ISSN 1011-8888

INSTITUTE OF ECONOMIC STUDIES

WORKING PAPER SERIES

W10:04 December 2010

Does month of birth affect individual health and education attainment in Iceland?

Thorhildur Olafsdottir and Tinna Laufey Asgeirsdottir

Address: Tinna Laufey Asgeirsdottir
University of Iceland
Oddi v/Sturlugotu
101 Reykjavik, Iceland
Iceland
Email: ta@hi.is

Þórhildur Ólafsdóttir **Tinna Laufey Ásgeirsdóttir**

Does Month of Birth affect Individual Health and Educational Attainment in Iceland?

Abstract

The main objective of this study is to examine whether there is a link between individual month of birth and later outcomes in Iceland. Later outcomes are defined here as self-assessed health and years of schooling. In previous research from social and natural sciences, month of birth has been proposed as an early determinant of adult outcomes. In an attempt to explain such an association, different theories have emerged. Some include effects as early as before conception pointing towards the importance of family background, particularly mother characteristics, as a causal factor for variations in outcomes by month of birth. Specifically, the results from the current study indicate whether future study within the Icelandic population should focus on a possible effect of family background on seasonality of outcomes by month of birth. Furthermore, the results have implications for previous studies regarding the effects of different schooling systems, the relative age effect and the use of month of birth as an instrumental variable (IV) for educational duration in two-stage estimations. The case of Iceland is interesting in this regard since a difference in mandatory schooling by month of birth does not exist in Iceland as in the United States. Thus, if the hypothesized reason that the compulsory schooling laws in the U.S. explain variations in years of schooling by month of birth, are true, one would expect different results when examining this relationship within the Icelandic cultural and institutional setting. The data originates from a postal survey, which includes a random sample of 20,000 Icelandic women aged 18-45. Regression methods are used to estimate whether month of birth is associated with self-assessed health and years of schooling. The results do not confirm an association between month of birth and self-assessed health and years of schooling at traditional levels of significance. However, in previous studies, the measured association of month of birth and years of schooling is small and if one examines the point estimates in this study without regard for the power of the analysis, one can detect a relationship that is somewhat consistent with the seasonal variations in schooling in the United States, where those born in the first quarter of the year have less educational attainment than those born in other quarters of the year. This does not lend support to the theory of compulsory schooling system nor the relative age effect as causal factors for variations in educational attainment by month of birth. Thus the results motivate future research on possible variations in outcomes by month of birth with regard to family background using data with greater statistical power.

1. Introduction

Does month of birth affect later outcomes such as educational attainment and health? In this analysis the main objective is to answer this question using Icelandic data. If variations in later outcomes such as education and health are detected by month of birth, the question of possible causal factors arises. Indication as to whether they involve schooling systems, family background or other mediating factors helps in constructing a clearer picture of this proposed association. Institutional aspects of Iceland make it interesting in this regard as will be explained further in this section.

Evidence on an association between month of birth and later outcomes has implications in terms of future human-capital accumulation. When choosing investments in human capital it is of valuable importance to learn what types of investments are most effective. Empirical research has revealed evidence on the long arm of early determinants for later outcomes. Month of birth is one of the proposed early factors among others, such as the fetal period and early childhood circumstances involving nutrition, viral infections and parents´ socioeconomic status.

Season of birth has been used as a natural experiment[1] in economics to estimate the impact of compulsory schooling laws on schooling and earnings in the United States. This use of season of birth got its impetus with Angrist and Krueger (1991) and many articles have since followed, especially focusing on the econometric techniques involved with this method. A detailed overview can be found in Buckles and Hungerman´s study (2008). As a possible remedy for the omitted variable problem in estimates of the returns to education, season of birth has been used as an instrumental variable in the estimated model. This idea entails that season of birth generates exogenous variation in education and is based on the assumption that one´s birthday is unlikely to be correlated with personal attributes and the fact that compulsory schooling laws are such that mandatory school duration varies by month of birth. However, doubt has been cast on this assumption pointing at possible relationship between month of birth and other factors that could in turn affect earnings (Bound, Jaeger & Baker, 1995; Bound & Jaeger, 1996; Buckles & Hungerman, 2008). Recent evidence offers new insight on the debate whether season of birth is a good natural experiment for studying variations in education. It is suggested that mothers with different characteristics have children at different times during the year (Bobak &

[1] A natural experiment is one when researchers exploit situations where the forces of nature or government policy produce an environment somewhat akin to a randomized experiment (Angrist & Krueger, 2001; Wooldridge, 2009).

Gjonca, 2001; Buckles & Hungerman, 2008). This strongly undermines the assumption that season of birth can be used as an instrumental variable for education in returns to schooling estimations. More importantly it offers a new perspective on season of birth as a possible determinant of later outcomes induced by circumstances as early as at conception, and continuing on through the context of the family environment.

Those developments within the literature, casting doubt on the compulsory schooling laws as a possible mediating factor, make an analysis within a community with different schooling commandments timely and relevant. Iceland does not have shooling laws that makes for variations in mandatory school duration by birth of month. Both countries, the U.S. and Iceland, have a single cutoff date at school entry but in Iceland the mandatory school duration is measured by schoolyears completed. That way the compulsory schooling laws in Iceland do not allow for variations in completed schooling by month of birth. If the mandatory schooling laws are truly the mediating factors, then one would expect the seasonal variation to be limited to societies with such set up of the schooling system. This has implication for the debate on whether month of birth is a valid instrumental variable for schooling in earnings equations. Furthermore, a relative age effect has also been proposed. With a single cutoff date at school start there is a maturity difference among children which is referred to as a relative age effect, suggesting that children that are older relative to their classmates might do better with regard to educational attainment. Results will have implications to this proposed effect.

In this paper we present a descriptive analysis of month of birth in relation to self-assessed health and educational attainment among women in Iceland. Such an analysis has not been done before. The final answer on the effect of birth month on later outcomes is unlikely to be provided with a single study, but as the literature grows, some theories are less favored, while others become more convincing. Researchers continue to contribute individual studies using different data and methods, each providing an important piece to the puzzle.

The following section is a literature review. It starts off with introducing relationships between month of birth and various health outcomes. Then the link between month of birth and education is explored in relation to research in econometrics, with earnings equations estimates under study. A debate on proposed exogeneity of month of birth in instrumental variable settings is introduced along with a recent research pointing towards the importance of mother characteristics as a determining factor of individuals month of birth. The role of parents´ socio-economic status is briefly discussed and w review some studies on birth seasonality as well. We then draw the general idea of economic theory of fertility. In section three the data are described and method and results follow in sections four and five. Section six concludes.

2. Literature Review

2.1. Variations in Outcomes by Month of Birth

Month of birth has been proposed as one of early determinants of later outcomes. An association between month of birth and outcomes such as health, earnings and educational attainment has been documented in numerous studies. Individuals born in the first quarter of the year (January-March) have been found to have worse outcomes related to schooling and earnings (Angrist & Krueger, 1991). Proneness to diseases such as schizophrenia (Castrogiovanni, Iapichino, Pacchierotti & Pieraccini, 1998; Tochigi, Okazaki, Kato & Sasaki, 2004), type 1 diabetes mellitus (Willis et al., 2002) and epilepsy (Procopio, Marriott & Davies, 2006) is documented as stronger for those born in January-May. Results from a study on mortality, measured in the Northern Hemisphere, show that those born in the autumn (October-December) live longer than those born in spring (April-June) (Doblhammer & Vaupel, 2001). Numerous other factors have been related to month of birth, such as shyness (Gortmaker et al., 1997), left-handedness (Martin & Jones, 1999), autism (Gillberg, 1990), dyslexia (Livingston et al., 1993), family income (Kestenbaum, 1987) and reproductive output (Huber, Didham & Fieder, 2008). An association between month of birth and later outcomes such as education and earnings has long been recognized within the economic literature (Angrist & Krueger, 1991; Bound & Jaeger, 1996; Chesher, 2007; Hoogerheide, Kleibergen & van Dijk, 2006; Plug, 2001).

Different theories have been put forward to explain this seasonality in outcomes by month of birth, including natural and social factors. Among the most prominent theories are those that regard nutrition and exposure to illness during the fetal period, childhood health and circumstance, parents socioeconomic status, relative age at school start and compulsory schooling laws. Research has also shown that there is a persistent pattern of seasonality in birth frequency among populations, but still there is no conclusion as to its causes. Although various biological and sociological factors are supposed to influence this well known phenomenon, their independent weights remains to be solved. In Appendix A, birth seasonality is explained further.

The following paragraphs review literature on early determinants for later outcomes and the proposed mechanisms by which month of birth may affect health and education.

2.2. Month of Birth and Health

The general question of what influences adult health motivates ongoing research in diverse fields. An interesting question is relevant to this discussion: Are early effects more important for adult health than often is suggested or are later outcomes in health to a greater degree the results of life-long accumulated effects? Among different theories that have emerged regarding the determinants of adult health, some attempt to explain the long lasting causal effects of early life conditions. One example is the fetal origins hypothesis. It states that fetal undernutrition can affect health status in middle age, through programming of chronic diseases such as ischemic heart disease, stroke, hypertension and diabetes (Barker & Osmond, 1986; Barker, 1995, 2001). These conclusions are based on correlations found between low birth weight and the prevalence of the aforementioned diseases among a sample of men and women born between 1911 and 1930 in the UK.[2] The fetal period was also of special interest in a study by Almond (2006). He studied whether exposure to illness in utero could act as an early factor determining adult outcomes. His results showed that cohorts in utero during the fall of 1918 influenza pandemic had worse adult outcomes compared with other birth cohorts. Adult outcomes measured were educational attainment, physical disability, income, socioeconomic status and mortality. These results suggest that seasonal variations in nutrition and illnesses during the fetal period could act as mediating factors in the proposed correlations of month of birth and health.

