SALT IODIZATION AND THE ENFRANCHISEMENT OF THE AMERICAN WORKER*

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Abstract

In 1924, The Morton Salt Company, the largest salt producer in the United States, began nationwide distribution of iodine-fortified salt. Access to iodine, a key determinant of cognitive ability, rose considerably, leading to increased intelligence quotients particularly in previously iodine-deficient areas. We compare economic outcomes for cohorts exposed *in utero* to iodized salt with those of slightly older, unexposed cohorts, across states with high versus low iodine deficiency rates prior to the advent of salt fortification. We estimate that labor force participation rose by 1.35 percentage points as a result of iodization. Analysis of income transitions by quintile shows that new labor force joiners entered at the bottom of the wage distribution, pulling down average wage income conditional on employment. Consistent with effects primarily on low-skilled, low-wage employment, we find little evidence of significant changes in high school completion rates. Results are driven by impacts on women: salt iodization can account for roughly 5 percent of the rise in female participation between 1950 and 1990. Our results inform the ongoing debate regarding micronutrient fortification campaigns in many low-income countries. We show that blanket iodized salt distribution in fact had a very targeted impact, benefiting those on the margin of employment and generating sizable economic returns at little public cost.

Keywords: early life, cognitive ability, iodine, labor force participation, wage distribution
JEL Codes: I12, I15, I18, J24, N32

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1 Introduction

Inadequate access to essential micronutrients such as iron, vitamin A, iodine, and zinc has staggering costs in terms of mortality, poor health, and lost productivity, particularly in low-income countries (Black et al., 2013). Though the short-term health benefits of improving micronutrient availability, especially for young children, are clear (Bhutta et al., 2013), little is known about impacts in the long run. Moreover, few studies have examined the impacts of large-scale supplementation or eradication campaigns.[1] How long do the effects of improved access to vital micronutrients last? If health effects do persist, do they spill over onto socioeconomic outcomes? Which individuals are most affected by blanket campaigns? These questions are still largely unanswered.

In this study, we draw lessons from the historical experience of the United States, where natural access to iodine, an essential micronutrient, was scarce in many areas of the country until the mid-1920s. Iodine regulates thyroid hormone availability, which determines the density of fetal neural networks (Lamberg, 1991). Medical studies suggest that iodine deficiency affects cognitive function at all ages, but is particularly detrimental during gestation, when even mild deficiency can greatly hamper cognitive development (Cao et al., 1994). Moreover, the effects of fetal iodine deficiency disorder (IDD) are irreversible: an inadequate supply of iodine in the first trimester of gestation permanently reduces intelligence quotients (IQ), regardless of subsequent supplementation (Hetzel and Mano, 1989; Pharoah and Connolly, 1987; Zimmermann et al., 2005).[2]

We study the labor force, education, and wage distribution impacts of rapid, large-scale salt iodization in the twentieth century US. The Morton Salt Company, the largest salt producer in the US, initiated nationwide iodized salt distribution shortly after the invention of iodine-fortified salt in the early 1920s. In less than half a decade, the US went from zero to nearly universal availability of iodized salt (Markel, 1987). Iodine deficiency rates plummeted in the following decade, most markedly in areas that were highly iodine deficient prior to the introduction of iodized salt (Brush and Atland, 1952; Hamwi et al., 1952; Schiel and Wepfer, 1976). Feyrer et al. (2013), in a recent paper, show that IQ may have risen substantially–up to 15 points–as a result. We ask: what happened to the economic out-

[1]Notable recent exceptions are Feyrer et al. (2013), Politi (2011b), and Politi (2011a), which we will discuss in detail. Much of the available evidence is from the INCAP longitudinal study (Martorell, 1995), which followed Guatemalan children from 4 small villages over 20 years, some of whom were exposed to a nutrient intervention *in utero* and in early life, and others who were given a placebo.

[2]It bears mention that studies from the medical literature are correlational: causal evidence on the effects of iodine exposure in humans is limited. The study by Feyrer et al. (2013) is important in this sense, because it provides the most rigorous evidence to date of the impact of fetal iodine access on adult cognitive performance.

comes of those whose *in utero* access to iodine improved? Did increased IQ lead to more schooling? Were labor supply and wages impacted significantly, and which part of the income distribution did salt iodization most affect?

We use a simple difference in differences strategy to identify these effects. We compare outcomes for cohorts born just before iodization (1920-1923) to those born during (1924-1927) and after (1928-1931), across areas with high and low pre-iodization deficiency rates. To identify the latter difference, we use pre-iodization rates of goiter, the main physical manifestation of IDD (Olesen, 1929). States with low goiter rates pre-iodization are appealing as a control group for the following reason. For normal cognitive functioning to be achieved, fetal iodine levels need to be above a "protective threshold" (Cao et al., 1994; Eltom et al., 1985; Furnee, 1997). Before salt fortification, iodine access was wholly determined through the amount of naturally occurring iodine in food. In areas where access to iodine through food was already adequate, additional iodine through salt fortification should have no *cognitive* effect, since most individuals were already above the protective threshold. We follow these cohorts through their productive lives, from ages 25 to 55, using data from the 1950-1980 censuses. We perform a variety of robustness and placebo checks in support of our claim that observed differences in trends are causally related to salt iodization.

We estimate substantial impacts on employment and wage and income distributions. Labor force participation increased by about 1.35 percentage points. These effects are driven by the impact on women. Labor force participation amongst women increased by 1.63 percentage points; while effects for men are small. We find little evidence of impacts on high school and college completion. Average impacts on income and wage earnings were negative. In order to better understand these income results, we analyzed transitions across income and wage quintiles over time. We find that iodization drove a shift into the bottom three quintiles and away from the upper two. Paired with the observed increase in labor force participation, we conclude that as a result of iodization (female) labor force joiners, working in low-paying jobs, swelled the bottom of the wage distribution, bringing down the average wage conditional on labor force participation.

Our findings further the recent work by Feyrer et al. (2013) on the cognitive impacts of salt iodization in the US. Using data on the spatial distribution of goiter from enlisted men in WWI, Feyrer et al. (2013) find that army recruits in WWII born in previously highly iodine-deficient regions experience a differential increase post-iodization in the likelihood of being placed in the Air Forces. The authors use this estimated effect, combined with the fact that placement in the Air Forces was partially determined by performance on the Armed Forces Qualifying Test, to approximate the probable IQ gain from iodization. They estimate a gain of nearly 15 points, which would account for a sizable proportion of the so-called Flynn Effect, the dramatic increase in IQ over the 20th century in the US.

The line of inquiry in our study–estimating the long-run economic impacts of salt iodization–is complementary to Feyrer et al. (2013)'s result. Does increased cognitive ability generate shifts in educational attainment and labor market participation? It is not obvious which answer we might predict. A larger cognitive endowment likely increases both the returns to education and the returns to experience, and perhaps differentially in high and low-skilled sectors. Given this, we believe it is crucial to estimate impacts on economic outcomes in addition to cognitive ability effects.

Our study is distinct from Feyrer et al. (2013) in several ways. Most importantly, we use different data sources and empirical specifications. Using US census data, we study economic outcomes, such as labor force participation, income and education, rather than cognitive ability, allowing contributions to distinct literatures for which these outcomes are of great importance.[3] Due to the nature of the outcome data in Feyrer et al. (2013), a comparison across women and men cannot be done; our finding that the labor force estimates are driven by impacts on women helps to fill this gap. Finally, our empirical strategy makes use of census divisions to include 9 simultaneous birth year trends as controls.

This study contributes to the growing literature on the long-term effects of early-life conditions.[4] Much of this "fetal origins" work has focused on demonstrating the impacts of traumatic experiences (disease, natural disasters, environmental factors, etc.) in early life. Few studies have estimated the gains to exposure to purposeful and beneficial large-scale distribution of resources. The distinction between the two types of studies is important because the latter "shock" can yield actionable information: policies with demonstrated positive impacts can be advocated for and reproduced. A small set of studies–including Hoynes et al. (2012), Bleakley (2007), Bleakley (2010), Field et al. (2009), Almond et al. (2010), Politi (2011b), Bhalotra and Venkataramani (2012), and Feyrer et al. (2013)–have recently made strides in this direction. We build on this evidence base: the results of these studies and ours offer lessons from historical policy experiments from which present-day policymakers, particularly in developing countries, might profitably draw.

The fact that our results are strongest for women is consistent with evidence from recent studies on

[3]Feyrer et al. (2013) mention in a footnote (p. 38, footnote 40) that they find no impact on educational attainment using census data. Our findings are consistent, though we use a different source of data on pre-iodization goiter rates; a slightly different specification which includes division of birth x birth year effects; and different focus on high school and college completion.

[4]See Heckman (2006), Almond and Currie (2011), and Currie and Vogl (2012) for syntheses of this literature.

the effects of other early life interventions (Bleakley, 2007; Field et al., 2009; Hoynes et al., 2012; Maccini and Yang, 2009). Moreover, this pattern relates to important previous work on the drivers of the marked rise in labor force participation and educational attainment of women over the 20th century. Goldin and Olivetti (2013) and Goldin (1991) estimate that WWII led to a roughly 20 percent rise in female participation for higher-educated women in cohorts born between 1915 and 1924. Goldin and Katz (2002) and Bailey (2006) show that increased access to oral contraceptives led to later marriage, higher likelihood of professional and graduate training in high skill occupations, and increased rate and duration of labor force participation among cohorts born after 1940. We present complementary evidence that salt iodization led to a rise in female labor force participation of roughly 3 to 4 percent among cohorts joining the labor force after the war, but largely completing their fertility prior to improved access to contraception. Our results also pertain to a lower-educated, lower-skilled portion of the workforce than do the results from previous work. The estimated 1.63 percentage point rise in female labor force participation as a result of iodization accounts for 5 percent of the total rise in female participation from 1950 to 1990.

We also contribute to the evaluation of micronutrient fortification campaigns, and in particular mass salt iodization as a means of eradicating iodine deficiency. Nearly 2 billion people worldwide–a third of the world's population–do not have adequate access to iodine (Andersson et al., 2010; de Benoist et al., 2004). Recent estimates from the economics literature suggest that the incidence of iodine deficiency, and thus the returns to reducing IDD, may be very large (Feyrer et al., 2013; Field et al., 2009; Politi, 2011b). Policymakers in IDD-endemic countries, as well as the WHO, UNICEF, and other international organizations, have made increasing access to iodine a high priority (WHO, 1992). Mass salt iodization to prevent IDD is, far and away, the preferred policy: iodizing salt is much cheaper than continuous supplementation in populations with iodine-deficient diets, and, taken with other micronutrients such as iron, is highly cost-effective in terms of fetal and infant deaths averted (Center, 2008).

It is important, then, as many low-income countries make decisions about investing in salt fortification and distribution infrastructure, to quantify in rigorous fashion the economic benefits of salt iodization. Clearly, there are many differences–related to infrastructure, centralization of distribution, competing disease risks, labor markets, etc.–between the US in the early- and mid-twentieth century and the low-income countries still suffering from high rates of IDD today. But drawing from the historical experience in the US offers some insight into the promise of salt iodization, in terms of the rate and completeness of adoption and the long-term economic returns that could be achieved. Paired with the IQ gains estimated in Feyrer et al. (2013), our results suggest that each IQ point accounts for nearly one tenth of a point increase in labor force participation.

The rest of the paper is organized as follows. Section 2 discusses iodine deficiency and its prevalence in the early twentieth century, as well as the history of salt iodization in the US. Section 3 discusses our data sources. Section 4 describes our empirical strategy. Section 5 describes the results. Section 6 concludes with a discussion of the size of the economic benefits of iodization.

2 Background

2.1 Iodine Deficiency and its Consequences

Iodine is crucial to the functioning of every body cell.[5] The thyroid gland in the lower part of the neck uses iodine from foods to produce thyroid hormones, which are released into the blood stream and transported throughout the body to control metabolism (the conversion of oxygen and calories to energy). The highest iodine contents for human consumption are found in some milks, leafy vegetables, and sea foods. The optimal iodine intake as recommended by the WHO is very small: a daily dose of 90 μg for infants of 0-59 months, 120 μg for ages 6 to 12, 150 μg for older ages, and 200 μg for pregnant and lactating women (Clar et al., 2002). (Half a teaspoon of iodized salt contains about 150 μg of iodine). Nevertheless, iodine deficiency can be a risk for many people due to the minute iodine content in most foods, and is most likely in areas far from the sea, especially mountainous areas due to erosion (Hetzel, 1989). When iodine intake is insufficient, the thyroid gland gets enlarged by working extra hard to produce the needed thyroid hormones.

