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Economic downturns and infant health

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ABSTRACT

We study the gender-specific impact of macroeconomic conditions around birth on infant health. We use a sample of over 50,000 respondents born between 1950 and 1994 from Lifelines—a cohort and biobank from the northern Netherlands. Our results show that high provincial unemployment rates decrease fertility and lead to a lower birthweight in boys. The negative impact of high unemployment on birthweight is particularly strong for boys born to older mothers and for babies born to smoking mothers.

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1. Introduction

Health insults early in life and even *in utero* persist through the lifetime and even a minor exposure early in life can increase the risk of chronic diseases later in life (Barker, 1995; Van den Berg et al., 2006). Moreover, infant health is an important determinant of a host of outcomes later in life such as accumulation of human capital, labour market outcomes, marital status and welfare dependency (Behrman and Rosenzweig, 2004; Almond et al., 2010; Brandt et al., 2016; Cruces et al., 2012; Nilsson, 2017). In addition, poor infant health is transmitted to the next generation (Currie and Moretti, 2007). In this sense infants born with poor health are set on a lifetime trajectory of inferior outcomes that can potentially spill over to the next generations.

Important determinants of infant health are the socio-economic status and income of the family (Currie, 2009; Catalano et al., 2011). To understand the relationship between health at various stages of the life-cycle and economic conditions around birth, a number of studies have analysed how life-course health outcomes are affected by the state of the business cycle at the time of birth since the state of the business cycle represents exogenous variation in the economic conditions families face (Van den Berg et al., 2006, 2009, 2011).

Focusing especially on infant health Dehejia and Lleras-Muney (2004) and Aparicio and González (2014) demonstrate that fewer babies are born with low birthweight during economic downturns than during booms in the United States and Spain respectively. Angelini and Mierau (2014) document that recessions are associated with higher levels of childhood health in European countries and Van den Berg and Modin (2013) find no relationship between economic conditions and birthweight in Sweden. By contrast, Kaplan et al. (2017) and Margerison-Zilko et al. (2011) show that elevated levels of unemployment led to an increase in the likelihood of babies being born with low birthweight in Memphis, TN and the National Longitudinal Survey of Youth 1979, respectively. In the context of developing countries, Bhalotra (2010) and Bozzoli and Quintana-Domeque (2014), among others, has shown that recessions have a negative impact on infant health.

Additionally, it is well established in the medical and epidemiological literature that male fetuses and infants are more sensitive to harsh conditions than female fetuses (e.g. Bruckner et al., 2010) – possibly due to differences in intra-uterine growth strategies (Eriksson et al., 2010). It has been documented in the US and various European countries that increased unemployment levels and business cycle fluctuations can lead to changes in sex ratios, male fetal deaths and low birthweight in males (Catalano and Serxner, 1992; Catalano, 2003; Catalano et al., 2005, 2010, 2012; Catalano and Bruckner, 2005, 2006). Remarkably, some studies suggest selection against the least fit males in utero during economic downturns, which results in better average health of surviving infants (Catalano et al., 2010, 2012). Interestingly, the

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Fig. 1. Female labour participation rate, for selected countries (1950–1994).

Data source: Compiled from Statistics Netherlands (www.cbs.nl), US Bureau of Labor Statistics (www.bls.gov), and World Bank (databank.worldbank.org).

economic literature on business cycle fluctuations and infant health, to the best of our knowledge, has not accounted for such gender differences.

There are three broad mechanisms by which an economic downturn might affect babies' health. First, economic downturns might affect the decision to become pregnant differently for different population groups, thus affecting the cohort composition of the babies born in a given year. Indeed, the positive relationship between being born in a recession and babies' health documented by, for instance, *Dehejia and Lleras-Muney (2004)* and *Aparicio and González (2014)* can be partially explained by different fertility responses across women with different skill levels. Moreover, *Orsini and Avendano (2015)* show that age-related selection into motherhood explains why the relationship between business cycle fluctuations and infant mortality in the United States differs by race and period. Aside from the fertility decision, the state of the business cycle may influence the probability of spontaneous abortions differently across groups, thereby also affecting the cohort composition (see, for instance, *Bruckner et al., 2016*).

