977)	(0.7633)	(0.8049)
Physical Demands	0.4197	0.5912	0.3911	0.5035
	(1.0195)	(1.0318)	(1.0390)	(1.0654)

Source: 1970 Swiss Census, England and Kilbourne (1988), and Wespi (1962)

7 The effect of Iodization on Characteristics of Occupations

In this section I analyze the effects of the introduction of iodized salt on occupational characteristics. As outlined in section 4, I match eight characteristics of occupations from the book *"Occupational Measures from the Dictionary of Occupational Titles for 1980 Census Detailed Occupations"* with ISCO occupational codes used in the Swiss Census (England and Kilbourne 1988), and construct two indices for each occupation, one corresponding to cognitive and the other to physical demands.

Figure 3: Change in occupational characteristics after iodization



(Source: 1970 Swiss Census and England and Kilbourne (1988))

Figure 3 shows how the mix of four of the characteristics used in those indices changed differentially for high- and low-goiter areas after iodization. More specifically, figure 3 shows the coefficients on an indicator variable equal to 1 if an individual was born after a jump in

Table 11: Occupational characteristics: Coefficient on Iodized Salt 1 year prior to birth

	ALL AREAS	HIGH-GOITER	LOW-GOITER
Cognitive Demands	0.0113*	0.0438***	0.0074
	(0.0066)	(0.0128)	(0.0089)
Physical Demands	−0.0006	−0.0148	0.0081
	(0.0079)	(0.0205)	(0.0122)
Cohort Fixed Effects	YES	YES	YES
Canton of birth Fixed Effects	YES	YES	YES
Canton of birth trends	YES	YES	YES
Observations	1073964	271705	262202

Notes: * significant at 10% level; ** significant at 5% level; *** significant at 1% level; The regression includes all Swiss-born males born in period 1905-1945 and recorded in 1970 Swiss Census.; High-goiter districts are those belonging to the top 25% of the population-weighted goiter distribution.; Low-goiter districts are those belonging to the bottom 25% of the population-weighted goiter distribution.; Standard errors in parentheses, clustered at the canton-year of birth level.

sales of iodized salt, in a regression which also controls for canton and cohort fixed effects, as well as a canton-specific trend. What is easy to see from figure 3 is that whereas people in low-goiter areas had the same mix of characteristics pre- and post-iodization, high-goiter areas saw a decrease in the physical and a corresponding increase in the cognitive component of occupations, signifying a shift towards occupations with higher cognitive demands than before.

Table 11 shows results of regressing both occupational indices on the percentage of iodized salt sales one year prior to birth, controlling for canton and cohort fixed effects, as well as a canton-specific trend. Looking at all areas, there seems to be a slight increase in cognitive skills. When we only look at high-goiter regions, the coefficient on cognitive demands increases both in magnitude and significance (the coefficient on physical demands increases in magnitude but it remains statistically insignificant). The change is of the order of 0.04, which is about 5% of a standard deviation in the sample. This is not a big change, but it is significant.

Table 12 shows the results of regressing the occupational indices on an indicator variable

Table 12: Occupational characteristics: Born after jump in iodized salt sales

	All cohorts		**Born +/- 10 years from jump**	
	(1)	**(2)**	**(3)**	**(4)**
Cognitive Demands	0.0178***	0.0223***	0.0331***	0.0366***
	(0.0068)	(0.0081)	(0.0088)	(0.0102)
Physical Demands	−0.0016	−0.0042	0.0226*	0.0217
	(0.0093)	(0.0116)	(0.0125)	(0.0140)
Cohort Fixed Effects	YES	YES	YES	YES
District Fixed Effects	YES	YES	YES	YES
District Trends	YES	YES	YES	YES
Observations	1077720	1077720	480005	480005

Notes: * significant at 10% level; ** significant at 5% level; *** significant at 1% level; The regression includes all Swiss-born males born in period 1905-1945 and recorded in 1970 Swiss Census.; Columns (1) and (3) assume common cohort fixed effects for high- and non-high-goiter districts.; Columns (2) and (4) assume different cohort fixed effects for high- and non-high-goiter districts.; High-goiter districts are those belonging to the top 25% of the population-weighted goiter distribution.; Low-goiter districts are those belonging to the bottom 25% of the population-weighted goiter distribution.; Standard errors in parentheses, clustered at the district-year of birth level.