At any stage from the fetal age to adulthood, insufficient iodine intake can cause a number of functional and developmental abnormalities, often referred to as iodine deficiency disorders (IDD). The main IDDs are goiter, hypothyroidism (causing fatigue, lethargy, slow speech and thought), impaired mental function, retarded physical development, and increased susceptibility of the thyroid gland to nuclear radiation (WHO, 2004).[6] Although the most detrimental IDD is cretinism due to severe iodine deficiency, less extreme in utero and postnatal deficiency can also be highly damaging and result in a 5%-50% loss of individual productivity depending on severity (Hetzel and Pandav, 1996).

[5] http://www.endocrineweb.com/thyfunction.html

[6] Goiter may not be visible if iodine deficiency is minimal. On the other hand, iodine deficiency is the primary, but not exclusive, cause of goiter. Goiter, when sufficiently large, may cause complications such as aspiratory difficulty.

Correlational evidence of the impact of iodine deficiency on human capital among school-age children is abundant. Huda et al. (1999) find that in Bangladesh hypothyroid children performed worse than those with normal thyroid gland function on reading, spelling and cognition, controlling for health and socioeconomics. Even in a developed-country area with very mild iodine deficiency (Jaen, Spain), Santiago-Fernandez et al. (2004) report the risk of having an IQ below 70 to be greater in children with urinary iodine levels less than 100 μg/liter.

Of course, the association between iodine intake and educational attainment documented in the studies mentioned above is not necessarily causal; many factors may drive both access to iodine and schooling decisions. Two recent studies, Field et al. (2009) and Politi (2011b), go further to provide estimates of the impacts of adequate access to iodine on schooling that take identification of causal effects seriously. Both show large impacts of iodine (pill-based supplementation in Tanzania in the case of Field et al. (2009), and salt iodization in Switzerland in the case of Politi (2011b)) on grade completion.

2.2 The Geography of Iodine Deficiency in the US

The map on the left in Figure I illustrates the geographic distribution of goiter incidence across the US based on data from the 1917 WWI draft examinations, which is, to our knowledge, the first and only nationwide goiter survey in the US. A "goiter belt" can be seen in the northern parts. The figure also shows a very high correlation between the geographic pattern of goiter incidence among WWI recruits and the geographic pattern of iodine content of drinking water as reported in 1924 by the then prominent scientist Jesse Francis McClendon (map on the right).

As mentioned above, there is a threshold of iodine intake beyond which more intake brings no additional benefit; it is thus appropriate to depict the relationship between goiter incidence and water iodine content in terms of low content versus high content, rather than in terms of continuous values. More details on this comparison can be found in McClendon and Hathaway (1924) and McClendon (1939).

In a publication in the Public Health Reports published in 1929, Robert Olesen, a surgeon at the U.S. Public Health Service, gathered goiter data dating from 1924. He consulted independent thyroid surveys and directly communicated with state, county and city health officers across the country to verify the geographic distribution of goiter in the general public against the findings from the WWI draft examinations. Olesen (1929) concludes that the evidence among the young population from elementary school to college confirms the geographic variation in goiter incidence among WWI recruits in those areas where he could collect data. Our paper uses the Olesen goiter rates because they are drawn from a sample more relevant to our focus on *in utero* iodine deficiency, compared to a potentially non-representative sample of adult male recruits. The high correlation between all three of these patterns suggests that the Olesen data would serve as a good representation of the geographic pattern of iodine deficiency in the general population.

The Olesen data, summarized in Table A.1, show variation in goiter prevalence across states within regions. This variation is crucial as it allows us to control for region-level time effects to remove any systematic coincidence between the goiter distribution and geographic differences in economic development over time, such as the North-South divide.

2.3 Introduction of Iodized Salt in the US in 1924

It was not until 1895 when iodine was first found in the thyroid gland by a German chemist Eugen Baumann (Baumann, 1896). Since then experiments were conducted to study the impact of changes in iodine content and the enlargement of the incidence of goiter in different kinds of animals, including dogs, cattle, hogs, and fish (Marine and Feiss, 1915; Marine and Lenhart, 1909; Smith, 1917). However, it was only in 1914-1915 that goiter in humans was reported in an organized manner in the US for the first time by Hall (1914) and Olesen (1915), using examination data from 3,339 University of Washington students and from 606 women and 193 men in Chicago, respectively. The experiment of scientist David Marine and colleagues in Ohio in 1917-1919, providing iodated syrup to school girls of grades 5 to 12, was the first known evidence that iodine supplementation could control and prevent goiter in humans (Marine and Kimball, 1917). Two grams of iodated syrup were given twice a year to 2,190 of 4,495 school girls in Akron, Ohio. As the test concluded, only five treated girls developed thyroid enlargement whereas 495 untreated girls did. Among the girls with initial thyroid enlargements, 70% of the treated showed a gland size decrease while only 15% of those not treated showed such a decrease (Marine and Kimball, 1921).

Coincidental with findings from the Ohio experiment, a few other factors put focus on goiter in humans as a health problem in America during the early 1920s (Annegers and Mickelsen, 1973), among them: (a) the decline of other childhood diseases allowed more attention to goiter; (b) McClendon discovered the coincidence between goiter and the iodine content of drinking water; and (c) the WWI draft examinations revealed the nationwide extent of goiter prevalence. The evidence by Marine and colleagues inspired Switzerland to set up prophylactic programs, one of which used salt as an iodization vehicle. The use of salt was adopted enthusiastically by David Cowie of the University of Michigan, who was interested in eliminating widespread simple goiter in his home state. Iodized salt appeared in Michigan groceries on May 1, 1924, and nationally in the fall of 1924. Although there was no law mandating salt iodization, with the continued educational efforts of the Michigan State Medical Society and zealous advertisements by salt producers, iodized salt rapidly grew popular. By 1930, iodized salt sales were eight times plain salt sales (Markel, 1987).

Many later surveys found marked decreases in thyroid enlargement, especially among continuous users of iodized salts. Interestingly, Schiel and Wepfer (1976) found that, among Michigan school children in 1924-51, there was a decline in goiter rates among non-users. Cowie attributed this to ingestion of iodized salt without realizing it, such as in school canteens and restaurants, which seems plausible given that iodized salt made up 90% of salt sales in Michigan at the time (Markel, 1987). This observation alleviates concerns about self-selection into using iodized salt and supports the approximate universality of the intervention. Figure II shows U.S. goiter survey results compiled by the Chilean Iodine Educational Bureau in 1950 and the American Geographical Society in 1953. The size of the endemic goiter areas decreased considerably between the WWI draft era (Figure I) and 1950, and further from 1950 to 1953.

2.4 Goiter and Confounding Factors

Marine's 1917-19 experiment was the first to inform the US public that iodine supplementation could prevent and treat goiter; hence there is little reason to suspect a *direct* role of iodine in residential selection or selection into iodine-rich diets. Supporting this claim, Figure I shows that goiter incidence was concentrated in the northern states, which were socioeconomically better off compared to the southern states.

However, one might still suspect that high goiter incidence areas prior to iodization were also more likely to have high incidence of other nutrient deficiencies or other health issues such as malaria or hookworm. Similarly, we might worry that concurrent with the roll out of iodized salt, there may have been other important changes in the U.S. diet or in other health conditions. In fact, food fortification in the US began with salt iodization in 1924, with discoveries of the role of vitamin and mineral deficiencies in many diseases and sicknesses (Backstrand, 2002). However, the knowledge remained mostly in the laboratory until May 1941 when President Roosevelt called a National Nutrition Conference for Defense, due to high malnutrition rates and fears of potential U.S. involvement in war.

Figure III shows the change in the per capita riboflavin, iron, niacin, and thiamin contents of American food between 1909 and 1994, which does not coincide with the timing of salt iodization. In order to address concerns about the contemporaneous eradication of infectious diseases, we check the robustness of our main results to controlling for baseline geographic variation in the prevalence of various diseases as well as the interactions of these prevalences with a post-iodization dummy. The robustness of our results alleviates concerns about the geographic pattern of goiter incidence, and hence of expected benefits from iodized salt, coinciding with the geographic pattern of other health-related improvements. [7]

3 Data

3.1 Goiter Data

Our information on the geographic distribution of iodine deficiency prior to salt iodization comes from Olesen (1929), which includes a compiled list of goiter rates among children. Starting in 1924, these rates were calculated by experienced health workers from samples of school children in a varying number of localities in 43 states. 6 out of these 43 states did not report a numerical goiter rate (only qualitative descriptions, like "very little goiter") and were therefore excluded. Table A.1 lists the remaining 37 states in ascending order of state-level goiter prevalence. The median goiter rate in this sample is 9.1%. For our main specification, all states above the median are classified as high deficiency states, while all states below the median are classified as low deficiency states. See Data Appendix for details on how the state-level averages were calculated.

[7] We also examine correlations between state-level goiter rates and state-level changes in total mortality and cause-specific mortality rates between 1930 or 1940 (after the introduction of iodized salt) and 1910 or 1920 (before the introduction of iodized salt) and find that more iodine deficient states experienced smaller decreases in those mortality rates (results available upon request).

3.2 Census Data

We also use data from the United States Decennial Census, restricting to individuals born in the twelve-year period spanning 1920 to 1931, which includes the years before, during, and after the nationwide spread of iodized salt. We are interested in labor and income outcomes for this cohort throughout their productive work life, from age 25 to 55. This tighter age restriction is used in order to exclude those still in school or early retirees. As a result, we pool data from the 1950 to 1980 Censuses.

Each individual in the sample is identified as having a high or low risk of being born to an iodine deficient mother, depending on whether their state of birth is a high or low goiter state (classified according to the methods described above). Individuals are also grouped according to their birth year. Those born in the years 1920 to 1923 are marked as "pre-iodization," those born from 1924 to 1927 are classified as born "during iodization," and those born from 1928 to 1931 are considered "post-iodization." Iodized salt first appeared in grocery stores in 1924 and was reported to have generated eight times more sales than regular salt by 1930 (Markel, 1987). In creating the "during" category, we allow four years of leeway following the initial introduction of iodized salt to ensure that the after cohort was exposed to an environment with sufficiently widespread iodized salt availability.

3.2.1 Outcome and Control Variables

In terms of labor and education outcomes, we are interested in the rates at which individuals are participating in the labor force, earning positive wages, and graduating from high school as well as college. The income outcomes we look at are wage income and total income. Additional variables taken from the Census include gender and race. In some specifications, in addition to including female and black dummy variables, we also control for pre-iodization demographic conditions in the individual's state of residence. This is done by by calculating the black and female proportions from the 1920 Census in the the individual's state of residence. For more details on the construction of variables, see the Data Appendix.

3.3 Region Controls

There are clear regional patterns in the distribution of goiter. This necessitates the inclusion of region by birth year dummies, which we use in all of our specifications. We control for region of birth using the nine Census Bureau divisions, reported in Table A.2. The inclusion of these interaction terms means we are identifying off of within-region variation, essentially comparing high and low goiter states within each of the nine divisions.

3.3.1 Summary Statistics

Table I reports summary statistics for the entire population aged 25-55 in the 1940 Census. As 1940 was the last Census year before the during and after cohorts entered our sample as working adults aged 25 and over, this gives us a snapshot of the pre-treatment conditions in high and low goiter states. About 60% of the population participated in the labor force, although around half earned a positive wage. High school and college graduation, positive wage earning, and wage income were significantly higher in high goiter states, which is consistent with the Northern states having better socioeconomic conditions prior to the iodization of salt. These significant differences, while they point to underlying level differences between high and low goiter states prior to the introduction of iodized salt, are accounted for in our difference-in-differences approach. They also emphasize the importance of our region-by-birth-year interaction dummies.

Figure IV compares the trends in average labor force participation by birth year cohort in high and low goiter states. An upward trend is apparent in both groups, with much higher participation rates in the younger cohorts (from around 0.61 for those born in the beginning of the century to over .75 for 1940 births). The vertical red line represents the introduction of iodized salt in 1924. There is a dramatic spike that begins with cohorts born around this time, which is driven primarily by female entry into the labor force. More important than the spike, however, is the divergence of high goiter and low goiter trends to the right of the 1924 line. While the high goiter and low goiter state trends are overlapping for all birth years before 1924, for the vast majority of cohorts born after 1924 (with the exception of two birth years), labor participation in high goiter states is higher than in low goiter states. As these raw trends can only offer suggestive evidence at best, we explore this divergence more rigorously in the remainder of the paper.