The second mechanism concerns the fact that, conditional on the decision to become pregnant, a decrease in income due to an economic downturn can lead to changes in health-related consumption by pregnant women, including changes in the quality and quantity of nutrition, but also changes in unhealthy consumption such as smoking or alcohol. Exploring this mechanism, *Ruhm (2000, 2003)* shows that recessions are associated with a positive change in health behaviour. *Margerison-Zilko (2014)*, however, shows that economic contractions are associated with an increased risk of alcohol use among pregnant women.

Third, economic downturns can lead to changes in the environment that, in turn, affect the foetus. Focusing on the beneficial effects, *Chay and Greenstone (2003)* show that pollution decreases during recessions. Reassessing and extending the analyses of *Ruhm (2000, 2003)* who shows that the health behaviour improves during recessions, *Miller et al. (2009)* highlight that a lion's share of the mortality gains experienced during recessions can be traced back to a decrease in traffic accidents. Focusing on negative effects, *Bruckner et al. (2014)* using data from California and *Pedersen et al. (2005)* with Swedish data show that maternal stress – a risk factor for foetal development (*Kuh and Hardy, 2002*) – increases during economic downturns.

Against the background of the above literature we use this paper to analyse the relationship between economic downturns and babies' health using individual level data from the Netherlands for cohorts born between 1950 and 1994. The Netherlands is an interesting country for exploring the mechanisms behind this for several reasons. First, the Netherlands is a small and homogeneous

country with high income. Second, female labour force participation in the Netherlands has been strikingly low throughout the 20th century (see *Fig. 1*) due to Christian-conservative beliefs (*Becker, 2000*) and started to increase only in the late '80s while, for example in the US, female labour participation has been steadily increasing since the '50s. Third, a generous social security scheme was introduced in the Netherlands in 1949 which is right before our period of analysis (see *Becker, 2000* for a discussion of the Dutch welfare state and employment).

For our analysis, we use Lifelines—a large-scale cohort study and biobank. Lifelines provides us with a sample of over 50,000 respondents born between 1950 and 1994 who are currently residing in one of the three northern provinces of the Netherlands. While the participants of Lifelines currently reside in the northern Netherlands, they can have been born in other parts of the Netherlands. Nevertheless, a lion's share of our sample was actually born in the northern Netherlands. To circumvent any inference problems arising from this data structure we employ various techniques to deal with the clustering of data. Combining Lifelines data with provincial unemployment data from Statistics Netherlands allows us to analyse the relationship between unemployment at the provincial level and birthweight – a standard measure of babies' health. Importantly, Lifelines also provides us with information on the age of the mother at birth as well as on her health behaviour – smoking in particular. We exploit this information to analyse who gives birth during economic downturns and how health behaviour of pregnant women is related to unemployment levels.

Using the data outlined above in combination with various econometric techniques allows us to conclude that an increase in the unemployment rate leads to a decrease in the birthweight of boys. While statistically significant, the effect is small in the sense that a 5 percentage point increase in the unemployment causes a 30 g decline in boys' birthweight. This implies that the birthweight remains within the normal range and, accordingly, we do not find an increase in the likelihood of being born with low birthweight (<2500 g). While in line with the findings of *Kaplan et al. (2017)* and *Margerison-Zilko et al. (2011)*, our results contrast the findings of *Dehejia and Lleras-Muney (2004)*; *Aparicio and González (2014)* and *Angelini and Mierau (2014)* who documented a positive relationship between adverse economic conditions surrounding birth and infant health.

The remainder of the paper is set up as follows. The next section provides a discussion of the relationship between economic downturns and babies' health within the context of the inter-temporal fertility model and its implications for the Dutch setting. Section 3 describes the study population and the empirical

methods. Section 4 discusses our empirical results and the final section concludes.

2. Economic downturns and infant health

Within the context of the intertemporal fertility model (Becker, 1960, 1965), we consider three possible mechanisms how economic conditions affect infant health. First, economic downturns may affect the decision to become pregnant differently in different population groups, thus changing the cohort composition and the resulting distribution of babies' health. Second, an economic downturn can decrease the income of households and in turn affect the consumption patterns of those women who have become pregnant. Third, economic downturns can lead to changes in the environment that, in turn, affect the foetus. In what follows, we discuss the role of the first two mechanisms within the Dutch setting. The third mechanism (i.e., stress) is less influenced by the institutional setting, therefore we refer the reader to our earlier discussion in the introduction.