The importance of fetal period for later outcomes is furthermore underscored in a study by Case, Fertig and Paxson (2005) on the lasting impact of childhood health and circumstance. They found that children who have experienced poorer uterine environments (mother´s smoking and low birth weight) have poorer health as middle

[2] According to Currie (2009) low birth weight has been used as the leading indicator of poor health among newborns.

age adults, controlling for parental income, education and social class. Health outcome measures were individuals´ four level self-reported health status.

Doblhammer & Vaupel (2001) propose an importance of fetal nutrition for later outcomes. They found that month of birth influences adult life expectancy at ages 50+. In their paper they link this correlation between month of birth and mortality to prenatal or early postnatal conditions related to nutrition and disease. Doblhammer and Vaupel looked at two countries of the Northern Hemisphere, Austria and Denmark, and found that people born in autumn (October-December) live longer than those born in spring (April-June). Furthermore, they examined data from Australia, which showed that the pattern is shifted by half a year in the Southern Hemisphere. The study´s results indicate that the differences in lifespan are independent of the social differences in the seasonal distribution of births and of the seasonal distribution of deaths. The authors´ proposed explanation for the study´s results is to look for determining factors before birth, such as nutritional deprivation in early life. They support that conclusion by referring to the considerable improvements in maternal and infant health that took place between the compared birth periods of 1863-1888 and 1889-1918. Results from their Danish data, show that differences in adult lifespan by month of birth are significantly smaller in the more recent cohorts than in the oldest cohorts.

Other researchers recommend that studies on early effects on later outcomes should include data about infancy, childhood and the full course of adult life and cast doubt on the idea of a direct influence of factors acting in early life on disease susceptibility such as adult coronary heart disease (Ben-Shlomo & Smith, 1991). Ben-Shlomo and Smith find that when socioeconomic conditions at death, aged 65-74 are controlled for, the correlation between infant mortality and deaths from chronic heart disease is reduced. In their view it is important to consider a life course approach to disease aetiology and they propose that the strong correlations seen between early environment and adult mortality may simply be an effect of continued deprivation throughout life, leading to an accumulation of detrimental health effects.

Heckman (2007) emphasized the importance of identifying early determinants of adult health when he developed a model of investment in human capabilities.[3] In the model, capabilities produced at one stage augment the capabilities attained at later

[3] Health, cognitive skills and noncognitive skills are defined as human capabilities in Heckman´s model (Heckman, 2007).

stages. That way skills accumulated early in childhood are complementary to later learning. This lifecycle investment framework is based on various evidence based conclusions and one of them is the existence of critical and sensitive periods in development.

2.3. Month of Birth and Education

Research has found that children born in the first quarter of the year have a slightly lower average level of education than children born later in the year (Angrist & Krueger, 1991[4]; Buckles & Hungerman, 2008[5]). This finding was a central theme in Angrist and Krueger´s study on the long term impact of compulsory schooling on wages (1991). They used quarter of birth as a natural experiment to estimate the impact of compulsory schooling laws in the United States. They found a small but systematic quarterly pattern in completed schooling attainment for men born in the 1930s - 1950s. Results from their empirical analysis show that men born early in the year have relatively low levels of both schooling and earnings. The suggested reason underlying this finding lies in combined effects of school start age policy and compulsory school attendance laws. In the U.S., the oldest students in a class are eligible to drop out of school after completing fewer years of schooling than individuals born near the end of the year (Angrist & Krueger, 2001).[6] The combination of school start age policies and compulsory schooling laws is therefore suggested to create a natural experiment in which children are compelled to attend school for different lengths of time depending on their birthdays. Supporting their compulsory schooling explanation they found no relationship between earnings and season of birth for men who were not constrained by compulsory schooling. They also reject impact of other possible effects on schooling like relative age effect, even though studies on relative age effect generally show that students who start school at older age are found to receive higher achievement test scores than younger students.

[4] Data consisted of all men born 1930-1949 in the 1980 census 5 percent sample. Sample size was 312,718 for 1930-1939 cohort and 457,181 for 1940-1949 cohort (Angrist & Krueger, 1991).

[5] Data consisted of males born between 1944-1955 in the 1980 census. Sample size was 1,090,826 (Buckles & Hungerman, 2008).

[6] School start age is a function of date of birth, since most states in the U.S. require students to enter school in the calendar year in which they turn six. In states with a December 31st birthday cutoff those born late in the year are young for their grade. That way, children born in the fourth quarter enter school at age 5 ¾, while those born in the first quarter enter school at age 6 ¾. Since compulsory schooling laws typically require students to remain in school until their 16th birthdays, these groups of students will be in different grades when they reach the legal dropout age. This is the rationale for Angrist and Krueger´s approach in 1991.

This contrasts Angrist and Krueger´s results but they claim that years of schooling is a better measure of academic success than test performance at an early age. This way Angrist and Krueger introduced quarter of birth as an instrumental variable for schooling in earning equations as an attempt to obtain consistent returns to schooling estimates.

The coefficient on schooling in a regression of log earnings on years of schooling, is often called a rate of return.[7] Economists have long sought to estimate the rate of return to schooling to determine whether there is underinvestment or overinvestment in education. It has been confirmed in many different countries that individuals with more education earn higher wages (Card, 1994). Despite this evidence, most economists are reluctant to interpret the earnings gap between more and less educated workers as an estimate of the causal effect of schooling. The reason for that lies in the fact that education is not randomly assigned across the population. As individuals make their educational choices schooling is not exogen by definition[8] which renders biased and inconsistent least squares estimates (Greene, 2008).

There are a variety of sources of bias associated with ordinary least-squares estimates of the return to schooling (Harmon & Walker, 1995). One such bias in the OLS estimates is due to omitted ability and other factors that are positively correlated with both education and earnings. A strategy for dealing with this is instrumental variable estimation. A suitable instrumental variable must be relevant and exogen. The relevance condition requires the instrument to be correlated with the number of years of schooling that an individual receives. The exogeneity condition requires that the instrument affects income only through the channel of schooling, and therefore that the instrument is uncorrelated with the error term in the income equation (Wooldridge, 2009). Conventional wisdom suggests that the causal effect of education is overstated by a comparison of wages between more and less educated workers. Card´s review of

---

[7] $Ln[w(s,x)] = \alpha_0 + \rho_s s + \beta_0 x + \beta_1 x^2 + \varepsilon$ is referred to as "Mincer equation" where w(s,x) is wage at schooling level s and work experience x, ρ_s is the "rate of return to schooling" (assumed to be the same for all schooling levels) and ε is a mean zero residual with $E[\varepsilon|s,x] = 0$. This model was estimated by Mincer in 1974 (Heckman, Lochner & Todd, 2006). The justification for interpreting the coefficient on schooling as a rate of return comes from a model by Becker and Chiswick in 1966 which later was expanded by Jakob Mincer, by incorporating experience to form "human capital earnings function". The earnings equation is regarded as the most common empirical regression in microeconomics (Becker, 1993; Heckman, Lochner & Todd, 2006).

[8] Exogeneity of the independent variables is one of the assumptions of the classical linear regression model: $E[\varepsilon_i|x_{j1}, x_{j2},...,x_{jk}] = 0$, i, j = 1,...,n. It states that the expected value of the disturbance at observation i in the sample is not a function of the independent variables observed at any observation, including this one. This means there is no correlation between the disturbances and the independent variables (Greene, 2008).

eight empirical findings suggests, however that the causal effect of education on earnings is understated by standard estimation methods. His conclusion is based on comparisons of OLS estimates to instrumental variables and fixed-effects estimators. Angrist and Krueger furthermore cast doubt on the importance of omitted variables bias in estimates of the return to education, when comparing OLS estimates to IV estimates, at least for years of schooling around the compulsory schooling level. They suggest that there is little bias from omitted ability variables in the ordinary least squares estimate of the effect of education on earnings, and they assume that the omitted variables in the earnings equation are weakly correlated or uncorrelated with education (Angrist & Krueger, 2001).

Bound, Jaeger and Baker (1995) call into question that compulsory schooling laws are the only reason for the correlation between month of birth and educational attainment.[9] Also, there cannot be any direct association between quarter of birth and wages for quarter of birth to be a legitimate instrument for educational attainment in wage equations. They emphasize the importance of examining characteristics of the first-stage estimates. Results from their research are indicative of a direct association between quarter of birth and earnings. Since Angrist and Krueger´s assumption is that the instruments (quarter of birth) are correlated with the endogenous explanatory variable (schooling) but have no direct association with the outcome under study (earnings) Bound et al. claim that the IV estimates of the effect of schooling may be inconsistent. In support of their view they review research documenting associations between quarter of birth and a variety of factors that either are known to affect earnings or might plausibly do so, such as performance in school, physical and mental health and socioeconomic status. This, in their view, makes it difficult to have confidence in the validity of causal inferences drawn from the estimation of wage equations in which quarter of birth is used to instrument for educational attainment. As Angrist and Krueger state in their paper "In other words, if season of birth influences earnings for reasons other than compulsory schooling, our approach is called into question" (Angrist & Krueger, 1991, p. 1007).