3.4 Other Diseases

In certain specifications, as robustness checks, we control for the pre-iodization rates of other diseases, including malaria, hookworm, and tuberculosis. For malaria, we use the malaria mortality rates from the 1890 Census, used in Bleakley (2010). Hookworm rates are also taken from Bleakley (2010). These rates were drawn from around 20,000 recruits in 1917 and 1918, a smaller and separate sample from the recruits tested in Love and Davenport (1920) (Kofoid and Tucker, 1921). As with goiter, the state-level medians of these disease prevalence rates were calculated, and each individual was assigned to either a low or high-prevalence indicator for that particular disease, depending on their state of birth.

3.5 Compulsory Schooling

In another robustness test, we add years of compulsory schooling as a control variable. We obtained this variable from state-level data used in Lleras-Muney (2002), compiled from multiple sources. This data reports the number of years of required schooling (either by compulsory attendance laws or implied by child labor laws) in each state in each year from 1915 to 1939. Using the same strategy as Lleras-Muney (2002), we match each individual to the law in place in their state of birth in the year they turned 14 (the minimum leaving age across all states and years), as this is arguably the most relevant to their schooling continuation choices.

4 Empirical Strategy

4.1 Overview of strategy

In this section, we describe the empirical strategy we use to identify the effects of salt iodization on economic outcomes. As described in section 2, once Morton Salt Co.'s decision to iodize its supply was made, the spread of iodized salt was wide scale and fairly rapid. Since iodization happened nationwide, however, there was no true exclusion from exposure. In the spirit of Bleakley (2010), Hornbeck (2012), and others, our basic strategy is to compare trends in economic outcomes in states with high v. low pre-iodization iodine deficiency rates. Feyrer et al. (2013) use a similar strategy to identify the impacts of iodization on recruits' placement into the Army v. the Air Force.

We use the spatial distribution of goiter in 1924 in the continental US to identify differences in pre-iodization deficiency rates. As described in section 3, we use data from Olesen (1929)'s list of goiter rates observed in school children. We assign each individual in the census a goiter rate using their state of birth. We do this to draw focus to the effects of *in utero* exposure to iodine rather than exposure through one's life.

We interpret the goiter value as a proxy for the extent of iodine deficiency in one's state of birth.

This proxy will, of course, not fully reflect actually iodine exposure *in utero*. Nevertheless, as shown in the previous sections, as well as in Feyrer et al. (2013), the spatial distribution of goiter generally mirrors well the distribution of iodine content in water sources. While admittedly an imperfect proxy, the distribution allows us to classify individuals generally as having a low v. high exposure to iodine *in utero*.

We interpret differences in trends in economic outcomes across individuals born in high v. low goiter states as being causally related to salt iodization. The particular features of the role of iodine in regulating cognitive ability bolster this interpretation. For normal cognitive functioning, fetal iodine must be above a "protective threshold" (Cao et al., 1994; Eltom et al., 1985; Furnee, 1997). Above this threshold, additional iodine does not yield much of a cognitive benefit; below it, even small changes in access to iodine can generate large shifts in IQ (Dugbartey, 1998; Lavado-Autric et al., 2003; Pop et al., 1999; Sundqvist et al., 1998).

The presence of this protective threshold has strong implications for our empirical strategy. While salt iodization increased iodine intake across the entirety of the US population, additional iodine in low deficiency areas, in which most of the population was already above the protective threshold, likely had little effect on cognitive abilities. In contrast, in high deficiency areas, in which the risk of falling below the threshold was more pronounced, the same increase in iodine intake likely generated large changes in IQ. Feyrer et al. (2013)'s back-of-the-envelope calculations suggest that average IQ went up by about 15 points as a result of iodization.

We study the outcomes of three cohorts born before (1920-1923), during (1924-1927), and after (1928-1931) salt iodization. We consider this middle ("during") group because, while the proliferation of iodized salt across the US was rapid, we do not have data on the geographic pattern of this nation-wide spread. During the proliferation period, it is possible that we find muted effects, if iodized salt had not yet reached some markets. To allow for this, we separate the "during" and "after" iodization period. In practice, the estimates for impacts in these two cohorts are indistinguishable, suggesting that iodized salt did indeed proliferate very quickly.

4.2 Specification

The basic difference in differences strategy, then, is to compare the outcomes of cohorts born before to those born during and after iodization, across individuals born in high v. low iodine deficiency areas.

In our baseline specification, we split the sample at the median state-level goiter rate, creating a high goiter (above median) v. low goiter (below median) exposure designation. We estimate the following base specification, for individual i born in year t in state s (census division r), for outcome o recorded in census year c, where T is a treatment dummy which equals 1 if the individual was born in a high goiter state, D is a dummy for belonging to the "during" cohort, and A is a dummy for belonging to the "after" cohort:

$$o_{ist} = \beta_1 T_s D_t + \beta_2 T_s A_t + (\zeta_r \text{ x } \delta_t) + \mu_s + \delta_t + \varepsilon_{ist}. \tag{1}$$

Here, β_1 and β_2 are the main coefficients of interest, measuring the difference in trends in outcome o across individuals born in high and low goiter states over time. The specification includes state of birth (μ_s) and year of birth fixed effects (δ_t), which absorb the main effects of T_s, D_t, and A_t. We also control for region of birth by birth year interactions (ζ_r x δ_t), defining regions as the 9 Census Bureau divisions. These interaction terms control for any division-specific trends over time that may coincide with the national goiter distribution. The inclusion of these controls means we are comparing differential trends across high and low goiter states within Census divisions.

In subsequent refinements to this basic specification, we add individual controls for race and gender, as well as controls for the average race and average gender (measured in 1920) of the individual's state of residence interacted with the during and after dummies. We also run this regression separately for men and women to identify differential effects by gender.

We test the robustness of the results to the inclusion of contemporaneous disease eradication programs (namely related to tuberculosis, hookworm, and malaria) as well as compulsory schooling laws. Finally, we run placebo checks using only individuals born before the iodization of salt. We replicate the same difference in difference regression on this sample, comparing individuals born in 1916-1919 (our placebo cohort) to indivduals born in 1920-1923. This specification would highlight any differential pre-treatment trends across high and low goiter states, which would indicate the potential violation of our difference in difference assumptions.

5 Results

5.1 Labor Supply

We begin by exploring effects of the availability of iodized salt in the year of birth on labor supply decisions. As discussed in section 4, our identification strategy is built on a comparison of outcomes across cohorts born before and after the availability of iodized salt, in states with above and below median goiter incidence prior to salt iodization. Figure V depicts comparisons in mean labor force participation and positive wage earning across four groups: those born just before and after 1924, in states with above and below median goiter incidence.

In Panel A, we see that cohorts born between 1920 and 1923 in states with above median goiter incidence had only slightly higher labor force percentage than cohorts born in the same years in states with below median goiter incidence. However, cohorts born between 1924 and 1931 in high goiter states have noticeably higher labor force participation than cohorts born in the same years in low goiter states. Contemporaneous to the rise in the availability of iodized salt in the US, there was a larger increase in labor force participation among cohorts born in high goiter states than among those born in low goiter states.

In Panel B, we check the same patterns for the percentage of positive wage earners in the cohort. This outcome corrects for any individuals reporting labor force participation without positive pay as well as counts those individuals not actively seeking employment as non-wage-earners. The patterns are qualitatively very similar, though the percentage of positive wage earners is of course lower than the percentage of labor force participants for each cohort.

Table II presents results from the analogous difference-in-difference analysis to the comparisons in Figure V. Panel A reports means and differences for labor force participation; while Panel B presents means and differences for positive wage earning. High goiter states experienced a rise in labor force participation after salt iodization that was roughly .82 percentage points larger than that in low goiter states. Similarly, high goiter states experienced a rise in positive wage earning after salt iodization that was roughly .92 percentage points larger than that in low goiter states.

Next, we run regressions analogous to the difference-in-differences analysis but with the inclusion of additional controls. Table III presents the results of this regression analysis. Specifically, as discussed in section 4 above, we include state of birth and year of birth fixed effects as well as Census division of birth by birth year dummies in all specifications. Specifications in columns 3 and 4 also include other demographic controls such as gender and race as well as pre-iodization state means for these variables and interactions of these state means with the during and after dummies.

Lastly, the specifications from Table III divide the post-iodization period into “during” iodization and “after.” That is, we include a dummy for being born between 1924 and 1927 (“during” the roll out of iodized salt) and a dummy for being born between 1928 and 1931 (“after” availability of iodized salt peaked), interacting each one with the dummy for above median state goiter incidence. These cohorts are compared to the omitted category, cohorts born between 1920 and 1923 (“before” salt iodization).

The labor supply results from our main specification (columns 1 and 2 of Table III) are remarkably consistent with the estimates from the simple difference-in-differences analysis reported in Table II. Comparing the after iodization and before iodization cohorts, estimates of the effects of the availability of iodized salt on labor outcomes are 1.35 percentage points for labor force participation and 0.8 percentage points for positive wage earning. Notably, comparing cohorts born during the roll out of iodized salt to cohorts born before salt iodization yield nearly identical (even at times *larger*) estimates to those from “after” cohort comparisons for these labor outcomes. This seems to suggest that roll out of iodized salt occurred quickly, affecting post-iodization cohorts almost immediately.

In columns 3 and 4, including demographic controls reduces the magnitude and significance of our coefficients slightly, but the general results remain. There is still a significantly positive impact (of about 1.1 percentage points) on the labor force participation differential in the “after” cohort.

5.2 Education

Since improvements in cognitive ability increase the returns to education as well as the returns to experience, theory is ambiguous in terms of predicting the direction of the potential shift in educational attainment. Higher cognitive ability might motivate higher educational attainment, or it might cause earlier shifts from school to the labor market. The labor market portion of this empirical question was answered in the section above; we now turn to the education-related element of the question, first analyzing the difference-in-differences results for high school and college graduation in Table IV. While there are significant differences in the high school completion rates of high and low goiter states, these differences remained roughly constant before and after the introduction of iodized salt. On the other hand, the differential in college graduation rates appear to have increased significantly (by 0.9 percentage points) after the iodization of salt.

In the regression specifications reported in Table V, the 0 effect on high school graduation remains, but the positive result for college graduation is no longer significant. This is the case in both columns 1 and 2, which report results without demographic controls, as well as columns 3 and 4, which do include demographic controls. Using state of birth and year of birth time trends, as well as including birth-region-by-birth-year dummies, we find that the iodization of salt had virtually no effect on high school and college graduation rates. This, in conjunction with the significant and positive estimates from Tables II and III, suggests that the effect of salt iodization on the returns to work experience may have dominated its effect on the returns to education.

5.3 Income

Having established effects of salt iodization on labor supply and educational attainment, we next explore whether incomes responded to salt iodization as well. In Table VI, we present results from the difference-in-difference analysis on wage income and total income. Note that all of these outcomes are conditional on employment: these regressions are only run on the sample of individuals with positve wage or total earnings. That is, effects on incomes and type of employment will reflect a composite of the effect on selection into employment as well as changes in the distribution of incomes and job type conditional on employment.

Panels A and B of Table VI report means and differences in wage incomes and total incomes, respectively. The means and differences reported in column 1 of both panels indicate that high goiter states had, on average, higher incomes. In column 2, we see that these gaps close measurably post iodization, though high goiter states continue to have slightly higher income. Column 3 reports that high goiter states experienced a lower rise in both wage income and total income compared to low goiter states. This difference in difference estimate was around -$521 for wage income and -$245 for total income. This attenuation in the effect for total income is possibly due to farm income offsetting the inability of low-skilled, low income laborers to find wage work in high goiter states pre-iodization.

Table VII presents results from the analogous regression analysis. As with the labor supply and education regressions, all of these specifications control for region by birth year dummies. Columns 1 and 2 include no demographic controls while columns 3 and 4 include the same demographic controls described above.

Using the Census division x birth year time trends, none of the coefficients of interest are significant, although the results in columns 3 and 4 (which include demographic controls) are similar in magnitude to the difference in differences estimates. Less stable than the results on labor supply and education, these income results motivate further investigation beyond mean effects, into how salt iodization changed the distribution of income.

5.4 Income Distribution

Figure VI plots income distributions for high and low goiter states before and after salt iodization. Panel A shows wage income distributions, while Panel B shows total income distributions. The left half of each panel plots the distributions for all 4 cohort groups, while the right half of each panel plots the post-pre-iodization difference for high and low goiter states.