2.1. Effect on fertility decision

To study the fertility decision, we use the framework provided by Becker (1960, 1965) who considers children as normal goods. We assume that changes in the unemployment rate affect the wages of women and their family members. Also, women are assumed to be primarily responsible for raising children in the household.

In the framework of Becker (1960), the effect of unemployment on fertility can be divided in income and substitution effects. The income effect means that a decline in the woman's wage lowers income, decreasing the demand for children along with other normal goods. The substitution effect arises because children are relatively time intensive, and thus, a decrease in wages lowers the relative cost of children and increases the demand for children. If the wages of other family members decrease, the total family income declines without affecting the value of the woman's time. This reduces the demand for children.

As discussed above, the female labour force participation rate in the Netherlands has been very low historically. Therefore, from a population perspective, an increase in unemployment levels leads to a relatively small average decrease in the women's wages and accordingly the relative cost of children. Thus, the substitution effect is expected to be comparatively small. The income effect is dampened by the social security provisions. Thus, the direction of the total change in fertility during periods of high unemployment remains to be tested empirically, but we expect that the size of the effect might be relatively small.

Furthermore, if an increase in the unemployment level leads to a transitory decrease in wages, in the standard life-cycle model setting, the total lifetime income and accordingly lifetime demand for children of the family should not be affected by unemployment rates. Unemployment can, however, affect the timing of fertility. If capital markets are perfect, women's fertility decisions will not depend on the path of wages of the household. However, if capital markets are imperfect, couples will postpone fertility to periods when income is high, since households can use the timing of births to smooth consumption. Thus, we hypothesize that credit-constrained, lower SES families would postpone fertility during periods of high unemployment, while less credit-constrained, higher SES families would be less inclined to do so.

2.2. Effect on consumption of health-related goods

The effect of unemployment levels on the consumption of health-related goods can also be separated into substitution and

income effects. Health-related activities, such as exercising or prenatal care, are time-intensive, and therefore a decrease in a woman's wage would reduce the relative cost of time and might lead to an increase in participation in health-related activities. However, decreases in family income would also lead to a lower consumption of all (normal) goods, including health-related goods such as high-quality food and prenatal vitamins, but could also reduce the consumption of health-damaging goods such as cigarettes and alcohol. Ruhm (2000, 2003) using US data, shows that recessions are associated with a positive change in health behaviour.

Given the low female labour participation, we expect that the substitution effect would be small in the Dutch setting. The income effect is also likely to be small, due to the generous unemployment benefits. The sign of the effect depends on whether it is the healthy or the unhealthy consumption that decreases more when unemployment increases.

3. Data & methods

To test our predictions empirically, we analyse the relationship between the regional unemployment level and birth outcomes in the Netherlands. In particular, we combine the individual data from the Lifelines cohort study with regional unemployment data from Statistics Netherlands.

3.1. Lifelines

Lifelines is a large population-based cohort study and biobank carried out in the three north-eastern provinces of the Netherlands. The study was established as a resource for research on complex interactions between environmental, phenotypic and genomic factors in the development of chronic diseases and healthy ageing (see Stolk et al., 2008, and Scholtens et al., 2015, for a detailed description of the study). Initially, all GPs in the three northern provinces invited their patients aged 25–49 to participate. Those who agreed to participate were asked to provide the contact details of their family members so that they could also be invited. In addition, all adults residing in the three northern provinces could volunteer to participate by self-registering through the Lifelines website. Overall, Lifelines covers more than 10% of the population in the provinces of Groningen, Friesland and Drenthe. Klijs et al. (2015) have studied the representativeness of the Lifelines sample. Their conclusion is that the sample is broadly representative of the population.

For our purpose, Lifelines provides us with a sample of 80,821 respondents born in the Netherlands between 1950 and 1994. Lifelines also contains respondents born before 1950 and after 1994; however, for the former we do not have unemployment data and the latter were administered a different survey due to their age.