As long as month of birth is regarded as essentially exogen, it is possible to instrument for educational attainment using month of birth. The important question to

[9] The relationship between quarter of birth and age at school entry must be the only reason for the association between quarter of birth and educational attainment, for quarter of birth to be a legitimate instrument for age at school entry in educational attainment equations (Bound & Jaeger, 1996).

ask is: Is there evidence to support or undermine the assumption that month of birth is randomly distributed? An educational pattern within the Icelandic data, despite the different compulsory schooling laws, would cause further reservation about the educational reasoning given.

It should be kept in mind however, that month of birth may have an effect on educational attainment not only by influencing the amount of schooling received by an individual who leaves at the compulsory leaving age, but also via the "relative age effect". Results from a recent study by Bedard and Dhuey (2006) show that age at school start is positively linked with student performance. They looked at the possible longer run impact of maturity difference at school start.[10] Their findings support a relative age effect. They found that initial maturity differences, with a single school cutoff date, have long-lasting effects on student performance in 19 OECD countries. Furthermore, using data from Canada and the U.S., the youngest members of each cohort are even less likely to attend university. The authors claim that the relative age effect may have important implications for adult outcomes and productivity, with those being oldest in a class doing better. That is opposite to the results from Angrist and Krueger (1991) and Buckles and Hungerman (2008) on month of birth and educational attainment. Leigh and Ryan (2008) found no relative age effect in their estimation of returns to education.

In a recent study by Buckles and Hungerman (2008) they document large seasonal changes in the socioeconomic characteristics of women giving birth throughout the year in the U.S. That is, children born at different times in the year are conceived by women with different socioeconomic characteristics. They propose that children born in the winter (first quarter of the calendar year) are disproportionally born to women who are more likely to be teenagers and less likely to be married or have a highschool degree. Children born in different seasons are then conceived by different groups of women. The authors claim that this could be a compliment, rather than a substitute, to existing explanations of the effect of season of birth on later outcomes. According to Buckles and Hungerman´s results, variations in family background play a role in explaining differences in outcomes for those born at different times of year. Their controls for family backgrounds explained 25-50% of

[10] Due to the use of a single school cutoff date, the oldest children at school entry are approximately 20 percent older than the youngest children. This is referred to as maturity differences in Bedard and Dhuey (2006).

the relationship between season of birth and adult outcomes.[11] This casts doubt on assumptions that month of birth can be regarded as a natural experiment to study variations on schooling since the exogen condition for IV does not comply.

2.4. Parents´ Socio-Economic Status and Month of Birth

One of the proposed reasons for seasonal variations in outcomes is parents´ socioeconomic status. Research has found that those of upper socioeconomic origin are more often born in the spring than late in the year (Bound & Jaeger,1996; Kihlbom & Johansson, 2004).

Bobak and Gjonca (2001) examined whether birth seasonality is influenced by socio-demographic factors. They used data on all live births registered in the Czech Republic in 1989-1991. Socio-demographic groups were defined by maternal age, marital status, education and birth order. They found large differences in the size of the seasonal variation in births by socio-demographic factors. The seasonal variation in births was highly pronounced in mothers who were 25-34 years old (as opposed to those who were younger or older), were married, had higher education and were pregnant with their second or third child. Based on their results they claim some social groups within populations could be more successful than others in timing their pregnancies in relation to seasonal preferences, which is in accordance with Buckles and Hungerman´s results discussed above.

Lam and Miron (1991) studied economic effects on seasonality of birth and find that the seasonal pattern of birth is similar across urban and rural families, across regions of the United States that have diverse economic and cultural conditions, and within countries before and after dramatic economic transitions. Their longest time series from England, Finland, Canada and Luxembourg cover a transition from an largely agricultural economy to a significantly industrial one, from 1920´s to 1980´s. Their conclusion is that the stability in the timing of the patterns over time suggests an absence of strong economic effects on seasonality of birth.

2.5. Birth Seasonality

[11] Outcomes: Years of schooling, percent dropouts and wages. Family background: Average mother´s education, fraction of mothers without a high-school degree, average mother´s age at birth, fraction of mother´s giving birth as teenagers, fraction of mothers working, fraction of mothers married, fraction white, and average cell family income as a percent of the poverty line (Buckles & Hungerman, 2008).

Research on birth seasonality has implications for the proposed association of month of birth and later outcomes because it helps to build further understanding of the behavioral and natural factors that are most important in determining individual´s month of birth. Birth seasonality may be influenced by social, environmental and cultural factors and that underscores the relevance of studying month of birth and later outcomes in countries with different institutional settings. Condon and Scaglion (1982) refer to birth seasonality as an ecologically responsive phenomenon linked to a complex network of environmental and cultural variables. In their research on birth seasonality, emphasis is on examining three sets of variables; environmental, biological and sociocultural, and the nature of their interaction in determining birth seasonality. They conclude that birth seasonality may be a result of the independent action of biorythms and sociorythms, or, a consequence of an interaction between the two.

Results from studies on birth seasonality and fertility are subject to how researchers use various related concepts. Bobak and Gjonca (2001) state that in epidemiological studies on childbearing three different concepts emerge: fecundability, fetal loss and fertility. In their view focus has been on fertility in analysing the distribution of birth. However, whether underlying mechanisms like fecundability and fetal loss should be taken into account depends on how one chooses to approach the subject.

Rodgers and Udry (1988) propose that volitional fertility decision making can act alongside nonvolitional biological processes such as weather and light patterns (photoperiod). Their hypothesis about the misinformed reproducer embodies the idea that some couples do not take into account the actual lag between the time they begin trying to get pregnant and the average time it takes for successful conception to occur, that in general people underestimate this lag. According to their questionnaire answered by 235 undergraduate students the most preferred months for having a child were April and May but least preferred months were August and September which is in contrast to the fertility pattern in the U.S., which peaks in late summer months. Basso et al. (1995) reported that summer is the preferred time for starting pregnancy based on interviews with 4.731 women from six European countries.

It seems reasonable to believe that seasonality of birth results from seasonality of conception, which is generally believed to be influenced by both biological and psychosocial factors. An interesting point to the discussion whether preferences influence month of birth is the concept of unwanted pregnancies. In the United States in 1988, 56% of pregnancies were unintended, either mistimed or unwanted at conception (Forrest, 1994). An equal proportion of unintended pregnancies end in abortion (44%) as with birth (43%), (which could imply that at least a quarter of all births are independent of seasonal preferences). Those women who are at greatest risk for unintended conceptions are adolescents, formerly married women and women of low socioeconomic status. This group of women is at the greatest risk for contraceptive nonuse and for contraceptive failure (Forrest, 1994). These characteristics are similar to the mother characteristics reported in Buckles and Hungerman´s study (2008) for those women who are more likely to give birth in the first quarter of the year.

2.6. Economic Theory of Fertility

When looking for reasons why month of birth could affect later outcomes such as education and health the literature draws one´s attention to theories of fertility. In the economic approach of fertility the focus is on behavioral factors. This approach has been reported as "a special case of consumer demand theory" (Robinson, 1997). It dates from Liebenstein´s model in 1957 which was motivated by fertility declines in the demographic transition (a model that describes population change over time) and focused on families´ decision process in balancing utilities against disutilities ascribed to having another child. Becker (1960) reformulated this approach and adapted his model to household production paradigm in which fertility decision is linked to other household economic processes, including labour force participation and consumption (as cited in Robinson, 1997).

The economic approach to fertility entails the idea that fertility is a result of conscious decision and deliberate purposeful action (Robinson, 1997). This perspective seems to some extent to contrast the complex nature of fertility and seasonality of birth. Becker´s approach to the traditional theory of individual rational choice may however be of important relevance in this context (Becker, 1993). He views the traditional theory of individual rational choice as a method of analysis, not an assumption about particular motivations. With such an approach it is recognized that behavior is driven by a much richer set of preferences and values than merely assumptions about self-interest. His method of analysis assumes that individuals maximize welfare as they conceive it. That their behavior is forward looking and is assumed to be consistent over time. Actions are constrained by income, time, imperfect memory and calculating capacities, and other limited resources (Becker, 1993). The most fundamental constraint in this theory of individual rational choice is time. This way of looking at individual rational choice seems to harmonize better with the complex nature of human fertility than assumptions about self-interest as controlling factors in fertility patterns.

In economic models of fertility parents are consumers who choose the quantity or number of children which maximizes their utility subject to the price of children and the budget constraint they face (Hotz, Klerman & Willis, 1997). Their demand for children is based on their demand for child services. Child services are produced within the household using the time and labour of the household member and inputs from outside the household and employ the technology possessed by the household for such production. One important concept of the model is child quality, introduced by Becker (1973).

This approach to fertility incorporates that the time spent on child care becomes more expensive when countries are more productive. With higher value of time the cost of raising children is higher which reduces the demand for large families (Becker, 1993). It is therefore proposed that there has been a preference shift towards higher-quality children, who require more purchased external inputs and are more time-intensive within the household. Hotz, Klerman and Willis (1997) discuss different models of fertility in their paper and conclude that all of them imply that the demand for children depends on various types of prices, among those are prices of children, their quality, the price of mother´s time, the prices of contraceptive practices, etc. and household income.

The economic approach to fertility as reviewed here may have important implications when studying season of birth and later outcomes, as preferences of the members of the household production may directly influence fertility and possibly month of birth.

In this analysis we explore the question of a possible link between month of birth and years of education and self-assessed health as later outcomes in Iceland. As the literature review has revealed there are numerous ways to approach the month of birth variable. Here the aim is to explore whether self-assessed health and educational attainment vary by month of birth among Icelandic women aged 18-45. The results of this analysis will give insight into whether there is a reason to explore a wider area of this research field, such as family background. Furthermore the results will enhance the knowledge to date on early determinants of later outcomes. It is of particular interest to explore the month of birth variable in different populations. Education systems, teenage pregnancies, contraceptive use, socioeconomic status etc. are variables which vary between countries. In general research on determinants of adult wellbeing has implication for human-capital investment as it helps policy makers choose investments in human capital that aim for long term efficiency.