It is clear that the effects of access to iodized salt were concentrated in the lower income quantiles. That is, the highest income quantiles (roughly above $45,000 per year in 1999 dollars) appear to have shifted nearly identically across high and low goiter states. On the other hand, the lowest quantile of income grew faster in high goiter states than in low goiter states; while the middle income quantile (roughly between $20,000 and $45,000) grew faster in low goiter states.

We next run quantile dummy regressions to validate these graphical patterns. First, we calculate income quintiles from the 1950 census (in 1999 dollars). We then define, for each individual, dummies for inclusion in each income quintile. We apply the same income cutoffs for inclusion in each quintile to later census observations to map how each cohort's income distribution shifted. We run five regressions, one for each of these quantile inclusion dummies. Results are reported in Table VIII. Panel A reports effects on wage income quintiles; while Panel B reports effects on total income quintiles.

In Panel A, columns 1 through 3 show positive effects of access to iodized salt on the probability of being in the lower wage income quantiles. Specifically, the likelihood of being in the second wage income quantile as defined by the 1950 census rose by 0.35 to 0.68 percentage points more during and after the roll out of iodized salt in high goiter compared to in low goiter states. These results are significant at the 10% and 5% levels for during and after, respectively. On the other hand, as presented in columns 3 to 5, the likelihood of being in the 3rd, 4th, and 5th quintiles were not significantly affected.

The pattern in the results presented in Panel B are quite similar to those in Panel A, with the estimates a bit smaller and less significant. The likelihood of being in the 2nd quintile of total income rises in high goiter states by .61 percentage points more after the roll out of iodized salt. The effect on the during coefficient is not significant.

The patterns of effects on wage and total income distributions are summarized in Figure VII.

5.5 Gender Differences

For these six outcomes of interest, we also analyze gender differences by running the regressions separately for men and women. The results reported in Table IX demonstrate that our labor force participation results are driven by women, while the null result for the education outcomes hold for both sexes. In Panel A, we see no significant impacts on male labor force participation or positive wage earning. In contrast, Panel B shows that female labor force participation increased by about 1.6 percentage points for the after cohort and positive wage earning increased by about 0.8 percentage points (significant for the during cohort).

The differential impact on labor force participation across genders could be due in part to the significantly higher labor force participation rates of men compared to women throughout our sample period. In 1940, when individuals in our sample were first entering the workforce, male labor force participation rates among those aged 25 to 55 was 94.8% , compared to only 28.2% for females. This could also be explained by biological mechanisms – in particular, a higher sensitivity to iodine among females than males (Friedhoff et al., 2000). Scientific evidence, along with empirical findings from previous literature showing larger cognitive benefits of iodine supplementation on girls compared to boys (Field et al., 2009), bolsters our argument for iodine availability being the main driver of our results.

Despite all this, women were not the only ones to benefit from salt iodization. In terms of total income, we see that the effect on males is positive and significant for the after cohort, whereas the "after" coefficient for women is negative (but insignificant). Men, who had little room for improvement on the extensive margin, saw productivity improvements on the intensive margin. Limited income-earning opportunities for women during our sample period (especially in earlier decades) may have counteracted the stronger biological effects of iodine on females compared to males.

We also run our income quintile analysis separately for men and women and find that the movement into the lower income quintiles was also driven primarily by women. Table X reports the results on wage income, Panel A for males and Panel B for females. Although we see that men and women have the same pattern of signs (positive for the lower quintiles and negative for the higher quintiles), none of the coefficients are significant on the male sample, and the magnitudes of the coefficients on the first three quintiles are larger for women. Moreover, high goiter women in the during cohort are 0.7 percentage points more likely to be in the first income wage quintile, and high goiter women in the after cohort are 0.9 percentage points more likely to be in the second income wage quintile than their low goiter state counterparts (significant at the 10% level). Table XI tells a similar story. High goiter women in the after cohort were significantly more likely to be in the second quintile for total income (reported in Panel B) while high goiter men do not show any significantly different movement across quintiles (Panel A). Consistent with our finding that women were the ones moving into the labor force, these results further inform us that women were taking jobs at the bottom of the income distribution.

5.6 Robustness

Finally, we run additional regressions to check the robustness of our main results to additional controls and alternate explanations for the patterns observed. We might be concerned that other contemporaneous health improvements, such as the eradication of many infections diseases, which occurred roughly contemporaneously to the roll out of iodized salt might be driving the results. Specifically, if high goiter states also had higher incidence of these diseases (e.g. tuberculosis, hookworm, or malaria), then the eradication of these diseases during the first quarter of the 20th century might be driving the relative change in labor supply, education, and incomes in these states.

In order to check for this possibility, we rerun the main results controlling additionally for a dummy for above median incidence of tuberculosis, hookworm, and malaria and the interaction of these dummies with the during and after dummies. These results are reported in Table XII. The pattern of results is overwhelmingly preserved (and even strengthened for some coefficients). In fact, this specification offers some evidence of a positive effect on educational attainment: a positive significant estimate of 1.2 percentage points for the after coefficient in column 3 (high school graduation). Combined with our results discussed above, this table adds to the strong evidence for a positive labor participation result, offers some indication of a positive education effect (for which the evidence overall is still rather weak), and emphasizes the ambiguous effects on average income (due to more subtle distributional shifts).

We also address the possibility that changes in compulsory schooling laws, implemented at different times across states, may partially be driving the differential changes in labor outcomes that we attribute to introduction of iodized salt. We use data collected by Lleras-Muney (2002), which records the minimum years of schooling required by law in each state from 1915 to 1939. Like Lleras-Muney (2002), we match each individual to the compulsory schooling laws in place at their state of birth when they turn 14 (lowest minimum leaving age across all states). For the analysis discussed here, we use the number of years of school required according to compulsory attendance laws, although the results are similar when we use the number of years required according to child labor laws. Table XIII shows that our main results are robust to the inclusion of the compulsory schooling variable.

As a final check, we run placebo regressions that are specified in the exact same way as our baseline specification, except we restrict the sample to individuals born from 1916 to 1923 and replace the during and after cohorts with a cohort of individuals born between 1916 and 1919. As all of the individuals in this sample were born before the iodization of salt (and the placebo group is older than our currently defined "before" cohort), we expect to see no differential trends across high and low goiter states. In Table XIV, it can be seen that this is exactly what we find. The fact that high and low goiter states were not experiencing differential trends before the iodization of salt adds further reason to causally attribute our results to the dramatic increase in iodine availability in 1924.

6 Conclusion

In this study, we document the effects of the rapid nationwide iodization of salt in the United States. We estimate substantial impacts on labor force participation. Most of these new participants entered the first and second quintiles of the wage distribution. Repeating the analysis on subsamples stratified by gender reveals that the impacts were strongest on females. Blanket intervention with iodized salt, interestingly, had a targeted effect, concentrated on women at the margin of low-wage employment.

Our results contribute to several strands of literature and current policy debates. We add to the literature exploring drivers of notable shifts in labor force participation, particularly for females, over the 20th century in the US. Additionally, the historical experience in the US holds lessons for the many low-income countries currently deciding whether to, and how best to, invest in the eradication of deficiencies in essential micronutrients such as iodine.

Previous studies have estimated the roles of historical events, such as World War II and the staged rise in access to contraception, in explaining increases in labor force participation among women (e.g. Goldin (1991), Goldin and Olivetti (2013), Goldin and Katz (2002), and Bailey (2006)). We contribute complementary evidence that salt iodization explains a rise of roughly 1.63 percentage points (5 percent of the total rise from 1950 to 1990). Our evidence pertains to cohorts born after those most affected by the war, but before those most affected by increased access to oral contraceptives.[8] Unlike for these previously studied events, impacts on participation of salt iodization appear strongest among a lower-skilled portion of the workforce.

Additionally, our study provides evidence of the magnitude of benefits from eradication of deficiencies in essential micronutrients such as iodine. Many developing country populations face myriad nutritional constraints which have long-lasting impacts on health, economic livelihoods, and general welfare. Our estimates show that salt iodization led to a larger than 1 percentage point rise in labor force participation, particularly in the first and second income quintiles. From a base labor force of 62 million in 1940, this amounts to nearly 2 billion USD in additional wage income using, conservatively, the mean of first income quintile (62 million x 0.01 x 3200 USD = 1.984 billion USD).

Lastly, it should be noted that the "intervention" cost the taxpayer nothing, in that the roll-out of iodized salt was completely undertaken by the private sector. That is, the cost of salt iodization was fully borne by the salt producer, while the cognitive benefit was realized by the general population. Indeed, the rapid rise in both supply and demand (as evidenced by the negligible difference between the "during" and "after" coefficients) might be attributable to the efficiency and underlying profit motive of the private firm that undertook the intervention. This historical event could provide inspiration for the optimal design of future interventions–by the government or the private sector–in developing countries.

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[8] Indeed, we estimate our rise in labor force participation due to salt iodization *relative* to the cohort affected by the war.

A Additional Tables

In Table A.II, we present the states ordered by goiter prevalence calculated from Olesen (1929). In the left column are the states with goiter rates below the median and in the right column are states with goiter rates above the median.

Table A.II lists all states by Census region, and identifies which states fall into our goiter belt classification.

B Data Appendix

B.1 State-Level Goiter Rates

Olesen (1929) reports goiter rates in various localities for 37 states. For each of these localities, there is a column for boys, a column for girls, as well as a column for boys and girls. For each of these columns, he reports the percent found with goiter and in some cases, also the number of children examined. Because the number of children examined is missing for over 400 localities, and also because weighting by this number would be artificial (since we do not have locality populations, which would be the ideal), we calculate the simple mean of the percentages across all localities within a state for each column. Our goiter rate of interest is the state-level goiter rate in the boys and girls column. For states which have no percentages reported in the boys and girls column, we take the average across the boys column and the girls column. For those that only have a boys column or a girls column, we use the state average of the non-missing column.

B.2 Independent Indicator Variables

- $before$=1 if individual was born in 1920-1924; $before$=0 otherwise
- $during$=1 if individual was born in 1924-1927; $during$=0 otherwise
- $after$=1 if individual was born in 1928-1931; $after$=0 otherwise
- $placebo$=1 if individual was born in 1916-1919; $placebo$=0 otherwise

Because the Census gives us a snapshot of the population every 10 years, each group only appears in our dataset at specific ages. For example, members of the "before" group are aged 27-30 in the

1950 Census, 37-40 in the 1960 Census, and so on. Meanwhile, the "during" individuals were aged 23-26 in the 1950 Census and ten years older each subsequent Census, while the "after" individuals were aged 19-22 in the 1950 Census and ten years older each following Census. We never see "before" individuals aged 31-36, for example, or "during" individuals aged 27-32. It is for this reason that we do not include age fixed effects with birth year fixed effects in our specification. This means that when we compare across cohorts, we are always comparing groups of different ages; however, our underlying assumption is that the differences between these cohorts is fixed across high and low goiter states in the absence of iodization.

B.3 Control Variables

- $female$=1 for females; $female$=0 for males
- $black$=1 for for black individuals; $black$=0 for all other races
- $femaleprop1920$: This measures the state-level proportion of the population that was female in the individual's state of residence (as reported in the 1920 Census).
- $blackprop1920$: This measures the state-level proportion of the population that was black in the individual's state of residence (as reported in the 1920 Census).

B.4 Outcome Variables

B.4.1 Basic Outcomes

- $1(GraduatedHighSchool)$=1 if the individual graduated high school. This includes those who completed the GED but not those who went to vocational school ;
  $1(GraduatedHighSchool)$=0 if the individual did not complete high school.
- $1(GraduatedCollege)$=1 if the individual graduated from college.;
  $1(GraduatedCollege)$=0 if the individual did not complete college.
- $1(ParticipatedinLaborForce)$=1 if the individual participated in the labor force;
  $1(ParticipatedinLaborForce)$=0 if the individual did not participate in the labor force
- $WageIncome$: This is the annual wage and salary income earned by the individual (for those earning positive wages/salary). This variable is missing for individuals recorded as having zero

wage/salary income. Although this variable is top-coded differently across Census years, we applied the top-coding from the 1950 Census to all years (setting the maximum income to $70,000). All values are adjusted to 1999 prices using to Census-provided multipliers.

- $TotalIncome$: This is the annual total income earned by the individual (for those earning positive total income). This variable is missing for individuals recording as earning zero total income. Although this variable is top-coded differently across Census years, we applied the top-coding from the 1950 Census to all years (setting the maximum income to $70,000). All values are adjusted to 1999 prices according to Census-provided multipliers.