The Lifelines questionnaire contains health and life histories, including information surrounding the respondents' birth, such as their birthweight, which is reported by 57,500 respondents. Given the important role attributed to birthweight for a host of outcomes later in life (Behrman and Rosenzweig, 2004) birthweight is a commonly used indicator of babies' health (Dehejia and Lleras-Muney, 2004). Since birthweight is self-reported by the respondent, we take measures to increase the reliability of these data. First, we use the fact that the Lifelines has asked the respondents to report their birthweight in two occasions. Since some of the answers of the first wave had unlikely values, in the second occasion the respondents were asked to pay a particular attention to this question. Therefore, we compare the answers for consistency and we use the second wave answer if they are different. Second, we exclude all observations that are medically

Table 1a

Comparison of descriptive statistics for observations with and without missing values.

Variable	Main sample	Missing values in the dependent variable			Missing values in the independent variable	
		Don't know	Missing value	Infeasible answer	No mother's age	No mother's smoking
Male	0.357 <i>0.479</i>	0.546 <i>0.498</i>	0.411 <i>0.492</i>	0.394 <i>0.489</i>	0.426 <i>0.495</i>	0.368 <i>0.483</i>
Birth year	1969.6 <i>9.885</i>	1965.9 <i>9.547</i>	1969.8 <i>9.929</i>	1967.0 <i>9.019</i>	1969.9 <i>9.295</i>	1970.3 <i>9.232</i>
Age of mother at birth	27.76 <i>5.151</i>	29.32 <i>5.891</i>	27.85 <i>5.526</i>	28.06 <i>5.549</i>	– <i>–</i>	26.59 <i>4.493</i>
Immigrant parent	0.029 <i>0.169</i>	0.037 <i>0.189</i>	0.032 <i>0.176</i>	0.027 <i>0.162</i>	0.040 <i>0.197</i>	0.034 <i>0.183</i>
Primary education	0.011 <i>0.105</i>	0.028 <i>0.164</i>	0.104 <i>0.305</i>	0.022 <i>0.145</i>	0.022 <i>0.148</i>	0.017 <i>0.131</i>
Secondary education	0.660 <i>0.474</i>	0.711 <i>0.453</i>	0.646 <i>0.478</i>	0.723 <i>0.447</i>	0.766 <i>0.424</i>	0.661 <i>0.473</i>
Higher education	0.328 <i>0.470</i>	0.260 <i>0.439</i>	0.251 <i>0.434</i>	0.254 <i>0.435</i>	0.212 <i>0.409</i>	0.320 <i>0.467</i>
Observations	54853	21055	2154	2759	547	519

Note: Means and standard errors (in *italics*) of selected variables for the main sample compared to the individuals with missing values in the dependent variable due to answer "don't know", missing answers, and infeasible answers as well as compared to the individuals with missing values in the independent variables – mother's age and smoking status.

infeasible (that is, extremely high (>6000 g) or extremely low (<500 g)). Even though birthweight is self-reported, the birthweight and incidence of low birthweight in the remaining sample (see Table 1b) are similar to the population averages of the Netherlands. For example, in 1989 the average birthweight in the Netherlands was 3372 g with just over 5% of the babies born weighing less than 2500 g (CBS, 2007). In our sample the average birthweight in 1989 is 3351 g with 7% of the babies being born with low birthweight. This suggests that the mean of the remaining measurement error in our dependent variable likely is close to zero, however we are unable to test whether this measurement error is correlated either to birthweight or unemployment levels. Such correlation could potentially bias our estimation results (see Wooldridge, 2010, chapter 4.4.).