If there is variation in education in the absence of compulsory schooling laws as those in the U.S. it points to other factors than compulsory schooling laws affecting years of schooling. Mother characteristics may then be of interest for further research. On the other hand if no variation exists in the data by month of birth, it has no implications regarding the compulsory schooling laws in the U.S. It would furthermore cast doubt to the theory of relative age effect as a possible influence on educational attainment. Such results would also raise a question on whether previous research regarding mother characteristics in the U.S. is overly emphasized**.** It could however be the case that mother characteristics is not a determining factor in this context in the Icelandic population. It may be that the population is too homogeneous for that to be the case or that extensive social insurance programs effect the child-parent outcome correlations.

3. Data

Data in this analysis come from the postal survey “Women´s lifestyle and health” carried out by the Icelandic Cancer Registry in October 2004. The survey includes a random sample of 20.000 Icelandic women aged 18-45 from the Icelandic population register. The respondents answered questions about their health, education, marital status, number of children, number of pregnancies, smoking and drinking habits, contraceptive use and sexually transmitted diseases.

3.1. Representation

The response rate was 55,47%, or in total 11.094 responses which represents 18,9% of the female population for the specified age group. There is some discrepancy in the age distribution between the sample and population data. Table 1 represents this discrepancy. Respondents are proportionally fewer in the youngest cohort than in the oldest.

Table 1. Representation of Age

	Proportion in census	Proportion in sample
Age	%	%
18-24	25.46	22.05
25-31	24.82	24.78
32-38	24.03	25.59
39-45	25.69	27.57

Month of birth representation of the sample, relative to census information is shown in table 2 and figure 1.[12] Table 2 represents average birth frequency per day for each month, accumulated for the years of birth in the sample data. Proportional numbers are calculated from the accumulated monthly average birth frequency for the purpose of convenience when comparing census and sample. The largest discrepancy between the sample data and the census for average birth frequency per day is in month number nine where proportion of accumulated monthly average birth frequency in census is 8,47% and proportion in sample is 9,02%.

Table 2. Representation of Average Birth Frequency per Day

Month	Census	Proportion	Sample	Proportion
January	338	8.03	29	8.02
February	346	8.21	29	7.88
March	354	8.43	31	8.43
April	362	8.61	30	8.33
May	369	8.78	32	8.92
June	361	8.57	31	8.50
July	363	8.63	31	8.39
August	354	8.41	31	8.38
September	356	8.47	33	9.02
October	347	8.24	31	8.48
November	331	7.87	28	7.74
December	326	7.75	29	7.91

[12] Average births per day per month were calculated for each month to account for the different number of days per month.

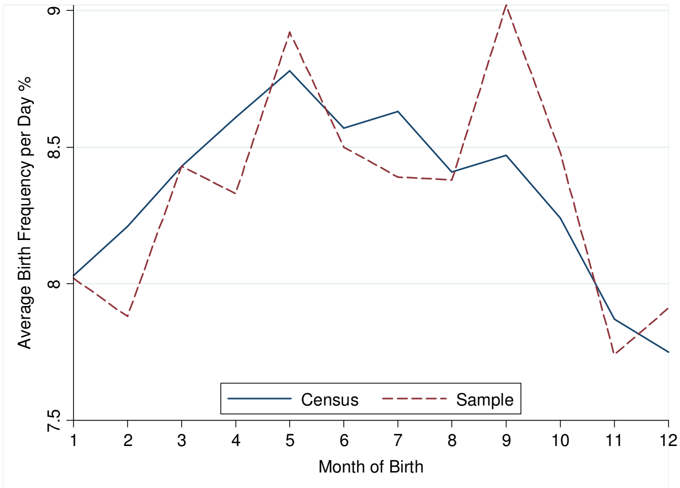

Figure 1. Representation of Month of Birth (Statistics Iceland, 2010a).

3.2. Description of Dependent Variables

Health: Self-assessed health (SAH) is a subjective measure of an individual´s health status. Respondents were asked to evaluate their overall health as 1 = excellent, 2 = very good, 3 = good, 4 = fair or 5 = poor. Self-assessment of health has been found to be a significant predictor of mortality in follow-up studies, even beyond the presence of various health and behavioral measures and as such a source of valuable data on health status (Idler & Kasl, 1991; Idler & Benyamini, 1997; McCallum, Shadbolt, & Wang, 1994). Research has consistently found a strong relationship between mortality and SAH (See for example Doblhammer and Vaupel, 2001). Therefore it is assumed here of relevance to link SAH as a dependent variable in a regression with month of birth as an explanatory variable. Just over 60 percent of respondents report excellent or very good health. Approximately 10% report fair or poor health. Summary for self-assessed health can be found in table 3.

Table 3. Summary Statistics: Self-assessed Health

	N = 11.048
Variable	Proportion
1 = Excellent	0.130
2 = Very good	0.489
3 = Good	0.284
4 = Fair	0.083
5 = Poor	0.013

Education: Education is measured in four ordinal years-of-schooling categories, where 1 = less than 9 years, 2 = 9-12 years, 3 = 13-16 years and 4 = more than 16 years.[13] This variable may be more prone to measurement error than if education was dichotomized by educational level, as people don´t generally keep their years of schooling in mind in the same sense as they do with their highest degree of education completed. However, even though a variable measuring educational level in terms of degree completion was available, it too was flawed by a large portion of the sample (528 individuals) answering an open response category of "other level of education". Based on this, years of schooling will be used as the main educational variable of interest, although robustness checks will be done with respect to degree completion. Summary statistics for years of schooling are shown in table 4. The sample was limited to those aged 25-45 to include only those respondents that had sufficient maturity to make all categories of education relevant, as students in the Icelandic school system generally receive their university degrees at age 23-25 depending on the degree chosen. The majority of the sample (75%) reports years of schooling to be greater than 13 years in total. 42% of the sample reports more than 16 years of education. Schooling in Iceland generally starts in the fall of the calendar year in which the student turns six years old. The respondents age after 16 years of schooling is 22 years old. If the student has not taken any breaks, that calendar year in which he/she turns 20 is the age of university commencement. Summary statistics for years of schooling can be found in table 4.

Table 4. Summary Statistics: Years of Schooling

	N = 8.552
Variable	Proportion
1 = < 9 years	0.0167
2 = 9-12 years	0.2326
3 = 13-16 years	0.3265
4 = >16 years	0.4242

[13] With school starting at the age of six in Iceland, 13-16 years of education corresponds to the age of 19-22 years.

Table 5 summarizes all variables used in the analysis, apart from SAH and years of schooling. Since additional analysis is done with some levels of education as binary dependent variables, those variables are included in the table. Season of birth is defined as month of birth, quarter of birth and months with highest average temperature. Lifestyle variables are Body Mass Index (BMI) and binary variables for defined smoking and drinking habits. BMI is a screening tool to identify weight problems for adults. Individuals´ weight and height is needed to calculate BMI as kg/m^2.

Table 5. Summary Statistics

	Mean	SD	N
Education variables			
Primary education	0.222	0.416	11075
On the job training	0.092	0.289	11075
Vocational education	0.056	0.229	11075
College education	0.262	0.440	11075
University education	0.321	0.467	11075
Other education	0.048	0.213	11075
Season of birth			
Month of birth	6.516	3.399	11094
January - March	0.241	0.428	11094
April - June	0.257	0.437	11094
July - September	0.259	0.438	11094
October - December	0.243	0.429	11094
April - September*	0.484	0.499	11094
Lifestyle variables			
BMI	25.276	5.178	10998
Daily smoker	0.180	0.384	11070
Lowest alcohol use**	0.398	0.490	10461

* Months of highest average temperature in Iceland (Icelandic Meteorologic Office, 2010).

** Never more than six drinks on one occasion.

4. Methods

In this analysis emphasis is on describing the data without resorting to formal theoretical modelling. As such this analysis is a statistical description of the data. We estimate equations with years of schooling and self-assessed health as the dependent variables. The independent variable of interest is month of birth. In previous research, months of the calendar year are grouped into four quarters when studying month of birth in relation to education (Angrist & Krueger, 1991[14]; Buckles & Hungerman, 2009[15]). In accordance to that and for reasons of comparability, quarter of birth division is done in this analysis. However as the month of birth is readily available from this data, it seems relevant to carry out separate estimations with the month of birth variable in the equations to avoid disposal of data**.** A dummy variable was created for each month and the regressions included eleven months as January was excluded.

The hypothesis testing is for the H_0 hypothesis of a zero month-of-birth (or quarter of birth) estimator. H_0: $\beta_{MOB(QOB)} = 0$.

We estimate years of schooling as a function of season of birth and then we include age as an independent variable. Finally variations in years of schooling is explained as a function of season of birth, age and health.[16]

With health as the dependent variable we also estimate 3 equations. The first one includes season of birth and age as the independent variables, the second is with years of education added as independent variables and the third equation explains variations in health as a function of season of birth, age and lifestyle variables.

[14] It may be of interest to know that the reason for the quarter of birth devision in Angrist and Krueger´s study is that data for seperate months was not available from the U.S. Census. Their analysis was thus constrained by using quarter of birth instead of month of birth which could be less sensitivite to proposed variability in education.