B.4.2 Income Quintile Analysis

$1(TotalIncomeQuintile1)$ to $1(TotalIncomeQuintile5)$ and $1(WageIncomeQuintile1)$ to $1(WageIncomeQuintile5)$ were constructed as follows. Using the entire population aged 25-55 from the 1950 Census, the 20th, 40th, 60th, and 80th percentiles were calculated for total income and total wage. These were used as the baseline quintiles to construct the following variables:

- $1(TotalIncomeQuintile1)$=1 if the individual's total income fell into the first quintile of $TotalIncome$; $1(TotalIncomeQuintile1)$=0 if the individual's total income falls outside of this first quintile. This variable is missing for those with missing total income in the Census. Analogous variables were constructed for the second, third, fourth, and fifth quintiles. For each individual, only one of these five variables is set equal to one.

- $1(WageIncomeQuintile1)$=1 if the individual's total income fell into the first quintile of $WageIncome$; $1(WageIncomeQuintile1)$=0 if the individual's wage income falls outside of this first quintile. This variable is missing for those with missing wage income in the Census. Analogous variables were constructed for the second, third, fourth, and fifth quintiles. For each individual, only one of these five variables is set equal to one.

References

Almond, D. and Currie, J. (2011). Killing me softly: The fetal origins hypothesis. *Journal of Economic Perspectives*, 25(3):153–172.

Almond, D., Doyle, J., Kowalski, A., and Williams, H. (2010). Estimating marginal returns to medical care: Evidence from at-risk newborns. *Quarterly Journal of Economics*, 125(2):591634.

Andersson, M., de Benoist, B., and Rogers, L. (2010). Epidemiology of iodine deficiency: Salt iodisation and iodine status. *Best Practice and Research Clinical Endocrinology and Metabolism*, 24:1–11.

Annegers, J. and Mickelsen, O. (1973). Goiter and iodized salt, a historical review and examination of the present role of iodized salt. Unpublished Manuscript.

Backstrand, J. (2002). The history and future of food fortification in the united states: A public health perspective. *Nutrition Reviews*, 60:15–26.

Bailey, M. J. (2006). More power to the pill: the impact of contraceptive freedom on women's life cycle labor supply. *The Quarterly Journal of Economics*, 121(1):289–320.

Baumann, F. (1896). Ueber das normale vorkommen von jod im thierkorper. *Physiol Chem*, 21:319–330.

Bhalotra, S. and Venkataramani, A. (2012). Shadows of the captain of the men of death: Early life health interventions, human capital investments, and institutions. working paper.

Bhutta, Z., Das, J., Rizvi, A., et al. (2013). The lancet nutrition interventions review group, and the maternal and child nutrition study group. evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost. *Lancet*, pages 60996–4.

Black, R. E., Victora, C. G., Walker, S. P., Bhutta, Z. A., Christian, P., de Onis, M., Ezzati, M., Grantham-McGregor, S., Katz, J., Martorell, R., et al. (2013). Maternal and child undernutrition and overweight in low-income and middle-income countries. *The Lancet*.

Bleakley, H. (2007). Disease and development: evidence from hookworm eradication in the american south. *The Quarterly Journal of Economics*, 122(1):73–117.

Bleakley, H. (2010). Malaria eradication in the americas: A retrospective analysis of childhood exposure. *American Economic Journal: Applied Economics*, 2(2):1–45.

Brush, B. E. and Atland, J. (1952). Goiter prevention with iodized salt: Results of a thirty-year study. *The Journal of Clinical Endocrinology And Metabolism*, 12(10):1380–1388.

Cao, X.-Y., Jiang, X.-M., Dou, Z.-H., Rakeman, M. A., Zhang, M.-L., O'Donnell, K., Ma, T., Amette, K., DeLong, N., and DeLong, G. R. (1994). Timing of vulnerability of the brain to iodine deficiency in endemic cretinism. *New England Journal of Medicine*, 331(26):1739–1744.

Center, C. C. (2008). Copenhagen consensus 2008. *Fredriksberg, Denmark: Copenhagen Consensus Center*.

Clar, C., Wu, T., Liu, G., and Li, P. (2002). Iodized salt for iodine deficiency disorders: A systematic review. *Endocrinology and Metabolism Clinics of North America*, 31:681–698.

Currie, J. and Vogl, T. (2012). Early-life health and adult circumstance in developing countries. Technical report, National Bureau of Economic Research.

de Benoist, B., Andersson, M., Egli, I., Takkouche, B., and Allen, H. (2004). Iodine status worldwide: Who global database on iodine deficiency. World Health Organization.

Dugbartey, A. T. (1998). Neurocognitive aspects of hypothyroidism. *Archives of Internal Medicine*, 158(13):1413–1418.

Eltom, M., Karlsson, F. A., Kamal, A. M., Boström, H., and Dahlberg, P. A. (1985). The effectiveness of oral iodized oil in the treatment and prophylaxis of endemic goiter. *Journal of Clinical Endocrinology and Metabolism,*, 61(6):1112–1117.

Feyrer, J., Politi, D., and Weil, D. N. (2013). The economic effects of micronutrient deficiency: Evidence from salt iodization in the united states. NBER Working Paper No. 19233.

Field, E., Robles, O., and Torero, M. (2009). Iodine deficiency and schooling attainment in tanzania. *American Economic Journal: Applied Microeconomics*, 1(4):140–169.

Friedhoff, A., Miller, J., Armour, M., Schweitzer, J., and Mohan, S. (2000). Role of maternal biochemistry in fetal brain development: Effect of maternal thyroidectomy on behaviour and biogenic amine metabolism in rat progeny. *International Journal of Neuropsychopharmacology*, 3:89–97.

Furnee, C. A. (1997). Prevention and control of iodine deficiency: A review of a study on the effectiveness of oral iodized oil in malawi. *European Journal of Clinical Nutrition*, 51(4):S9–10.

Goldin, C. and Katz, L. F. (2002). The power of the pill: Oral contraceptives and women's career and marriage decisions. *Journal of Political Economy*, August 2002. ¡p¿revised version of NBER Working Paper no. 7527¡/p¿.

Goldin, C. and Olivetti, C. (2013). Shocking labor supply: A reassessment of the role of world war ii on women's labor supply. *American Economic Review: Papers and Proceedings*, 103(3):257–262.

Goldin, C. D. (1991). The role of world war ii in the rise of women's employment. *The American Economic Review*, 81(4):741–756.

Hall, D. (1914). The prevalence of goiter in the northwest, based on the examinations of 3,339 students entering the university of washington. *Northwest Medicine*, 6:189–391.

Hamwi, G. J., Van Fossen, A. W., Whetstone, R. E., and Williams, I. (1952). Endemic goiter in ohio school children. *American Journal of Public Health*, 45(10):1344–1348.

Heckman, J. J. (2006). Skill formation and the economics of investing in disadvantaged children. *Science*, 312(5782):1900–1902.

Hetzel, B. and Pandav, C. (1996). *S.O.S for a Billion: The Conquest of Iodine Deficiency Disorders*. Oxford University Press.

Hetzel, B. S. (1989). *The Story of Iodine Deficiency: An International Challenge in Nutrition*, chapter The Biology of Iodine. Oxford University Press.

Hetzel, B. S. and Mano, M. T. (1989). A review of experimental studies of iodine deficiency during fetal development. *Journal of Nutrition*, 119(2):145–151.

Hornbeck, R. (2012). The enduring impact of the american dust bowl: Short- and long-run adjustments to environmental catastrophe. *American Economic Review*, 102(4):1477–1507.

Hoynes, H. W., Schanzenbach, D. W., and Almond, D. (2012). Long run impacts of childhood access to the safety net. Technical report, National Bureau of Economic Research.

Huda, S., Grantham-McGregor, S., Rahman, K., and Tomkins, A. (1999). Biochemical hypothyroidism secondary to iodine deficiency is associated with poor school achievement and cognition in bangladeshi children. *Journal of Nutrition*, 129:980–987.

Kofoid, C. A. and Tucker, J. P. (1921). On the relationship of infection by hookworm to the incidence of morbidity and mortality in 22,842 men in the united states army at camp bowie, texas, from october 1917 to april 1918. *American Journal of Hygiene*, 1(1):79–117.

Lamberg, B.-A. (1991). Endemic goitreiodine deficiency disorders. *Annals of Medicine*, 23(4):367–372.

Lavado-Autric, R., Auso, E., Garca-Velasco, J. V., del Carmen Arufe, M., del Rey, F. E., Berbel, P., and de Escobar, G. M. (2003). Early maternal hypothyroxinemia alters histogenesis and cerebral cortex cytoarchitecture of the progeny. *Journal of Clinical Investigation*, 111(7):1073–1082.

Lleras-Muney, A. (2002). Were compulsory attendance and child labor laws effective? an analysis from 1915 to 1939. *Journal of Law and Economics*, 45(2):401–435.

Love, A. G. and Davenport, C. B. (1920). *Defects Found in Drafted Men. Statistical Information Compiled from the Draft Records Showing the Physical Conditions of the Men Registered and Examined in Pursuance of the Requirements of the Selective-Service Act.* Washington DC: Government Printing Office.

Maccini, S. and Yang, D. (2009). Under the weather: Health, schooling, and economic consequences of early-life rainfall. *American Economic Review*, 99(3):1006–1026.

Marine, D. and Feiss, H. (1915). The absorption of potassium iodid by perfused thyroid glands and some of the factors modifying it. *Journal of Pharmacology and Experimental Therapeutics*, 7:557–576.

Marine, D. and Kimball, O. (1917). The prevention of simple goiter in man. *Journal of Laboratory and Clinical Medicine*, 3:40–48.

Marine, D. and Kimball, O. (1921). The prevention of simple goiter in man. *Journal of the American Medical Association*, 77:1068–1070.

Marine, D. and Lenhart, C. (1909). Effects of the administration or withholding of iodin-containing compounds in normal, colloid, or actively hyperplastic thyroids of dogs. *Archives of Internal Medicine*, 4:253–270.

Markel, H. (1987). When it rains it pours: Endemic goiter, iodized salt and david murray cowie, md. *American Journal of Public Health*, 77(2):219–229.

Martorell, R. (1995). Results and implications of the incap follow-up study. *The Journal of nutrition*, 125(4 Suppl):1127S–1138S.

McClendon, J. F. (1939). *Iodine and the Incidence of Goiter*. University of Minnesota Press.

McClendon, J. F. and Hathaway, J. C. (1924). Inverse relation between iodin in food and drink and goiter: Simple and exophthalmic. *Journal of the American Medical Association*, 82:1668–72.

Olesen, R. (1915). Goiter, its prevalence in chicago, as shown by the examination of 800 individuals. *Illinois Medical Journal*, 27:16.

Olesen, R. (1929). Distribution of endemic goiter in the united states as shown by thyroid surveys. *Public Health Reports*, 44:1463–87.

Pharoah, P. and Connolly, K. (1987). A controlled trial of iodinated oil for the prevention of endemic cretinism: A long-term follow-up. *International Journal of Epidemiology*, 16(1):68–73.

Politi, D. (2011a). The effects of the generalized use of iodized salt on occupational patterns in switzerland. Working Paper.

Politi, D. (2011b). The impact of iodine deficiency eradication on schooling: Evidence from the introduction of iodized salt in switzerland. Working Paper.

Pop, V. J., Kuijpens, J. L., van Baar, A. L., Verkerk, G., van Son, M. M., de Vijlder, J. J., Vulsma, T., Wiersinga, W. M., Drexhage, H. A., and Vader, H. L. (1999). Low maternal free thyroxine concentrations during early pregnancy are associated with impaired psychomotor development in infancy. *Clinical Endocrinology*, 50(2):149–155.

Santiago-Fernandez, P., Torres-Barahona, R., Muela-Martinez, A., Rojo-Martinez, G., Garcia-Fuentes, E., M., G., Leon, A., and Soriguer, F. (2004). Intelligence quotient and iodine intake: A cross-sectional study in children. *The Journal of Clinical Endocrinology & Metabolism*, 89:3851–57.

Schiel, J. B. J. and Wepfer, A. J. (1976). Distributional aspects of endemic goiter in the united states. *Economic Geography*, 52(2):116–126.

Smith, G. (1917). Fetal athyreosis. *Journal of Biological Chemistry*, 29:215–225.

Sundqvist, J., Wijetunga, M., Assey, V., Gebre-Medhin, M., and Peterson, S. (1998). Salt iodation and risk of neonatal brain damage. *Lancet*, 352(9121):34–35.