Clearly, Lifelines participants are not able to recall information about their birth from their own memory. Instead, they have had to learn this information from their parents or other sources either already before the survey or at the time of taking the survey. Therefore, the high number of individuals who did not report their birthweight likely were not able to acquire this information, for example, because their parents are dead or ill or because any written records are lost. In Table 1a we compare some descriptive statistics for the individuals who answered 'Don't know' when asked about their birthweight (N = 21,055) with those who were excluded from the final sample due to infeasible birthweight value (N = 2759), those with missing answer (N = 2154) and those who reported feasible birthweight (N = 54,853). As could be expected, the individuals who did not know their birthweight are, on average, somewhat older, born to older mothers and more likely to have at least one parent who has been born in another country than our main sample. Similarly, the sample that reported infeasible values is also on average older and born to older mothers. Accordingly, they might have faced difficulties in acquiring the information about their birth. In contrast, the individuals who did not answer the question at all are, on average, less educated than our main sample. Moreover, men are much less likely to be able to report their (correct) birthweight than women. Arguably, since women are likely to give birth themselves at some point in life, they might be more interested in acquiring and retaining information about their own birth than men as it might prove useful for them due to genetic reasons. In sum, the individuals that are excluded from our sample are on average,

older, born to older mothers, more likely to be male and have lower SES. As discussed in the introduction, these population groups might be more sensitive to economic downturns than our main sample. In that case our estimates of the effect of unemployment level on birthweight might be biased towards zero and can be considered as a lower bound for the true effect.

To assess the potential changes in cohort composition and health behaviour during economic downturns, we need background information about respondents' parents. Even though Lifelines contains rich information about the respondents themselves, the information about their parents is limited. Nevertheless, Lifelines provides us with two useful pieces of information on the respondent's mother that we use as proxies for socioeconomic status. First, we are able to calculate the mothers' age at the time of childbirth from her date of birth. The mother's age, apart from having a biological effect on child health, might also serve as a proxy for SES of the parents, since early motherhood is associated with lower SES (Hobcraft and Kiernan, 2001). Second, Lifelines contains a question whether the respondent's mother smoked during the pregnancy and whether she stopped before or during pregnancy, decreased smoking or continued smoking as before. Smoking in general and especially smoking during pregnancy is highly correlated with low SES (see, for example, reviews in Cutler and Glaeser, 2005; or Cutler and Lleras-Muney, 2006), thus, using this information, we are able to assess whether mothers change their behaviour during economic downturns (decrease or stop smoking) or the (socioeconomic) cohort composition changes (that smokers are less or more likely to get pregnant). This approach leaves us with a sample size of 54,306 for the analysis with mother's age and sample size of 54,334 for the analysis including mother's smoking status. As with birthweight, respondents are likely to suffer from recall loss when it comes to detailing events surrounding their birth. However, only a small fraction (less than 1%) of those who reported their birthweight were unable to provide information about their mother's smoking (see Table 1a) while those who did not know their birthweight also did not report if their mother smoked during pregnancy. It seems that those who were able to e.g. ask their mother about their birth weight have also asked about her smoking.

Finally, by linking the data with birth certificates from the Municipal Personal Records Database (in Dutch:

Table 1b

Descriptive statistics.

Variable	Observations	Mean	Std. Dev.	Min	Max
Birthweight (grams)	54853	3412.982	732.767	500	6000
Low birthweight (less than 2500 g)	54853	0.0631	0.2431	0	1
Provincial unemployment (%)	54853	4.762	3.117	0.5	13.8
Year of birth	54853	1969.559	9.8848	1950	1994
Male	54853	0.3571	0.4791	0	1
Mother's age	54306	27.7616	5.1515	10	56
Mother smoked during pregnancy	54334	0.1856	0.3888	0	1
Mother never smoked before pregnancy	54334	0.5438	0.4981	0	1
Stopped before pregnancy	54334	0.1660	0.3720	0	1
Decreased/stopped during pregnancy	54334	0.1192	0.3240	0	1
Smoked as before	54334	0.0664	0.2490	0	1
Age of the mother at birth <25	54306	0.3711	0.4831	0	1
Age of the mother at birth 25–35	54306	0.5430	0.4982	0	1
Age of the mother at birth >35	54306	0.0860	0.2803	0	1

Table 1c

Number of observations per province.

Province	Observations	% of the total
Friesland	20,726	37.8%
Groningen	15,662	28.6%
Drenthe	9,581	17.5%
Zuid-Holland	2,112	3.9%
Overijssel	1,876	3.4%
Noord-Holland	1,874	3.4%
Gelderland	1,230	2.2%
Utrecht	709	1.3%
Noord-Brabant	607	1.1%
Zeeland, Flevoland and Limburg	476	0.9%
Total	54,853	100%

Note: The three Northern provinces are marked in bold.