[15] Buckles and Hungerman also used quarter of birth from census data for years 1960 and 1980 when studying mother characteristics, years of schooling and wages (male sample). Sample sizes varied from 927,954-1,090,826 depending on dependent variable being observed. Their data from Natality Files, 1989-2001 included 52,041,054 observations which they used to study variations in mother characteristics by month of birth.

[16] One element in Becker´s Model on complementarity of health and education is that health increases education because of longer expected (working) life to recoup investments/because healthier students may be more efficient producers of additions to the stock of knowledge through formal schooling (Grossman & Kaestner, 1997).

Assuming linearity, the classical linear regression model is expressed as:

$$\mathbf{y} = \mathbf{X}\boldsymbol{\beta} + \mathbf{e}$$

Where **y** is health or education, depending on the estimation, **β** is a vector of estimates, **X** is a matrix of independent variables and **e** is an error term.

Both dependent variables in the analysis are inherently ordered multinomial-choice variables. In the case of an ordinal dependent variable, a linear regression would inappropriately treat the difference between each adjacent categories the same, whereas they are only a ranking and that would affect inference from estimation. As such, ordered probit is the chosen framework for the analysis (Greene, 2008).

5. Results

We fail to reject the null hypothesis of a zero estimator for month of birth in the estimated equations when using 95% confidence intervals. That is, results do not confirm an existing relationship between month of birth and the dependent variables; years of schooling and self-assessed health. Ordered probit regression results are shown in tables 6 and 7. As shown in table 6 three equations were calculated with years of schooling as the dependent variable. In the first equation 11 months of birth are the only explanatory variables. Equation two includes age as well and equation three includes explanatory variables for self-assessed health. In table 7 three equations are estimated with self-assessed health as the dependent variable. First, 11 months and age are the proposed explanatory variables. In the second equation education variables are also included. The third equation includes 11 months, age and years of education.

Table 6. Regression

Method of estimation: Ordered probit

Dependent variable: Years of schooling (older than 24)

	(1)		(2)		(3)	
Variable	Coefficient	SE	Coefficient	SE	Coefficient	SE
Month of birth						
February	0.033	0.061	0.033	0.061	0.025	0.061
March	0.059	0.059	0.050	0.059	0.048	0.059
April	0.093	0.060	0.093	0.060	0.084	0.060
May	0.060	0.058	0.057	0.058	0.046	0.058
June	0.061	0.059	0.061	0.059	0.055	0.060
July	0.104	0.059*	0.107	0.059*	0.115	0.059*
August	0.104	0.059*	0.104	0.059*	0.112	0.059*
September	0.000	0.059	0.004	0.059	0.016	0.059
October	0.029	0.059	0.032	0.059	0.031	0.059
November	0.041	0.060	0.054	0.060	0.040	0.060
December	0.044	0.059	0.047	0.059	0.049	0.060
Age			-0.016	0.002***	-0.015	0.002***
Self-assessed health						
Excellent					0.729	0.104***
Very good					0.599	0.099***
Good					0.314	0.100***
Fair					0.032	0.106
/cut1	-2.075	0.052	-2.662	0.088	-2.171	0.132
/cut2	-0.624	0.043	-1.204	0.082	-0.685	0.129
/cut3	0.244	0.043	-0.331	0.082	0.209	0.129
PseudoR2	0.0004		0.0040		0.0190	
chi2(11)	7.93		7.68		7.92	
Prob>chi2	0.72		0.74		0.72	
N	8552		8552		8516	

*Indicates (0.05<p-value≤0.10)
**Indicates (0.01<p-value≤0.05)
***Indicates (p-value<0.01)

Table 7: Regression

Method of estimation: Ordered probit

Dependent variable: Self-assessed health

	(1)		(2)		(3)	
Variable	Coefficient	SE	Coefficient	SE	Coefficient	SE
Month of birth						
February	-0.044	0.052	-0.044	0.052	-0.060	0.054
March	0.040	0.050	0.041	0.050	0.038	0.052
April	0.010	0.050	0.017	0.051	0.018	0.052
May	-0.043	0.049	-0.043	0.050	-0.050	0.051
June	-0.021	0.050	-0.021	0.051	-0.021	0.052
July	0.000	0.050	0.008	0.050	-0.010	0.052
August	0.016	0.050	0.025	0.050	-0.003	0.052
September	0.092	0.049*	0.086	0.050	0.091	0.052*
October	0.032	0.050	0.031	0.050	0.048	0.052
November	-0.042	0.051	-0.045	0.052	-0.048	0.054
December	-0.021	0.051	-0.016	0.051	-0.018	0.053
Age	0.003	0.001***	0.004	0.001***	-0.003	0.001**
Education						
9-12 years of schooling			-0.136	0.086		
13-16 years of schooling			-0.417	0.085***		
>16 years of schooling			-0.633	0.085***		
Lifestyle variables						
BMI					0.050	0.002***
Daily smoker					0.532	0.027***
Lowest alcohol					0.040	0.022*
/cut1	-1.014	0.055	-1.421	0.101	0.104	0.073
/cut2	0.416	0.055	0.034	0.101	1.613	0.074
/cut3	1.417	0.056	1.054	0.101	2.684	0.077
/cut4	2.344	0.063	1.999	0.105	3.683	0.084
PseudoR2	0.001		0.014		0.038	
chi2(11)	14.52		13.82		16.21	
Prob>chi2	0.21		0.24		0.13	
N	11048		10915		10347	

*Indicates (0.05<p-value≤0.10)

**Indicates (0.01<p-value≤0.05)

***Indicates (p-value<0.01)

In table 6 all estimates for month of birth variables are positive but due to large SE, inference should be approached with extreme caution. Estimates for July and August could, however, indicate that those born in July and August have more years of education compared to those born in January, at the 10% significance level. The estimated coefficient for these months becomes slightly larger when controls for age and self-assessed health are added. The younger women in the cohort have more years of education since estimated coefficient for age is negative. Estimates of coefficients for excellent health, very good health and good health are positive and significant at the 1% significance level. It can also be pointed out that although standard errors are large, all point estimates of included months are positive, which could indicate that the lowest education level is obtained by those born in January.

In table 7 the small sized estimated coefficient for September in equation 1 is not robust to controlling for education as in equation 2. The estimated coefficient for age is very small and it is robust to controls for education but when controlling for lifestyle variables the point estimate turns negative indicating better health with age, which is not what would generally be expected. Higher BMI is related to poorer self-assessed health with positive estimate and significance at the 1% significance level. The estimate for daily smoker in equation 3 is large and those who smoke daily have worse self-assessed health as expected. Those with 9 years or less of schooling seem to have worse health compared to those with 13-16 years and more than 16 years of education as signs of the estimates indicate. Point estimates in the health equations do not show an obvious systematic pattern.

Hypothesis testing for equations in table 6 and 7 did not reject null hypothesis of month of birth estimates jointly being equal to zero. When estimating an equation with education as the dependent variable chi-squared (for 11 month variables jointly being equal to zero) was 7.93, 7.68 and 7.92 with p-value 0.72 in all instances. With health as a dependent variable chi-squared (11) was 13.82, 16.21 and 15.04 with a p-values 0.20, 0.24 and 0.13 respectively. These results are reported in tables 6 and 7.

Grouping the months into quarters did not change the results, but considering the size of the sample the power of hypothesis testing is such that grouping months is not directly indicated here although it is sometimes used for the purpose of increasing the power of the statistics. It is more a way of producing comparable methods to previous research. See Appendix B for results of the regression with years of schooling as a function of quarters of birth.

The results were also robust to analysis that tested for variation in level of education by month of birth using probit methods with binary dependent variables for primary education, highschool education and university education. To further check the results for robustness the health variable was dichotomized for a probit regression on a binary dependent health variable taking the value 1 for SAH = 1 and 2, and the value 0 for SAH = 3, 4 and 5. The aforementioned results were robust to that analysis. Since it is suggested within the literature on birth seasonality that temperature and photoperiod affect birth seasonality a probit regression was calculated with a binary dependent variable were months of the calendar year were divided in two periods accounting for higher and lower temperature. No pattern in estimates for schooling or health was detected to support such theory with this data. Finally regressions were run with BMI, smoking and drinking as dependent variables and month of birth as an explanatory variable, which did not reveal variations in the dependent variables by month of birth.

6. Discussion

The results of this analysis, with data from a random sample of 11,084 Icelandic women, do not confirm an association between month of birth and the later outcomes, measured as years of schooling and self-assessed health. However, if one examines the point estimates without regard for the power of the analysis, one can detect a relationship that is somewhat consistent with the seasonal variations in schooling in the United States. In previous studies, the measured association of month of birth and years of schooling is small. Keeping that in mind, the point estimates of the results are of the same sign for years of schooling as the dependent variable, as in the U.S. and they do show a suggestive pattern without much significance at traditional levels. This does not lend support to the theory of compulsory schooling system nor the relative age effect as causal factors for variations in educational attainment by month of birth, but more interestingly may motivate future research on possible variations in outcomes by month of birth with regard to family background, using data with even more statistical power. The results indicate a similar pattern in the coefficients as results from the U.S. on the relationship between month of birth and years of schooling which have reported worse outcomes in educational attainment for those born in the first quarter of the calendar year compared to those born in other quarters of the year. In previous results from the U.S. it is proposed that compulsory schooling laws and age at school start work together to create a link between month of birth and years of schooling. Research showing that mother characteristics could explain variations in later outcomes by month of birth proposes a complimentary effect of family background and compulsory schooling on later outcomes (education, earnings, highschool dropouts). In the absence of the U.S. compulsory laws the results of this analysis indicates that variation in years of schooling by month of birth could be a function of factors other than the schooling system. Family background, with mother characteristics as the main variable may be one of those factors as previous research has revealed.