Table 13: Occupational characteristics: Fuzzy Regression Discontinuity

	ALL AREAS	**HIGH-GOITER**	**LOW-GOITER**
Cognitive Demands	0.0012	0.0587***	0.0023
	(0.0079)	(0.0171)	(0.0087)
Physical Demands	−0.0039	0.0114	0.0050
	(0.0088)	(0.0283)	(0.0131)
Cohort Fixed Effects	YES	YES	YES
Canton of birth Fixed Effects	YES	YES	YES
Canton of birth trends	YES	YES	YES
Observations	1073964	271705	262202

Notes: * significant at 10% level; ** significant at 5% level; *** significant at 1% level; The regression includes all Swiss-born males born in period 1905-1945 and recorded in 1970 Swiss Census.; High-goiter districts are those belonging to the top 25% of the population-weighted goiter distribution.; Low-goiter districts are those belonging to the bottom 25% of the population-weighted goiter distribution.; Standard errors in parentheses, clustered at the canton-year of birth level.

for belonging to the treatment group (born in a high-goiter district after a jump in iodized salt sales) and other covariates. There are cohort fixed effects which are allowed to be both common across all districts and different for high-goiter districts and the rest of the country. The results here are smaller in magnitude than in table 11, though they are still significant. Cognitive demands increase by an average of 0.028, whereas coefficients on physical demands remain, again, largely insignificant (with the exception of the specification in column (3), where they display a small increase). The reasons for this discrepancy in magnitude are similar to those pointed out in the discussion of section 6 on Tables 9 and 8.

Finally, results from the fuzzy regression discontinuity exercise appears on Table 13. According to Table 13 cognitive demands in high-goiter areas increased by 0.06 after widespread use of iodized salt, which corresponds to 7.8% of a standard deviation. Physical demands seem to have decreased in high-goiter areas, but the coefficient is not statistically significant.

To summarize, the mix of occupational characteristics shifted slightly towards a bigger cognitive component for those cohorts born after iodization in previously highly-deficient areas. The shift was quantitatively small -accounting at most for almost 8% of a standard deviation- but it was significant. During the period of examination, the average cognitive demands index in high-goiter areas rose from -0.06 to 0.09, a 0.15 point increase (see Table 10). According to the estimates in this section, iodization accounted for between 25% and 40% of this change, which is a significant impact on the composition of occupational characteristics.

8 Concluding remarks

The Swiss Iodization Campaign was the first major nutritional intervention, and many others, such as milk fortification with vitamin D, followed. Yet its impact on long-term economic outcomes has never been studied before. The effects of correcting iodine deficiency on cognition had real and significant effects for the populations treated. The cost-effectiveness of providing universal prophylaxis with iodized salt is indisputable, even if one only takes into account the lower hospitalization costs of people with thyroid disorders, without factoring in the big impact on the economy resulting from improved cognition.

Apart from an policy impact evaluation, though, the Swiss Iodization Campaign can also be viewed as an experiment of what happens to a given country and a given population within that country when there is an arguably exogenous change in its cognitive ability. Indeed, one can view iodine deficiency eradication as an "injection of IQ" in the population.

Once one thinks about iodization in that light, new and interesting empirical questions pop up. For example, it is usually very hard to de-couple innate ability from schooling when measuring the returns to education in a population, because there is usually not enough variation in the data, as presumably people of low ability do not achieve high education levels, whereas most high-ability people do (for a discussion of this issue, see Heckman and Vytlacil (2001)). In the case of iodization interventions, however, we are faced with a change in overall ability in the population for all levels of schooling, so we are already one step further in solving that problem. It is still a complex issue, however, since one would have to make assumptions about the initial distribution of ability in the population prior to the intervention, and how it changed after the correction. Average observed ability could increase either by a shift of the ability distribution to the right, or by a decrease of its left tail, however the implications for the interpretation of the findings would be different in each case, as would be our capacity to de-couple ability from schooling.

In related work (Politi 2009) I show that iodization improved schooling outcomes mainly for females, whereas it is hard to find any such effects for males. This is also supported in related literature on iodine deficiency in a different setting (Field, Robles and Torero 2009), where the effect on years of schooling for females is higher than for males. In this paper, in an intriguing twist, I show that even though there was very little evidence of an effect on male graduation rates, there is a significant effect on post-schooling outcomes, such as occupational choice. For females, on the contrary, such an effect is not present; females do not seem to translate increased schooling into improved occupational outcomes. One must, of course, take into account the fact that, as pointed in the text, most women were not active in the labor force in the time period of examination, and look at this result in that light. That said, I also have found that iodization did not increase the probability of joining the labour force, in spite of increased female graduation rates from secondary and tertiary education. In addition, there are no effects on occupational choice when one conditions on female labour force participation. These results give rise to interesting questions regarding women's selection into employment (see, for example, Mulligan and Rubinstein (2008)), but also whether, historically, females benefited from improved cognition and longer schooling in other ways, such as better matching in the marriage market.

Another question arising from this particular intervention is whether the spatial distribution of comparative advantage changed as workers selected into more different types of occupations. This can have implications for the local economy (which we can treat as open), as well as the economy of the country as a whole and its neighbors. For example, do we observe worker migration into other areas, and if yes, what is the profile of the workers who migrate and of the receiving regions? How are local and countrywide relative wages affected, and are there spillover effects in neighboring countries? These are just a few of the interesting questions that arise in this context, but which can have great practical significance and implications in other settings as well, especially when one thinks about the urban and development economics literature.