Gemeentelijke Basis Administratie), we can obtain information on the province of birth of each respondent. Although the study is based in the north-eastern Netherlands and the three north-eastern provinces (Groningen, Drenthe and Friesland) are overrepresented, our data includes respondents born in all twelve Dutch provinces. All data and their descriptive statistics are summarized in [Tables 1b and 1c](#); in [Table 1d](#) we display the descriptive statistics by province.

3.2. Unemployment

We draw provincial unemployment data from Statistics Netherlands. These are available from 1950 onward, which creates the lower bound for the birth year of our respondents. Over the period between 1950 and 1994, the Netherlands went through all phases of the business cycle multiple times, which is also reflected in the unemployment data ([Fig. 2](#)). In the post-World War II years

Table 1d

Descriptive statistics (means and standard deviations) of variables across provinces.

Province	Friesland	Groningen	Drenthe	Overijssel	Noord-Holland	Gelderland	Zuid-Holland	Noord-Brabant	Utrecht	Zeeland	Limburg	Flevoland	Total
Male	0.359	0.361	0.358	0.343	0.332	0.334	0.352	0.367	0.334	0.427	0.387	0.325	0.357
Std. Dev.	0.480	0.480	0.479	0.475	0.471	0.472	0.478	0.482	0.472	0.497	0.488	0.470	0.479
Birthweight	3424.2	3405.9	3409.8	3394.4	3410.9	3415.5	3402.5	3431.9	3405.5	3461.1	3363.2	3441.4	3413.7
Std. Dev.	743.421	731.641	721.13	726.719	735.314	705.126	726.492	669.086	744.26	660.07	825.522	594.230	732.96
Low birthweight	0.062	0.064	0.063	0.062	0.065	0.056	0.068	0.053	0.057	0.040	0.084	0.065	0.063
Std. Dev.	0.241	0.246	0.243	0.241	0.247	0.229	0.253	0.225	0.232	0.198	0.279	0.248	0.243
Unemployment	4.712	5.182	6.218	3.548	2.040	2.728	1.889	3.024	1.924	2.749	2.516	7.803	4.763
Std. Dev.	2.905	3.190	2.840	2.969	2.048	2.509	1.912	2.397	1.972	1.433	2.476	3.153	3.117
Age of mother	27.914	27.551	27.625	28.244	27.880	27.859	27.861	28.323	27.994	27.504	28.248	27.750	27.773
Std. Dev.	5.268	5.043	5.147	5.091	5.130	4.929	5.207	4.768	4.991	5.061	5.578	4.401	5.156
Mother smoked	0.171	0.198	0.200	0.172	0.199	0.163	0.181	0.142	0.213	0.169	0.222	0.236	0.186
Std. Dev.	0.377	0.398	0.400	0.378	0.399	0.369	0.385	0.349	0.410	0.377	0.417	0.426	0.389
Age	40.602	40.478	40.703	42.391	43.569	42.627	43.754	42.662	42.368	44.190	44.436	29.524	40.959
Std. Dev.	9.869	9.822	10.017	9.760	8.968	9.013	8.926	8.960	8.946	8.031	8.457	5.099	9.818
Education low	0.011	0.010	0.015	0.006	0.013	0.007	0.011	0.005	0.009	0.000	0.004	0.016	0.011
Std. Dev.	0.103	0.100	0.122	0.080	0.113	0.086	0.102	0.071	0.092	0.000	0.067	0.127	0.104
Education medium	0.677	0.683	0.707	0.518	0.580	0.495	0.537	0.473	0.556	0.451	0.520	0.577	0.660
Std. Dev.	0.468	0.465	0.455	0.500	0.494	0.500	0.499	0.500	0.497	0.500	0.501	0.496	0.474
Education high	0.312	0.307	0.277	0.476	0.405	0.497	0.452	0.518	0.436	0.549	0.476	0.407	0.328
Std. Dev.	0.463	0.461	0.448	0.500	0.491	0.500	0.498	0.500	0.496	0.500	0.501	0.493	0.470

Fig. 2. Provincial unemployment rates in the Netherlands (1950–1994).

Data source: Statistics Netherlands (www.cbs.nl).