Regarding the health variable there is not a direct comparison available. The aforementioned study by Doblhammer and Vaupel on mortality rates by month of birth is used as an indication for using self-assessed health as a proxy for mortality to test for differences by month of birth. The reason for this is that SAH has been shown to correlate with mortality in numerous studies.

It has been hypothesised, with some scientific support, that the relationships between season of birth and later outcomes are confounded by parental characteristics, with the proportions of births by parents of different socio-economic status differing by months. Such an influence may be attenuated in societies that through generous welfare systems attempt to limit the correlation between a childs and parents outcomes. Iceland would be considered to have a strong welfare system that may have this effect. This welfare system and the equalitarian views toward early human-capital investment may also have an attenuating effect on mothers. For example, adolescent pregnancy is three times more common in the U.S. than in Iceland. Such a system would not be expected to change the qualitative nature of the relationships between season of birth and later outcomes, but it may have an attenuating effect.

The complexity of human fertility patterns is such that despite research from various fields of study there is little known about what factors play the biggest part in influencing the persistent pattern of birth seasonality within populations or as studied here, individual´s month of birth. The economic point of departure for theory of fertility builds on theory of demand. The only obvious reason for that to influence month of birth is by different costs and benefits over the calendar year to reveal itself clearly to parents. Monetary motivations and preferences would then proposedly work together. Should there exist a monetary motivation to have children in some particular months some individuals might respond to that, but such situations are not recognized.

It may be of relevance when interpreting the results of this analysis that other studies have used male samples (Angrist & Krueger, 1991; Buckles & Hungerman, 2008) but in this study we use a female sample. It is not clear if and to what extent results would differ whether using male or female cohorts. It would however make comparison even more reliable since male and female samples may differ in relation to educational attainment. Icelandic data has revealed that test performance is poorer for boys at the primary school level and male students are proportionately fewer than female students at higher educational levels (The Ministry of Science, Education and Culture, 2004). That underscores the importance of looking at both sexes if possible to include the variance in educational outcomes when studying education of any sort as an outcome in general. However the included time window is relevant. For example males attending university in Iceland have since 1990 been outnumbered by females attending university, with females amounting to 60% of all enrolled students in the University of Iceland in 2002. Before 1990 women attending university education were proportionately fewer than men (University of Iceland, 2010).

It is noteworthy that in Buckles and Hungerman´s study (2008) the binary variables in the regression of mother characteristics on their children´s birth month, define whether mother´s have highschool degree and whether they are teenagers (among other characteristics). This implies that the results are based around mothers who are 19 years of age or younger. When comparing adolescent fertility in Iceland to adolescent fertility in the U.S. there is a large difference. Adolescent fertility rate is 41 births per 1000 women in the U.S. compared to 14 per 1000 births in Iceland (World Economic Forum, 2009). This variation in adolescent fertility rate between those two countries may explain the different outcomes to some extent, in particular, if mother characteristics are related to month of birth irrelevant of country of origin.

Both aforementioned studies used very large sample sizes ranging from hundreds of thousands to tens of millions. Standard error becomes small and hypothesis testing will reject null hypothesis. It points to the importance of correct inference procedures. However Plug (2001) reports variations in earnings by quarter of birth within sample size of 1,168.

The large literature on early determinants on later outcomes often focuses on variations in nutrition and other factors affecting fetal or child development at proposed sensitive periods in life. In an article by Dora Costa (2007) she emphasizes how research on health in any form benefits from understanding the relationships among the choices we make, the environment, initial health and luck. Her conclusion is related to economic history and its relevance when studying early effects on later health outcomes. In particular, Fogel´s work on economic history puts into context how nutrition has played an important role in economic growth in western populations (Fogel & Costa, 1997). With that in mind results of research on early determinants of later outcomes are restricted to being time specific and may not have implications for later birth cohorts.

The results of this analysis, using female sample, do not confirm an association between month of birth and the later outcomes under study here; individual health and educational attainment in Iceland. However, the results indicate similar pattern in the coefficients as in results from the U.S. on the relationship between month of birth and years of schooling. Further research using a larger sample including both genders would be an interesting pathway for future work.

Appendix A: Seasonal Patterns in Birth Frequency

Pronounced and persistent seasonal patterns in births have been observed across human populations (Lam & Miron, 1991, 1994). These seasonal patterns have raised questions about the behavioral and biological determinants of reproduction. The seasonality of births varies between populations. In Northern Europe most births occur in spring (March-April) while birth rates are lowest in the autumn (October-December). In the United States, by contrast, most births occur in summer and early autumn (September peak) and the minimum is in spring (April-May) (Lam & Miron, 1994).

Figure 3 shows birth frequency in Iceland for years corresponding to the data used in this analysis separated into two periods to show more precisely the pattern in birth frequency. This pattern is in line with patterns as described by Lam and Miron for the Northern Hemisphere with most births occurring in April-May and lowest birth rates close to the end of the year.

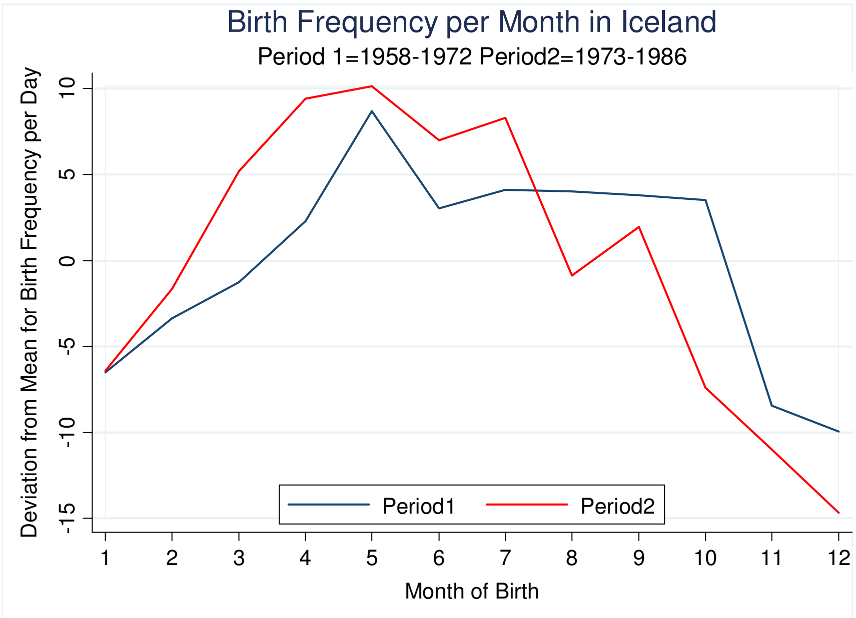

Figure 2. Birth Frequency per Month in Iceland (Statistics Iceland, 2010b).

The causes of these seasonal variations are not fully understood. Possible explanations may partly be linked to seasonal fluctuations in environmental factors, such as temperature and photoperiod (daily exposure to light). The effect of temperature on conception may result from changes in coital frequency or may reflect direct physiological effects. Lam and Miron (1994) found mixed evidence on the role of temperature in explaining birth seasonality and suggest that other factors play an important role in birth seasonality. The southern U.S. pattern appears to be heavily influenced by summer heat, but the northern European pattern appears to have little to do with temperature.

One proposed explanation for the summer heat effect is related to a socioeconomic differential in birth seasonality (Kestenbaum, 1987). Kestenbaum found more pronounced birth seasonality in lower socioeconomic groups (measured by parental income) and interprets that as a reflection of the greater ability of those better-off to control climate, for example through air-conditioning. In a study by Buckles and Hungerman (2008) summer weather is claimed to differentially affect fertility patterns across socioeconomic groups with those in lower groups being more effected than others. This is in contrast to other results that have found more pronounced birth seasonality within higher socioeconomic groups as measured by education, age and marital status (Bobak & Gonjka, 2001) which may indicate that those in higher socioeconomic groups have more control of their reproduction by individual choices. These theories are contradictory as to whether birth seasonality is more pronounced in higher or lower socioeconomic groups. At the same time they emphasize different explanations to birth seasonality; temperature and preferences.

Photoperiod is often linked to weather conditions in this literature but there is little evidence on the proposed effect of photoperiod on birth seasonality. Other proposed explanations to birth seasonality are seasonality in pregnancy loss (Weinberg, Moledor & Baird, 1994) or cultural factors like the choice of the time of pregnancy (Basso et al., 1995). Seasonal patterns in marriages, holidays, temporary migration and economic variables, including agricultural cycles are among speculations that have been documented (Lam & Miron, 1991). Religious festivals, business cycles and the existence of occupations requiring the temporary absence of the husband have also been cited as determinants of birth seasonality (Condon & Scaglion, 1982).

Appendix B: Regression of Quarters of Birth on Years of Schooling

Table 8: Regression

Method of estimation: Ordered probit

Dependent variable: Years of schooling

	(1)		(2)		(3)	
Variable	Coefficient	SE	Coefficient	SE	Coefficient	SE
Quarter of birth						
2nd quarter	0.039	0.034	0.042	0.034	0.036	0.034
3rd quarter	0.038	0.034	0.044	0.034	0.056	0.034
4th quarter	0.007	0.034	0.017	0.034	0.015	0.035
Age			-0.016	0.002***	-0.015	0.002***
Self-assessed health						
Excellent					0.733	0.103***
Very good					0.602	0.099***
Good					0.318	0.100***
Fair					0.035	0.106*
/cut1	-2.106	0.039	-2.690	0.081	-2.192	0.128
/cut2	-0.655	0.026	-1.233	0.075	-0.707	0.124
/cut3	0.213	0.025	-0.360	0.074	0.186	0.124
PseudoR2	0.000		0.004		0.019	
N	8552		8552		8516	

7. References

Almond, D. (2006). Is the 1918 influenza pandemic over? Long-term effects of in utero influenza exposure in the post-1940 U.S. population. *Journal of Political Economy, 114*(4), 672-712.