Tremendous steps have been taken for the global eradication of iodine deficiency in the past 20 years, but there is still a long way to go before nobody is affected by iodine deficiency disorders. Given the obvious cost-effectiveness of universal salt iodization, and the beneficial impacts for the treated populations as they were estimated in this paper, it should be clear that eradicating iodine deficiency should be at the top list of priorities for governments and health-promoting organizations.

9 Appendix

Table 1A-1: Annual iodized salt sales as a percentage of total salt sales

	Year													
Canton Name	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Zürich		18	21	18	18	18	17	15	13	14	53	51	53	54
Bern		1	1	4	4	4	4	5	6	6	6	7	8	11
Luzern		5	3	4	6	6	6	7	7	8	6	8	8	8
Uri								100	100	97	97	97	93	88
Schwyz			1	1	100	100	100	100	100	100	100	100	100	100
Nidwalden		47	100	100	100	100	100	100	100	100	100	100	100	100
Obwalden		7	8	8	50	100	100	100	100	100	100	100	100	100
Glarus		4	83	37	27	37	33	41	60	66	67	68	70	72
Zug		23	26	81	97	88	100	100	100	100	100	100	100	100
Fribourg				2	2	2	3	2	2	1	3	3	?	?
Solothurn		1	2	2	2	3	3	3	3	3	3	3	3	3
Basel-Stadt		5	10	12	12	13	14	15	14	13	14	14	10	10
Basel-Land		2	5	5	11	12	9	10	34	15	14	14	12	28
Schaffhausen		4	3	11	100	100	100	100	100	100	100	96	100	100
Ap. Ausserrhoden	43	55	75	75	67	67	67	73	74	70	77	67	68	69
Ap. Innerrhoden		34	50	50	48	46	53	54	49	51	51	53	39	59
St. Gallen		12	24	27	25	26	27	47	52	51	58	55	54	64
Graubünden		3	6	9	9	13	16	18	17	20	22	21	20	21
Aargau		4	9	11	11	12	12	10	11	13	12	9	10	9
Thurgau		27	36	39	35	34	35	36	32	34	37	35	37	35
Ticino								100	100	98	100	100	100	100
Vaud		25	100	100	100	100	100	100	100	100	100	100	100	100
Valais			33	63	65	75	78	80	87	95	96	100	100	100
Neuchâtel			15	70	70	70	70	70	70	70	70	70	70	70
Genève						1	1	1	2	3	4	3	27	66
Switzerland		8	16	22	26	29	27	30	34	33	39	38	40	40

	Year													
Canton Name	36	37	38	39	40	41	42	43	44	45	46	47	48	49
Zürich	52	53	52	53	55	55	48	63	67	70	70	70	77	77
Bern	54	64	65	66	63	73	69	71	71	73	69	74	73	75
Luzern	8	9	7	8	8	6	5	54	100	81	92	97	100	100
Uri	79	90	90	88	90	87	88	100	100	100	100	100	100	100
Schwyz	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Nidwalden	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Obwalden	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Glarus	73	76	76	81	82	87	92	94	93	94	93	94	95	97
Zug	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Fribourg	?	3	3	4	7	39	31	36	50	76	76	100	100	100
Solothurn	4	4	54	74	69	58	62	65	66	67	64	63	60	58
Basel-Stadt	14	13	15	23	25	23	25	28	28	28	29	27	27	27
Basel-Land	16	15	15	18	17	17	18	18	18	19	18	20	21	21
Schaffhausen	100	100	100	100	100	97	95	100	100	100	100	97	96	100
Ap. Ausserrhoden	71	71	71	71	68	71	70	74	74	77	79	87	89	92
Ap. Innerrhoden	64	64	60	62	57	59	56	44	48	49	86	100	100	100
St. Gallen	69	68	68	68	67	59	67	78	88	89	91	91	93	93
Graubünden	24	24	26	43	75	85	86	94	94	93	93	96	94	95
Aargau	11	11	10	10	8	7	14	8	7	7	7	8	7	7
Thurgau	38	39	39	39	36	41	37	36	38	46	67	76	84	88
Ticino	100	100	100	98	97	100	100	100	100	100	100	100	100	100
Vaud	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Valais	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Neuchâtel	70	70	70	70	70	70	70	70	70	70	70	67	70	68
Genève	90	90	89	88	90	89	81	93	91	88	88	91	92	93
Switzerland	51	54	55	58	59	62	60	64	72	73	75	77	78	79

Notes: The canton of Jura is not in this table, since it was only created in 1979, after secession from the canton of Bern. Jumps in iodized salt sales, which are used in the fuzzy regression discontinuity exercise in the paper, are highlighted. Source: Wespi (1962)

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