(and after the so-called Hunger Winter), the Netherlands enjoyed a period of substantial economic prosperity with low associated unemployment rates. Toward the end of the '70s and for much of the early '80s, the Netherlands were hit by a strong recession due to the second oil crisis. This recession was particularly severe in the north-eastern Netherlands where unemployment peaked at well over 10% at the depth of the recession. In the early '90s alongside the world-wide economic boom, unemployment rates dropped substantially all over the Netherlands.

3.3. Methods

Most of the literature, such as Dehejia and Lleras-Muney (2004) and Aparicio and González (2014) use data aggregated at state and year of birth level in their analysis. We, however, exploit individual level data. Therefore, to analyse the relationship between birthweight and regional unemployment level, we use the following model:

$$Y_{ipt} = \alpha + \beta_1 u_{pt} + \gamma m_i + \theta_t + \rho_p + u_{ipt} \quad (1)$$

where Y_{ipt} denotes birthweight of baby i born in province p in year t , u_{pt} is the unemployment rate in province p and year t , m_i is a dummy variable taking value 1 if male and 0 if female, ρ_p is a province fixed effect, and θ_t is a year of birth fixed effect.

While above we have referred generically to birthweight as our outcome variable, for the purpose of our analysis we focus on two realizations of birthweight. That is, following Dehejia and Lleras-Muney (2004), we focus on birthweight in grams and on the incidence of low birthweight (<2500 g). For birthweight in grams, we estimate the model (1) by OLS. In the case of low birthweight the outcome variable Y_{ipt} becomes a dummy variable such that the estimated model is a linear probability model. As a robustness check, we also estimate our models by probit regressions. The average marginal effects of the probit model are virtually identical to the OLS coefficients. However, we present only the results of the linear probability model because for it we can address the issue of the small number of clusters as discussed below. The probit results are available on request.

Our main explanatory variable – the unemployment level – is measured at the province level; therefore, the error terms are likely to be correlated within province and cluster-robust standard errors are required for statistical inference. The province fixed effects included in the model control for a part of the within-province correlation but perhaps not all of it. In addition, since there are only 12 provinces in the Netherlands (the three provinces with smallest number of observations, Zeeland, Flevoland and Limburg were

grouped together so effectively we have 10 provinces), the use of the Dutch provincial unemployment level data leads to the issue of “few clusters” which means that the estimated variance matrix of the OLS estimator is likely to be downwards biased (Cameron and Miller, 2015). Therefore, we employ a bias-correction by Bell and McCaffrey (2002), which was named CR2VE in Cameron and Miller (2015, sections VI.B. and VI.D.), to the standard cluster robust variance estimates. CR2VE correction proposes scaling the province specific vector of residuals $\hat{u}_p$ so that $\sim u_p = (I_{N_p} - H_{pp})^{-0.5} \hat{u}_p$, where $H_{pp} = X_p(X'X)^{-1}X'_p$ and N_p the size of the sample in province p . In addition, we face the problem that the number of observations varies considerably across provinces which basically implies that the effective number of clusters is reduced further (see Imbens and Kolesar, 2015). We therefore base the Wald tests on a $t(v^*)$ -distribution where the degrees of freedom v^* are determined by the data as proposed by Imbens and Kolesar (2015).

Further, we exploit the individual data provided to us through Lifelines and extend the model in (1) by including individual specific regressors. First, taking into account the possible differences between men and women, we allow the effect of unemployment depend on the gender. Therefore, we include interaction terms between dummies indicating each gender and the provincial unemployment level. Effectively, we split the effect of unemployment on birthweight by gender, while keeping other covariates and fixed effects non gender-specific. Also, we enrich the model by including the age of the mother when the child was born and a dummy variable indicating whether the mother smoked during pregnancy as additional explanatory variables. Doing so enables us to control for potential changes in the composition of the birth cohort due to high unemployment. Moreover, we allow the effect of the unemployment rate on health outcomes to depend on the individual characteristics so that we can assess to what extent the effect is stratified over different subgroups of the population.