Angrist, J. D. & Krueger, A. B. (1991). Does compulsory school attendance affect schooling and earnings? *The Quarterly Journal of Economics, 106*(4), 979-1014.

Angrist, J. D., & Krueger, A. B. (2001). Instrumental variables and the search for identification: From supply and demand to natural experiments. *Journal of Economic Perspectives, 15*(4), 69-85.

Barker, D. J. P. (1995). Fetal origins of coronary heart disease. *British Medical Journal, 311*(6998), 171-174.

Barker, D. J. P., & Osmond, C. (1986). Infant-mortality, childhood nutrition, and ischemic-heart-disease in England and Wales. *Lancet, 1*(8489), 1077-1081.

Barker, D. J. P. (2001). Fetal and infant origins of adult disease. *Monatsschrift Kinderheilkunde, 149*(1), 2-6.

Basso, O., Olsen, J., Bisanti, L., Juul, S., Boldsen, J., Karmaus, W., et al. (1995). Are seasonal preferences in pregnancy planning a source of bias in studies of seasonal-variation in reproductive outcomes? *Epidemiology, 6*(5), 520-524.

Becker, G. S. & Lewis, H. G. (1973). On the interaction between the quantity and quality of children. *The Journal of Political Economy, 81*(2), 5279-5288.

Becker, G. S. (1993). Nobel Lecture - the Economic Way of Looking at Behavior. *Journal of Political Economy, 101*(3), 385-409.

Bedard, K. & Dhuey, E. (2006). The persistence of early childhood maturity: International evidence of long-run age effects. *Quarterly Journal of Economics, 121*(4), 1437-1472.

Ben-Shlomi,Y. & Smith, G. D. (1991). Deprivation in infancy or in adult life: Which is more important for mortality risk? *Lancet, 337*(8740), 530-534.

Bobak, M., & Gjonca, A. (2001). The seasonality of live birth is strongly influenced by sociodemographic factors. *Human Reproduction, 16*(7), 1512-1517.

Bound, J., Jaeger, D. A., & Baker, R. M. (1995). Problems with instrumental variables estimation when the correlation between the instruments and the endogenous explanatory variable is weak. *Journal of the American Statistical Association, 90*(430), 443-450.

Bound, J. & Jaeger, D. A. (1996). On the validity of season of birth as an instrument in wage equations: A comment on Angrist and Krueger´s “Does compulsory school attendance affect schooling and earnings?”. *National Bureau of Economic Research.* Cambridge, MA.

Buckles, K. S. & Hungerman, D. M. (2008). Season of birth and later outcomes: Old questions, new answers. *National Bureau of Economic Research.* Cambridge, MA.

Card, D. (1994). Earnings, schooling, and ability revisited. *National Bureau of Economic Research.* Cambridge, MA.

Case, A., Fertig, A., & Paxson, C. (2005). The lasting impact of childhood health and circumstance. *Journal of Health Economics, 24*(2), 365-389.

Castrogiovanni, P., Iapichino, S., Pacchierotti, C., & Pieraccini, F. (1998). Season of birth in psychiatry - A review. *Neuropsychobiology, 37*(4), 175-181.

Chesher, A. (2007). Instrumental values. *Journal of Econometrics, 139*(1), 15-34.

Condon, R. G., & Scaglion, R. (1982). The ecology of human birth seasonality. *Human Ecology, 10*(4), 495-511.

Costa, D. L. (2007). The economics and demography of aging. *Proceedings of the National Academy of Sciences of the United States of America, 104*(33), 13217-13218.

Currie, J. (2009). Healthy, wealthy, and wise: Socioeconomic status, poor health in childhood, and human capital development. *Journal of Economic Literature, 47*(1), 87-122.

Doblhammer, G., & Vaupel, J. W. (2001). Lifespan depends on month of birth. *Proceedings of the National Academy of Sciences of the United States of America, 98*(5), 2934-2939.

Elo, I. T., & Preston, S. H. (1992). Effects of early-life conditions on adult mortality - a review. *Population Index, 58*(2), 186-212.

Fogel, R. W., & Costa, D. L. (1997). A theory of technophysio evolution, with some implications for forecasting population, health care costs, and pension costs. *Demography, 34*(1), 49-66.

Forrest, J. D. (1994). Epidemiology of unintended pregnancy and contraceptive use. *American Journal of Obstetrics and Gynecology, 170*(5), 1485-1489.

Gillberg, C. (1990). Do children with autism have March birthdays? *Acta psychiatrica Scandinavica, 82*(2), 152-156.

Greene, W. H. (2008). *Econometric Analysis*(6th ed.). Pearson Prentice Hall. New Jersey.

Gortmaker, L., Kagan, J. Caspi, A. & Silva, P. A. (1996). Daylength during pregnancy and shyness in children: Results from Northern and Southern hemispheres. *Developmental Psychobiology, 31*, 107-114.

Grossman, M. & Kaestner, R. (1997). Effects of education on health. In Jere R. Behrman and Nevzer Stacey (Eds.). *The Social Benefits of Education* (pp.69-123). Ann Arbor, MI: University of Michigan Press.

Harmon, C., & Walker, I. (1995). Estimates of the economic return to schooling for the United Kingdom. *American Economic Review, 85*(5), 1278-1286.

Heckman, J. J. (2007). The economics, technology, and neuroscience of human capability formation. *Proceedings of the National Academy of Sciences of the United States of America, 104*(33), 13250-13255.

Hotz, V. J., J. Klerman, & R. Willis (1997). The economics of fertility in developed countries: A survey," in M.R. Rosenzweig and O. Stark (Eds.). *Handbook of Population and Family Economics*, North Holland: Elsevier.

Hoogerheide, L., Kleibergen, F., & van Dijk, H. K. (2007). Natural conjugate priors for the instrumental variables regression model applied to the Angrist-Krueger data. *Journal of Econometrics, 138*(1), 63-103.

Heckman, J. J., Lochner, L. J. & Todd, P. E. (2006). Earnings functions, rates of return and treatment effects: The Mincer equation and beyond, in E. A. Hanushek and F. Welch (Eds.). *Handbook of the Economics of Education, Volume I*, North Holland: Elsevier.

Huber, S., Didham, R., & Fieder, M. (2008). Month of birth and offspring count of women: data from the southern hemisphere. *Human Reproduction, 23*(5), 1187-1192.

Icelandic Meteorologic office (2010). Website: http://en.vedur.is/

Idler, E. L., & Benyamini, Y. (1997). Self-rated health and mortality: A review of twenty-seven community studies. *Journal of Health and Social Behavior, 38*(1), 21-37.

Idler, E. L., & Kasl, S. (1991). Health perceptions and survival - Do global evaluations of health-status really predict mortality. *Journal of Gerontology, 46*(2), 55-S65.

Kestenbaum, B. (1987). Seasonality of birth: Two findings from the decennial census. *Social Biology, 34*, 244-248.

Kihlbom, M., & Johansson, S. E. (2004). Month of birth, socioeconomic background and development in Swedish men. *Journal of Biosocial Science, 36*(5), 561-571.

Lam, D. A. & Miron, A. (1991). Seasonality of births in human populations. *Social Biology, 38*(1-2), 51-78.

Lam, D. A. & Miron, J. A. (1994). Global patterns of seasonal variation in human fertility. *Annals of the New York Academy of Sciences, 709*(1), 9-28.

Leigh, A., & Ryan, C. (2008). Estimating returns to education using different natural experiment techniques. *Economics of Education Review, 27*(2), 149-160.

Livingston, R. B., Adam, S. & Bracha, H. S. (1993). Season of birth and neurodevelopmental disorders: Summer birth is associated with dyslexia. *Journal of the American Academy of Child and Adolescent Psychiatry, 32*(3), 612-616.

Martin, M. & Jones, G. (1999). Handedness and season of birth: A gender-invariant relation. *Cortex, 35*(1). 123-128.

Mccallum, J., Shadbolt, B., & Wang, D. (1994). Self-rated health and survival - a 7-year follow-up-study of Australian elderly. *American Journal of Public Health, 84*(7), 1100-1105.

Plug, E. J. S. (2001). Season of birth, schooling and earnings. *Journal of Economic Psychology, 22*(5), 641-660.

Procopio, M., Marriott, P. K., & Davies, R. J. E. (2006). Seasonality of birth in epilepsy: A southern hemisphere study. *Seizure-European Journal of Epilepsy, 15*(1), 17-21.

Robinson, W. C. (1997). The economic theory of fertility over three decades. *Population Studies, 51*(1), 63-74.

Rodgers, J. L. & Udry, J. R. (1988). The season-of-birth paradox. *Social Biology, 35*(3-4), 171-84.

Statistics Iceland (2010a). Retrieved June 2010:

http://www.statice.is/?PageID=1175&src=/temp_en/Dialog/varval.asp?ma=MAN05302%26ti=Births+by+months+1853%2D2008+++++%26path=../Database/mannfjoldi/faeddir/%26lang=1%26units=number

Statistics Iceland (2010b). Retrieved June 2010: http://www.statice.is/?PageID=1170&src=/temp_en/Dialog/varval.asp?ma=MAN00101%26ti=Population+by+sex+and+age+1841%2D2010++++%26path=../Database/mannfjoldi/Yfirlit/%26lang=1%26units=Number

The Ministry of Science, Education and Culture (2004). Retrieved June 2010: http://www.menntamalaraduneyti.is/frettir/Frettatilkynningar/nr/2905

Tochigi, M., Okazaki, Y., Kato, N., & Sasaki, T. (2004). What causes seasonality of birth in schizophrenia? *Neuroscience Research, 48*(1), 1-11.