WHO (1992). National strategies for overcoming micronutrient malnutrition. Unpublished.

WHO (2004). Iodine status worldwide. global database on iodine deficiency.

Zimmermann, M. B., Aeberli, I., Torresani, T., and Bürgi, H. (2005). Increasing the iodine concentration in the swiss iodized salt program markedly improved iodine status in pregnant women and children: A 5-y prospective national study. *American Journal of Clinical Nutrition*, 82(2):388–392.

Table I
Summary Statistics for Individuals Aged 25-55, 1940 Census

	(1)	(2)	(3)	(4)
	Whole Sample	*High Goiter States*	*Low Goiter States*	*High-Low Difference*
1(Participated in Labor Force)	0.614	0.611	0.617	-0.00543***
	(0.487)	(0.487)	(0.486)	(0.00152)
1(Earned Positive Wage)	0.503	0.517	0.484	0.0325***
	(0.500)	(0.500)	(0.500)	(0.00157)
1(Graduated High School)	0.291	0.322	0.248	0.0742***
	(0.454)	(0.467)	(0.432)	(0.00142)
1(Graduated College)	0.0555	0.0626	0.0457	0.0170***
	(0.229)	(0.242)	(0.209)	(0.000715)
Wage Income	13540.2	15009.9	11399.0	3610.9***
	(10803.5)	(11087.6)	(9996.1)	(47.51)
1(Female)	0.503	0.502	0.505	-0.00361*
	(0.500)	(0.500)	(0.500)	(0.00156)
1(Black)	0.0949	0.0147	0.204	-0.190***
	(0.293)	(0.121)	(0.403)	(0.000869)
Number of Observations	418791	241689	177102	

Table II
Labor Supply Differences

Panel A: 1(Participated in Labor Force)

	(1)	(2)	(3)
	Pre-Iodization	Post-Iodization	Post-Pre Difference
Born in a Low Goiter State	0.668	0.697	0.0287***
	(0.471)	(0.460)	(0.00144)
Born in a High Goiter State	0.677	0.714	0.0369***
	(0.468)	(0.452)	(0.00118)
High-Low Difference	0.00898***	0.0171***	0.00816***
	(0.00169)	(0.000852)	(0.00186)

Panel B: 1(Earned Positive Wage)

	(1)	(2)	(3)
	Pre-Iodization	Post-Iodization	Post-Pre Difference
Born in a Low Goiter State	0.659	0.669	0.0107***
	(0.474)	(0.470)	(0.00164)
Born in a High Goiter State	0.666	0.686	0.0199***
	(0.472)	(0.464)	(0.00133)
High-Low Difference	0.00705***	0.0163***	0.00922***
	(0.00193)	(0.000887)	(0.00211)

Table III
Effects of Salt Iodization on Labor Supply

	(1)	(2)	(3)	(4)
	1(Participated in Labor Force)	1(Earned a Positive Wage)	1(Participated in Labor Force)	1(Earned a Positive Wage)
After x High Goiter	0.0135***	0.00852**	0.0109***	0.00541
	(0.00378)	(0.00337)	(0.00402)	(0.00387)
During x High Goiter	0.00901**	0.00703*	0.00602	0.00386
	(0.00407)	(0.00405)	(0.00421)	(0.00471)
Fixed Effects	State of Birth, Year of Birth		State of Birth, Year of Birth	
Region Time Trends	Census Division of Birth x Birth Year Dummies		Census Division of Birth x Birth Year Dummies	
Demographic Controls	No		Yes	
Observations	1,427,788	1,322,567	1,427,788	1,322,567
Mean of Dependent Variable	0.700	0.676	0.700	0.676

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table IV
Education Differences

Panel A: 1(Graduated High School)

	(1)	(2)	(3)
	Pre-Iodization	Post-Iodization	Post-Pre Difference
Born in a Low Goiter State	0.477	0.542	0.0654***
	(0.499)	(0.498)	(0.00174)
Born in a High Goiter State	0.634	0.697	0.0634***
	(0.482)	(0.460)	(0.00133)
High-Low Difference	0.157***	0.155***	-0.00204
	(0.00200)	(0.000904)	(0.00216)

Panel B: 1(Graduated College)

	(1)	(2)	(3)
	Pre-Iodization	Post-Iodization	Post-Pre Difference
Born in a Low Goiter State	0.0823	0.114	0.0319***
	(0.275)	(0.318)	(0.00108)
Born in a High Goiter State	0.108	0.149	0.0410***
	(0.310)	(0.356)	(0.000996)
High-Low Difference	0.0256***	0.0347***	0.00922***
	(0.00121)	(0.000648)	(0.00211)

Table V
Effects of Salt Iodization on Education

	(1)	(2)	(3)	(4)
	1(Graduated High School)	1(Graduated College)	1(Graduated High School)	1(Graduated College)
After x High Goiter	-0.00560	-0.000434	-0.0109	0.00431
	(0.00760)	(0.00426)	(0.0104)	(0.00634)
During x High Goiter	0.00163	0.000409	-0.00468	0.00307
	(0.00566)	(0.00299)	(0.00896)	(0.00453)
Fixed Effects	State of Birth, Year of Birth		State of Birth, Year of Birth	
Region Time Trends	Census Division of Birth x Birth Year Dummies		Census Division of Birth x Birth Year Dummies	
Demographic Controls	No		Yes	
Observations	1,322,567	1,322,567	1,322,567	1,322,567
Mean of Dependent Variable	0.623	0.128	0.623	0.128

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table VI
Income Differences

Panel A: Wage Income

	(1)	(2)	(3)
	Pre-Iodization	Post-Iodization	Post-Pre Difference
Born in a Low Goiter State	25988.1	29357.0	3368.8***
	(17975.1)	(19417.0)	(82.30)
Born in a High Goiter State	30833.7	33681.0	2847.3***
	(18942.7)	(20438.0)	(70.55)
High-Low Difference	4845.6***	4324.0***	-521.6***
	(93.36)	(46.32)	(109.5)

Panel B: Total Income

	(1)	(2)	(3)
	Pre-Iodization	Post-Iodization	Post-Pre Difference
Born in a Low Goiter State	26344.6	28915.0	2570.4***
	(19071.8)	(20407.5)	(79.94)
Born in a High Goiter State	31197.6	33522.8	2325.2***
	(19991.2)	(21387.6)	(68.83)
High-Low Difference	4853.0***	4607.8***	-245.2*
	(91.63)	(44.37)	(106.4)

Table VII
Effects of Salt Iodization on Income

	(1)	(2)	(3)	(4)
	Wage Income	Total Income	Wage Income	Total Income
After x High Goiter	9.972	431.3	-661.7	-276.7
	(317.8)	(267.7)	(453.7)	(388.0)
During x High Goiter	46.54	434.9	-685.9	-306.7
	(345.6)	(300.2)	(434.6)	(389.1)
Fixed Effects	State of Birth, Year of Birth		State of Birth, Year of Birth	
Region Time Trends	Census Division of Birth x Birth Year Dummies		Census Division of Birth x Birth Year Dummies	
Demographic Controls	No		Yes	
Observations	894550	1059916	894550	1059916
Mean of Dependent Variable	31619.6	31400.5	31619.6	31400.5

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table VII
Effects of Salt Iodization on Income by Quintile

Panel A: Wage Income

	(1)	(2)	(3)	(4)	(5)
	1st Quintile	2nd Quintile	3rd Quintile	4th Quintile	5th Quintile
After x High Goiter	0.00498	0.00677***	0.000988	-0.000896	-0.00332
	(0.00329)	(0.00184)	(0.00228)	(0.00261)	(0.00480)
During x High Goiter	0.00615**	0.00349*	0.000845	-0.000327	-0.00313
	(0.00274)	(0.00182)	(0.00219)	(0.00271)	(0.00605)
Fixed Effects	State of Birth, Year of Birth				
Region Time Trends	Census Division of Birth x Birth Year Dummies				
Demographic Controls	No				
Observations	1,322,567	1,322,567	1,322,567	1,322,567	1,322,567
Mean of Dependent Variable	0.0748	0.0683	0.0737	0.0715	0.388

Panel B: Total Income

	(1)	(2)	(3)	(4)	(5)
	1st Quintile	2nd Quintile	3rd Quintile	4th Quintile	5th Quintile
After x High Goiter	-0.00145	0.00606***	-0.00260	-0.00444	0.00473
	(0.00288)	(0.00221)	(0.00289)	(0.00312)	(0.00480)
During x High Goiter	-0.000129	0.00275	-0.000267	-0.00546*	0.00658
	(0.00284)	(0.00299)	(0.00231)	(0.00309)	(0.00600)
Fixed Effects	State of Birth, Year of Birth				
State Time Trends	Census Region of Birth x Birth Year Dummies				
Demographic Controls	No				
Observations	1,319,342	1,319,342	1,319,342	1,319,342	1,319,342
Mean of Dependent Variable	0.102	0.0919	0.0851	0.0975	0.426

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table IX

Effects of Salt Iodization, By Gender (Labor Force, Education, and Income)

Panel A: Males

	(1)	(2)	(3)	(4)	(5)	(6)
	1(Participated in Labor Force)	1(Earned a Positive Wage)	1(Graduated High School)	1(Graduated College)	Wage Income	Total Income
After x High Goiter	0.00562	0.00551	-0.00372	-0.000758	301.7	738.2**
	(0.00346)	(0.00499)	(0.00805)	(0.00704)	(374.9)	(319.2)
During x High Goiter	0.00252	0.00230	-0.00194	0.00223	259.2	625.7*
	(0.00313)	(0.00508)	(0.00629)	(0.00570)	(426.3)	(361.2)
Fixed Effects	State of Birth, Year of Birth				State of Birth, Year of Birth	
Region Time Trends	Census Division of Birth x Birth Year Dummies				Census Division of Birth x Birth Year Dummies	
Demographic Controls	No				No	
Observations	689,747	640,248	640,248	640,248	535,562	625,650
Mean of Dependent Variable	0.918	0.836	0.609	0.171	40061	40240

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Panel B: Females

	(1)	(2)	(3)	(4)	(5)	(6)
	1(Participated in Labor Force)	1(Earned a Positive Wage)	1(Graduated High School)	1(Graduated College)	Wage Income	Total Income
After x High Goiter	0.0163**	0.00864	-0.00736	-0.00149	-543.4*	-162.4
	(0.00799)	(0.00523)	(0.0100)	(0.00368)	(302.1)	(283.3)
During x High Goiter	0.0102	0.00888*	0.00507	-0.00244	-306.1	87.73
	(0.00702)	(0.00497)	(0.00775)	(0.00268)	(259.3)	(272.5)
Fixed Effects	State of Birth, Year of Birth				State of Birth, Year of Birth	
Region Time Trends	Census Division of Birth x Birth Year Dummies				Census Division of Birth x Birth Year Dummies	
Demographic Controls	No				No	
Observations	738,041	682,319	682,319	682,319	358,988	434,266
Mean of Dependent Variable	0.496	0.526	0.636	0.0880	18528	18227

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table X
Effects of Salt Iodization on Income by Wage Income Quintile and Gender

Panel A: Males

	(1)	(2)	(3)	(4)	(5)
	1st Quintile	2nd Quintile	3rd Quintile	4th Quintile	5th Quintile
After x High Goiter	0.00461	0.00476	0.00215	-0.000747	-0.00526
	(0.00336)	(0.00330)	(0.00299)	(0.00355)	(0.00770)
During x High Goiter	0.00587	0.00302	0.00305	-0.00176	-0.00788
	(0.00336)	(0.00318)	(0.00259)	(0.00403)	(0.00918)
Fixed Effects	State of Birth, Year of Birth				
Region Time Trends	Census Division of Birth x Birth Year Dummies				
Demographic Controls	No				
Observations	640248	640248	640248	640248	640248
Mean of Dependent Variable	0.0343	0.0362	0.0504	0.0653	0.650

Panel B: Females

	(1)	(2)	(3)	(4)	(5)
	1st Quintile	2nd Quintile	3rd Quintile	4th Quintile	5th Quintile
After x High Goiter	0.00634	0.00970*	0.000912	-0.000510	-0.00780
	(0.00413)	(0.00368)	(0.00417)	(0.00306)	(0.00435)
During x High Goiter	0.00717*	0.00461	-0.000520	0.00128	-0.00366
	(0.00336)	(0.00323)	(0.00319)	(0.00317)	(0.00391)
Fixed Effects	State of Birth, Year of Birth				
State Time Trends	Census Region of Birth x Birth Year Dummies				
Demographic Controls	No				
Observations	682319	682319	682319	682319	682319
Mean of Dependent Variable	0.111	0.0983	0.0937	0.0767	0.146