University of Iceland (2010). Retrieved June 2010: http://www.hi.is/is/skolinn/heildarskraning_nemenda_i_haskola_islands_fra_upphafi_0

Weinberg, C. R., Moledor, E., & Baird, D. D. (1994). Is there a seasonal pattern in risk of early-pregnancy loss. *Epidemiology, 5*(5), 484-489.

Willis, J. A., Scott, R. S., Darlow, B. A., Lewy, H., Ashkenazi, I., & Laron, Z. (2002). Seasonality of birth and onset of clinical disease in children and adolescents (0-19 years) with type 1 diabetes mellitus in Canterbury, New Zealand. *Journal of Pediatric Endocrinology & Metabolism, 15*(5), 645-647.

Wooldridge, J. M. (2009). *Introductory Econometrics. A Modern Approach* (4th ed.). Canada: South–Western.

World Economic Forum (2009). *The Global Gender Gap Report.* http://www.weforum.org/pdf/gendergap/report2009.pdf

INSTITUTE OF ECONOMIC STUDIES WORKING PAPERS 1987-2009
Formerly Iceland Economic Papers Series

Editor Sveinn Agnarsson

A complete list of IoES Working Papers and Reprints can be accessed on our World Wide Web site at http://www.ioes.hi.is

W10:03 Gylfi Magnusson: Lessons from a small country in financial crisis or Dr. Minsky and Mr. Ponzi in Iceland

W10:02 Olafur G. Halldorsson and Gylfi Zoega: Iceland's financial crisis in an international perspective.

W10:01 Yu-Fu Chen and Gylfi Zoega: Life-cycle, effort and academic deadwood.

W09:10 Yu-Fu Chen and Gylfi Zoega: Strong hysteresis due to age effects.

W09:09 Yu-Fu Chen and Gylfi Zoega: An essay on the generational effect of employment protection.

W09:08 Anna Gunnthorsdottir, Roumen Vragov and Jianfei Shen: Tacit coordination in contribution-based grouping with two endowment levels.

W09:07 Axel Hall and Gylfi Zoega: Working in spite of High Taxes: On the Role of Culture in Explaining High Employment in the Nordic Countries.

W09:06 Gylfi Zoega: Employment and asset prices.

W09:05 Gylfi Zoega: Market forces and the continent's growth problem.

W09:04 Gylfi Zoega: A double-edged sword: High interest rates in capital-control regimes.

W09:03 Jon Danielsson and Gylfi Zoega: The collapse of a country.

W09:02 Manoj Atolia, Tor Einarsson and Milton Marquis: Understanding liquidity shortages during severe economic downturns.

W09:01 Thorolfur Matthiasson: Spinning out of control: Iceland in crisis.

W08:07 Ragnar Arnason: Natural resource rents: Theoretical clarification.

W08:06 Axel Hall and Gylfi Zoega: Feminism and labour supply in the Nordic countries.

W08:05 Gylfi Zoega: Productivity, wages and relationships.

W08:04 Thrainn Eggertsson: Knowledge and economic progress: The role of social technologies.

W08:03 Thrainn Eggertsson: Genetic technology and the evolution of property rights: The case of Decode Genetics.

W08:02 Tinna Laufey Asgeirsdottir and Gylfi Zoega: Sleeping.

W08:01 Thorvaldur Gylfason: Development and growth in mineral-rich countries.

W07:14 Ragnar Arnason: Fisheries enforcement with a stochastic response function.

W07:13 Thorvaldur Gylfason and Eduard Hochreiter: Growing apart? A tale of two republics: Estonia and Georgia.

W07:12 Thorolfur Matthiasson: Economic gain from education in Iceland during the period 1985 to 1999.

W07:11 Alison L. Booth and Gylfi Zoega: Worker heterogeneity, new monopsony and training.

W07:10 Yu-Fu Chen and Gylfi Zoega: Aging and job security.

W07:09 Ron Smith and Gylfi Zoega: Keynes, investment, unemployment and expectations.

W07:08 Thorolfur Matthiasson and Claire W. Armstrong: Effects of foreshortening of transferred quota in an ITQ market.

W07:07 Helgi Tomasson: Likelihood based surveillance of continuous-time processes.

W07:06 Helgi Tomasson: Review of Econometric Modeling Approaches in Finance.

W07:05 Anna Gunnthorsdottir, Roumen Vragov, Kevin McCabe and Stefan Seifert: The meritocracy as a mechanism to overcome social dilemmas.

W07:04 Gylfi Zoega: Endogenous employment cycles in Euroland.

W07:03 Thorvaldur Gylfason: The international economics of natural resources and growth.

W07:02 Helga Kristjansdottir: Talking trade or talking aid? Does investment substitute for aid in the developing countries?

W07:01 Ali Choudhary, Thorlakur Karlsson and Gylfi Zoega: Testing for customer markets using survey data.

W06:13 Brynhildur Davidsdottir: Sustainable energy development.

W06:12 Helga Kristjansdottir: Substitution between inward and outward foreign direct investment.

W06:11 Helga Kristjansdottir: Evaluation of Icelandic trade flows, the gravity model approach.

W06:10 Brynhildur Davidsdottir: Capital constraints and the effectiveness of environmental policy.

W06:09 Gylfi Zoega: Market forces and the continent's growth problem.

W06:08 Fridrik M Baldursson and Nils-Henrik M von der Fehr: Vertical integration and long-term contracts in risky markets.

W06:07 Ragnar Arnason: Conflicting uses of marine resources: Can ITQ's promote an efficient solution?

W06:06 Thorvaldur Gylfason and Gylfi Zoega: A golden rule of depreciation.

W06:05 Ron Smith and Gylfi Zoega: Global factor, capital adjustment and the natural rate.

W06:04 Thorolfur Matthiasson: To whom should the rent accrue?

W06:03 Tryggvi Thor Herbertsson and Gylfi Zoega: Iceland's Currency Dilemma.

W06:02 Thorolfur Matthiasson: Possible stakeholder conflicts in quota regulated fisheries,contribution to the political economics of fisheries.

W06:01: Eyjolfur Sigurdsson, Kristin Siggeirsdottir, Halldor Jonsson jr , Vilmundur Gudnason, Thorolfur Matthiasson, Brynjolfur Y Jonsson:Early discharge and home intervention reduces unit costs after total hip replacement: Results of a cost analysis in a randomized study.

W05:14 Gylfi Zoega and J Michael Orszag: Are Risky Workers More Valuable to Firms?

W05:13 Friðrik Már Baldursson: Fairness and pressure group competition.

W05:12 Marias H. Gestsson and Tryggvi Thor Herbertsson: Fiscal Policy as a Stabilizing Tool.

W05:11 Tryggvi Thor Herbertsson and Gylfi Zoega: On the Adverse Effects of Developement Aid.

W05:10 Thráinn Eggertsson and Tryggvi Thor Herbertsson: Evolution of Financial Institutions: Iceland's Path from Repression to Eruption.

W05:09 Tryggvi Thor Herbertsson: The Icelandic Pension System in 2004.

W05:08 Ron Smith and Gylfi Zoega: Unemployment, investment and global expected returns: A panel FAVAR approach.

W05:07 Gylfi Zoega and Thorlakur Karlsson: Does Wage Compression Explain Rigid Money Wages?

W05:06 Thorvaldur Gylfason: India and China

W05:05 Edmund S. Phelps: Can Capitalism Survive?

W05:04 Thorvaldur Gylfason: Institutions, Human Capital, and Diversification of Rentier Economies

W05:03 Jón Daníelsson and Ásgeir Jónsson: Countercyclical Capital and Currency Dependence

W05:02 Alison L. Booth and Gylfi Zoega: Worker Heterogeneity, Intra-firm Externalities and Wage Compression

W05:01 Tryggvi Thor Herbertsson and Martin Paldam: Does development aid help poor countries catch up?

W04:12 Tryggvi Thor Herbertsson: Personal Pensions and Markets

W04:11 Fridrik M. Baldursson and Sigurdur Johannesson: Countervailing Power in the Icelandic Cement Industry

W04:10 Fridrik M. Baldursson: Property by ultimatum: The case of the Reykjavik Savings Bank

W04:09 Ingólfur Arnarson: Analyzing Behavior of Agents of Economic Processes in Time

W04:08 Otto Biering Ottosson and Thorolfur Matthiasson: Subsidizing the Icelandic Fisheries

W04:07 Niels Vestergaard and Ragnar Arnason: On the Relationship between Greenland's Gross Domestic Product and her Fish Exports: Empirical Estimates

W04:06 Ingolfur Arnarson: Modelling Fishery Management Schemes with an Olympic System Application

W04:05 Ingolfur Arnarson and Pall Jensson: Adding the Sales Markets Dimension to Bio-Economic Models. The Case of Fishery Management

W04:04 Edmund S. Phelps: Changing Prospects, Speculative Swings: Structuralist Links through Real Asset Prices and Exchange Rates

W04:03 Ingolfur Arnarson: Analysing Behavior of Agents of Economic Processes in Time

W04:02 Ron Smith and Gylfi Zoega: Global Shocks and Unemployment Adjustment