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table XI
Effects of Salt Iodization on Income by Total Income Quintile and Gender

Panel A: Males

	(1)	(2)	(3)	(4)	(5)
	1st Quintile	2nd Quintile	3rd Quintile	4th Quintile	5th Quintile
After x High Goiter	-0.00186	0.00561	-0.00348	-0.00648	0.00553
	(0.00331)	(0.00381)	(0.00396)	(0.00418)	(0.00725)
During x High Goiter	0.00101	0.00104	0.00114	-0.00895	0.00514
	(0.00309)	(0.00473)	(0.00333)	(0.00462)	(0.00843)
Fixed Effects	State of Birth, Year of Birth				
Region Time Trends	Census Division of Birth x Birth Year Dummies				
Demographic Controls	No				
Observations	638245	638245	638245	638245	638245
Mean of Dependent Variable	0.0434	0.0581	0.0637	0.0953	0.720

Panel B: Females

	(1)	(2)	(3)	(4)	(5)
	1st Quintile	2nd Quintile	3rd Quintile	4th Quintile	5th Quintile
After x High Goiter	0.000275	0.00749*	-0.000816	-0.00199	-0.00275
	(0.00421)	(0.00354)	(0.00393)	(0.00363)	(0.00502)
During x High Goiter	0.0000321	0.00502	-0.000984	-0.00194	0.00230
	(0.00449)	(0.00301)	(0.00345)	(0.00365)	(0.00413)
Fixed Effects	State of Birth, Year of Birth				
State Time Trends	Census Region of Birth x Birth Year Dummies				
Demographic Controls	No				
Observations	681097	681097	681097	681097	681097
Mean of Dependent Variable	0.156	0.124	0.103	0.0991	0.155

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table XII
Robustness to Contemporaneous Disease Eradication

	(1)	(2)	(3)	(4)	(5)	(6)
	1(Participated in Labor Force)	1(Earned a Positive Wage)	1(Graduated High School)	1(Graduated College)	Wage Income	Total Income
After x High Goiter	0.0122***	0.00972**	0.0124*	0.00178	54.39	396.5
	(0.00382)	(0.00400)	(0.00638)	(0.00454)	(316.0)	(299.1)
During x High Goiter	0.00902**	0.00860**	0.00769	0.00219	113.0	463.7
	(0.00372)	(0.00402)	(0.00523)	(0.00341)	(322.1)	(301.0)
After x High Tuberculosis	-0.00295	-0.00192	0.0274***	0.00171	69.46	-129.4
	(0.00379)	(0.00447)	(0.0102)	(0.00483)	(162.5)	(160.9)
During x High Tuberculosis	4.22e-05	0.000130	0.000437**	3.68e-05	1.233	-6.472
	(0.000118)	(0.000144)	(0.000181)	(0.000102)	(6.724)	(7.480)
After x High Hookworm	-0.000953	-0.00158	-0.0166	-0.00331	309.7	157.6
	(0.00316)	(0.00353)	(0.0103)	(0.00513)	(248.9)	(226.7)
During x High Hookworm	-0.00494*	-0.00388	-0.0132**	-0.00201	212.1	33.29
	(0.00285)	(0.00260)	(0.00594)	(0.00271)	(293.1)	(303.9)
After x High Malaria	0.000373	0.00614	0.00531	0.00276	180.6	172.1
	(0.00323)	(0.00373)	(0.00936)	(0.00621)	(180.4)	(195.8)
During x High Malaria	-0.00317	-6.62e-05	0.00252	0.00379	284.8	272.0
	(0.00347)	(0.00360)	(0.00524)	(0.00388)	(207.0)	(237.7)
Fixed Effects	State of Birth, Year of Birth				State of Birth, Year of Birth	
Region Time Trends	Census Division of Birth x Birth Year Dummies				Census Division of Birth x Birth Year Dummies	
Demographic Controls	No				No	
Observations	1,427,788	1,322,567	1,322,567	1,322,567	894,550	1,059,916
Mean of Dependent Variable	0.700	0.676	0.623	0.128	31422	31241

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table XIII
Robustness to Inclusion of Compulsory Schooling Laws

	(1)	(2)		(3)	(4)	(5)
	1(Participated in Labor Force)	1(Earned a Positive Wage)	1(Graduated High School)	1(Graduated College)	Wage Income	Total Income
After x High Goiter	0.0133***	0.00853**	-0.00463	0.000965	19.68	428.9
	(0.00390)	(0.00344)	(0.00752)	(0.00461)	(322.2)	(278.2)
During x High Goiter	0.00883**	0.00704*	0.00255	0.00174	55.79	432.6
	(0.00417)	(0.00410)	(0.00550)	(0.00325)	(347.4)	(309.9)
Years of Compulsory Schooling	0.000855	-3.47e-05	-0.00433	-0.00628	-45.01	10.95
	(0.00147)	(0.00156)	(0.00294)	(0.00380)	(109.3)	(96.79)
Fixed Effects	State of Birth, Year of Birth				State of Birth, Year of Birth	
State Time Trends	Census Division of Birth x Birth Year Dummies				Census Division of Birth x Birth Year Dummies	
Demographic Controls	No				No	
Observations	1,427,788	1,322,567	1,322,567	1,322,567	894,550	1,059,916
Mean of Dependent Variable	0.700	0.676	0.623	0.128	31422	31241

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table XIV
Placebo Checks

	(1)	(2)		(3)	(4)	(5)
	1(Participated in Labor Force)	1(Earned a Positive Wage)	1(Graduated High School)	1(Graduated College)	Wage Income	Total Income
Placebo x High Goiter	0.00301	-0.000960	-0.00942	-0.00134	67.89	414.7
	(0.00372)	(0.00382)	(0.00692)	(0.00287)	(296.9)	(314.7)
Fixed Effects	State of Birth, Year of Birth				State of Birth, Year of Birth	
State Time Trends	Census Division of Birth x Birth Year Dummies				Census Division of Birth x Birth Year Dummies	
Demographic Controls	No				No	
Observations	571,461	431,443	431,443	431,443	284,612	330,919
Mean of Dependent Variable	0.674	0.658	0.543	0.0917	28678	28953

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table A.I
Goiter Prevalence by State from Oleson (1929)

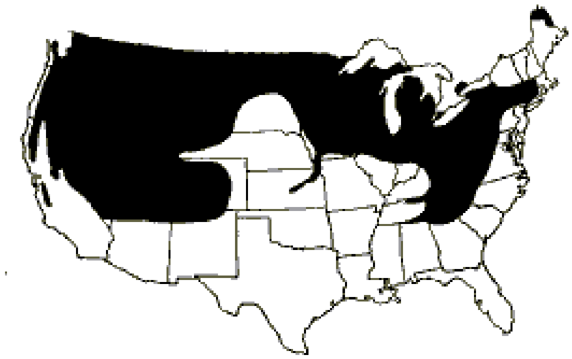
Low Goiter States		High Goiter States	
California	0.023	New Jersey	9.100
Alabama	0.067	Oklahoma	10.410
Arizona	0.080	New York	12.050
New Mexico	0.100	Wyoming	15.000
New Hampshire	0.200	Pennsylvania	15.470
North Carolina	0.200	Washington	17.642
Mississippi	0.310	Connecticut	18.200
Georgia	0.800	Michigan	19.577
Rhode Island	0.860	Illinois	20.377
Massachusetts	1.600	Montana	20.400
Missouri	3.000	Oregon	22.500
North Dakota	3.967	Minnesota	23.635
Tennessee	5.217	Maine	24.800
Louisiana	5.525	Ohio	28.435
Maryland	6.150	Colorado	35.413
Kentucky	6.890	West Virginia	43.943
Kansas	8.371	Utah	44.900
Virginia	8.955	Wisconsin	46.632
		Indiana	76.000

Notes: All prevalence rates are in percentage points.

Table A.II
Regional Classifications of States

Census Region	State	High Goiter (Olesen)
New England Division	Connecticut	1
New England Division	Maine	1
New England Division	Massachusetts	0
New England Division	New Hampshire	0
New England Division	Rhode Island	0
New England Division	Vermont	
Middle Atlantic Division	New Jersey	1
Middle Atlantic Division	New York	1
Middle Atlantic Division	Pennsylvania	1
East North Central Div.	Illinois	1
East North Central Div.	Indiana	1
East North Central Div.	Michigan	1
East North Central Div.	Ohio	1
East North Central Div.	Wisconsin	1
West North Central Div.	Iowa	
West North Central Div.	Kansas	0
West North Central Div.	Minnesota	1
West North Central Div.	Missouri	0
West North Central Div.	Nebraska	
West North Central Div.	North Dakota	0
West North Central Div.	South Dakota	
South Atlantic Division	Delaware	
South Atlantic Division	District of Columbia	
South Atlantic Division	Florida	
South Atlantic Division	Georgia	0
South Atlantic Division	Maryland	0
South Atlantic Division	North Carolina	0
South Atlantic Division	South Carolina	
South Atlantic Division	Virginia	0
South Atlantic Division	West Virginia	1
East South Central Div.	Alabama	0
East South Central Div.	Kentucky	0
East South Central Div.	Mississippi	0
East South Central Div.	Tennessee	0
West South Central Div.	Arkansas	
West South Central Div.	Louisiana	0
West South Central Div.	Oklahoma	1
West South Central Div.	Texas	
Mountain Division	Arizona	0
Mountain Division	Colorado	1
Mountain Division	Idaho	
Mountain Division	Montana	1
Mountain Division	Nevada	
Mountain Division	New Mexico	0
Mountain Division	Utah	1
Mountain Division	Wyoming	1
Pacific Division	Alaska	
Pacific Division	California	0
Pacific Division	Oregon	1
Pacific Division	Washington	1

Figure I
Comparison of Goiter Rates and Iodine Content in Drinking Water in the US (1924)



Simple goiter among drafted men in the US in WW I

Black areas: High goiter incidence, i.e. 6 and more goiter cases per 1,000 drafted men
White areas: Low goiter incidence, i.e. 5 and less goiter cases per 1,000 drafted men

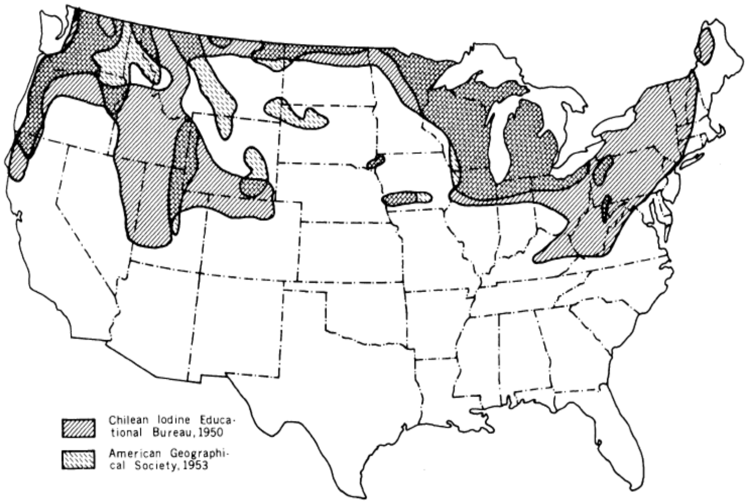
Source: McClendon (1939)

Iodine concent in drinking water in the US

Black areas: Iodine-poor, i.e. 22 and less parts of iodine per hundred billion parts of water
White areas: Iodine-rich, i.e. 23 and more parts of iodine per hundred billions parts of water

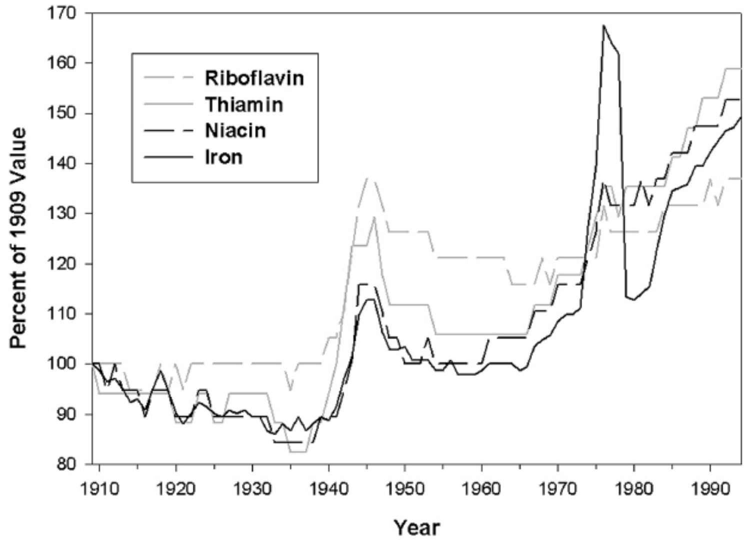
Source: McClendon and Hathaway (1924)

Figure II
U.S. Goiter Distribution, Early 1950s



Source: Schiel and Wepfer (1976)

Figure III
Change in Nutrient Content of the U.S. Food Supply between 1909 and 1994



Source: Backstrand (2002)

Figure IV
Labor Force Participation Rates by Birth Year, Individuals Aged 25-55

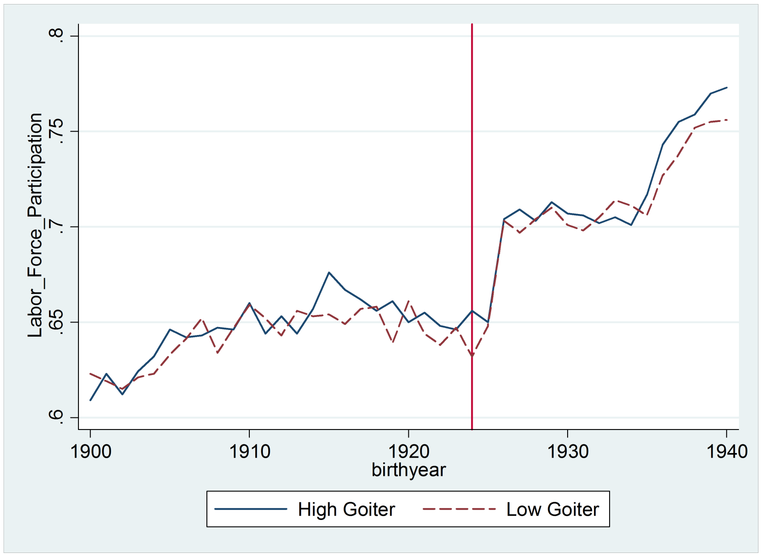
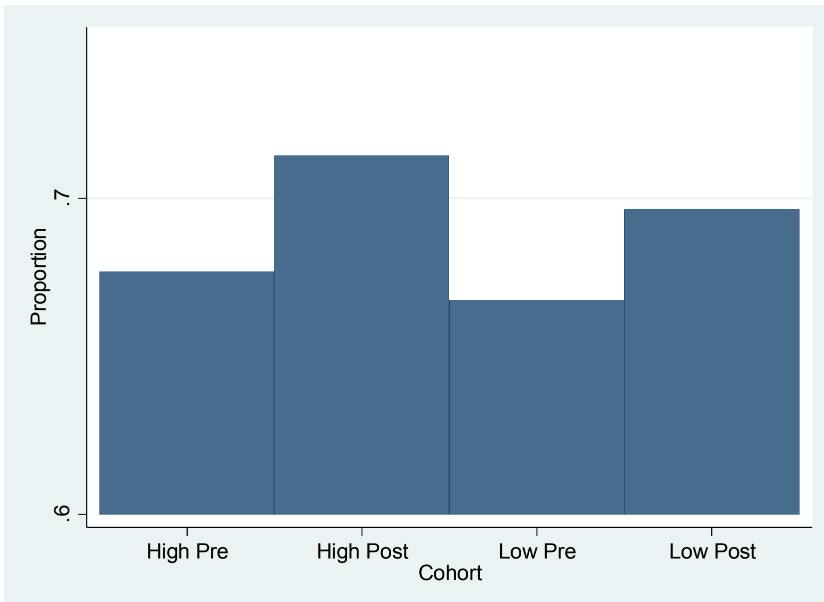


Figure V
Proportion of Labor Force Participants and Positive Wage Earners in Each Cohort

Panel A: Labor Force Participation



Panel B: Positive Wage Earners

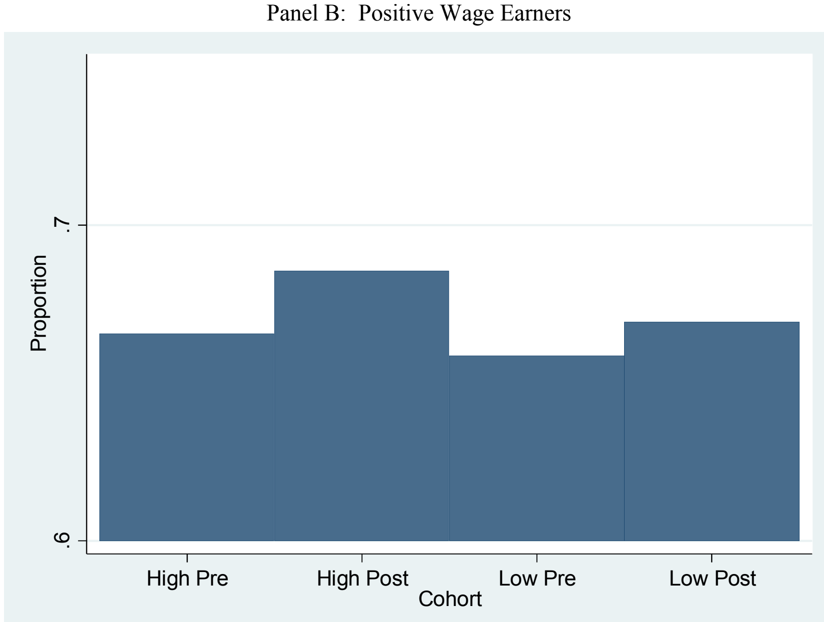
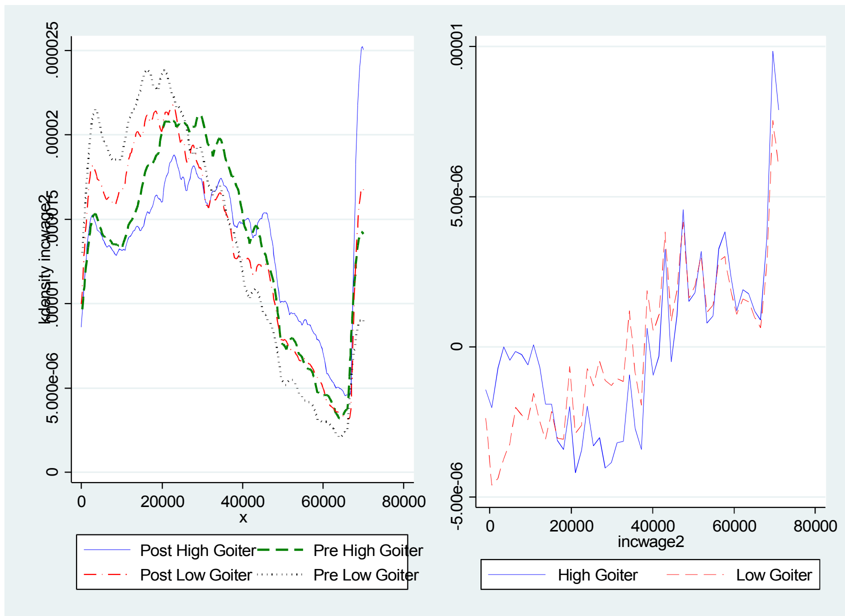


Figure VI
Positive Income Distributions of Each Cohort

Panel A: Wage Income



Panel B: Total Income

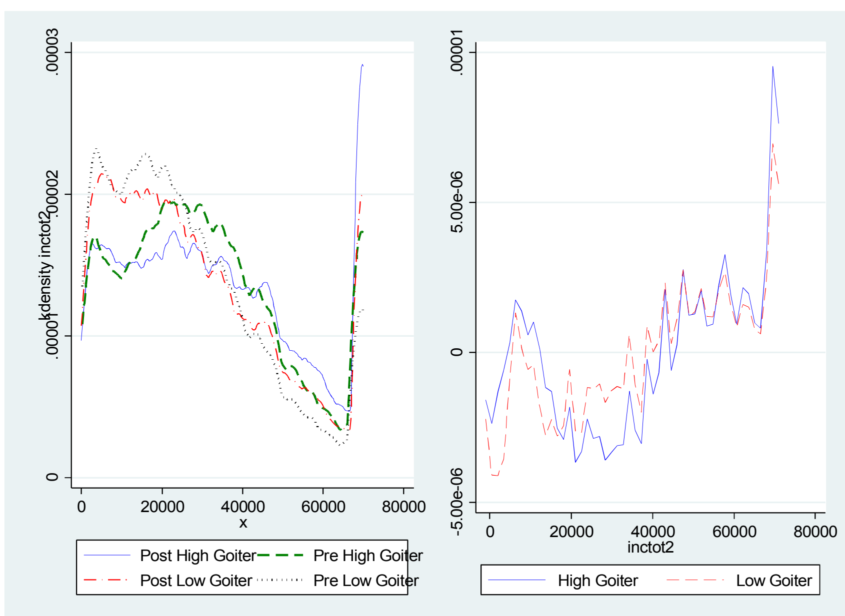
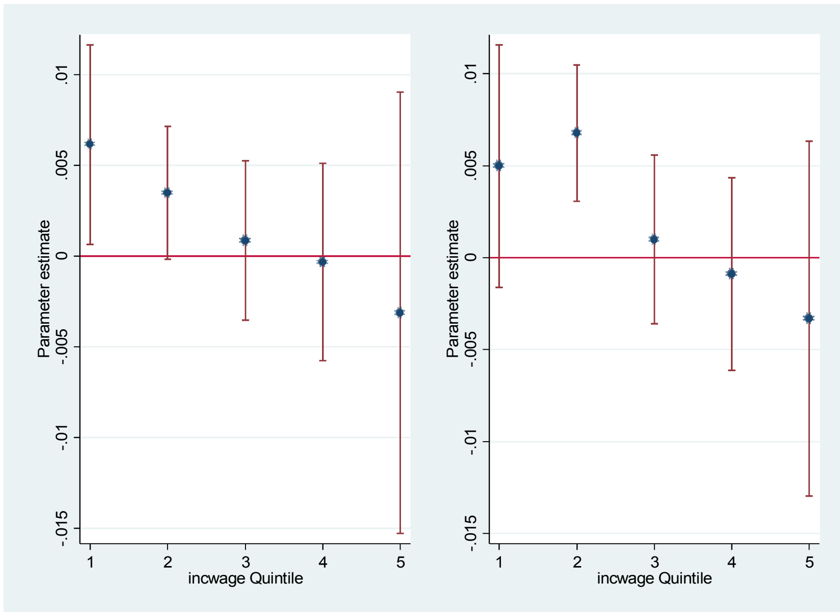


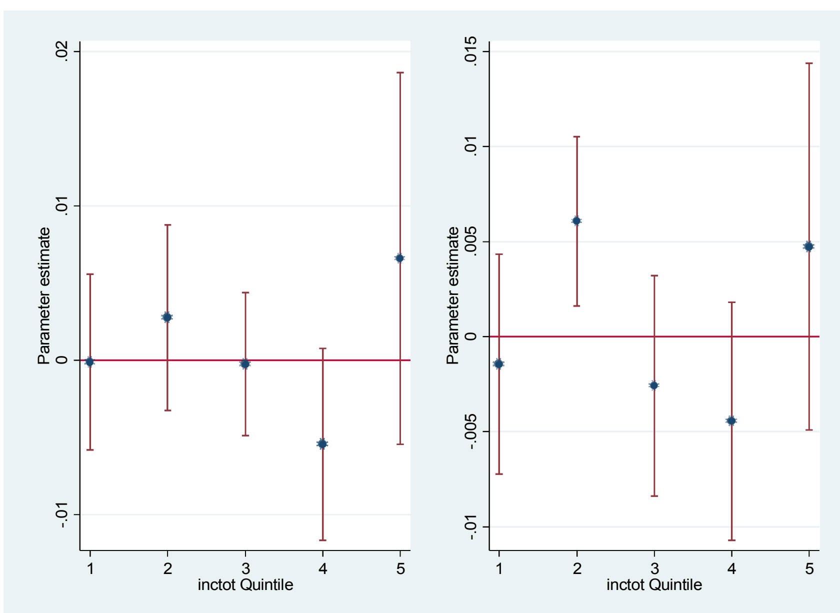
Figure VII
Income Quintile Regression Coefficients

Panel A: Wage Income



During After

Panel B: Total Income



During After