Finally, we follow a similar empirical approach to analyse changes in cohort composition directly. In that case the outcome variable is the probability of a mother being in a given age or smoking status group while the main explanatory variable is not interacted with gender, since we assume that babies' gender is assigned randomly and should not affect the cohort composition of mothers. Even though studies have shown that the secondary sex-ratios can be affected by maternal conditions (e.g. Almond et al., 2010; Nilsson, 2017), it seems plausible that in the 20th century Dutch setting the business cycle fluctuations are comparatively mild shocks that are not likely to cause actual foetal deaths.

Table 2
Provincial unemployment and birth rate.

	(1)	(2)	(3)
Provincial unemployment	–0.718*** <i>0.064</i>	–0.348*** <i>0.050</i>	–0.390*** <i>0.038</i>
Observations	622	622	622
R-squared	0.354	0.696	0.790
Linear time trend	No	Yes	Yes
Province FE	No	No	Yes

Note: OLS coefficients. Standard errors clustered at the province level are reported in italics under the coefficients. P-values are calculated from *t*-tests based on a *t* distribution with 9 degrees of freedom (*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$). The dependent variable is the number of live births in a given province per 1000 average population. Data source: Statistics Netherlands (www.cbs.nl).

Table 3
Cohort composition by mothers' characteristics.

	Dependent variables Mothers' characteristics	Effect of provincial unemployment level	Standard error	Observations	IK degrees of freedom, unemployment
(1)	Age <25	–0.0017	<i>0.00295</i>	54,306	6.5
(2)	Age 25–35	0.0002	<i>0.00235</i>	54,306	6.5
(3)	Age >35	0.0015	<i>0.00206</i>	54,306	6.5
(4)	Smoked during pregnancy	–0.0075**	<i>0.00276</i>	54,334	6.5
	Detailed smoking				
(5)	Never smoked	0.0170***	<i>0.00281</i>	54,334	6.5
(6)	Stopped before pregnancy	–0.0020	<i>0.00124</i>	54,334	6.5
(7)	Decreased/stopped during	–0.0044	<i>0.00293</i>	54,334	6.5
(8)	Smoked as before	–0.0031*	<i>0.00143</i>	54,334	6.5

Note: Linear probability model regression results. CR2VE standard errors are clustered at the province level. The Imbens Kolesar degrees of freedom used in the *t*-tests for the key variables are reported in the last column (*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$). The specification includes birth year and province fixed effects.

4. Empirical results

4.1. Provincial unemployment and fertility decision

Our theoretical predictions suggest that, in the Dutch setting, the direction of the change in fertility during economic downturns is ambiguous. Since Lifelines does not cover the whole population, we cannot analyse birth rates with our data. Nevertheless, in Table 2, we use population data from Statistics Netherlands that are available for the period between 1959 and 1994, to show the effect of provincial unemployment levels on birth rates. The table contains OLS coefficients for a regression of provincial birth rate on provincial unemployment levels. Column 1 provides the results without any covariates, column 2 includes a linear time trend to account for decreasing fertility over time, column 3 includes both time trend, and province fixed effects. The results in columns 1, 2 and 3 show that when provincial unemployment levels increase by 1 percentage point (p.p.) the provincial birth rate in the Netherlands decreases by respectively 0.72, 0.35 and 0.39 births per 1000 population. This effect is highly significant.

Next, we focus on whether the decreasing fertility changes the cohort composition of mothers. For this purpose, we use the information available in the Lifelines about respondent's mother, that is – mother's age and smoking behaviour during pregnancy. Table 3 shows the linear probability model results. We regress dummy variables indicating the mother's age or smoking status on provincial unemployment level and province and year fixed effects. The first three rows of Table 3 show the effect of provincial unemployment level on the probability of the mother being in a given age group. The effect is insignificant in all three age groups indicating that mother's age composition does not vary with the business cycle.

The fourth row of Table 3 shows the effect of provincial unemployment on the probability that the mother smoked during pregnancy. The effect is negative and significant at 5% level. If the unemployment level increases by 1 p.p., the probability that the mother smoked during pregnancy decreases by 0.7 p.p.

In rows 5–8 we unpack this effect by looking in more detail at the probabilities that the mother had never smoked before pregnancy, that she stopped before becoming pregnant, that she decreased smoking or stopped during pregnancy and that she continued smoking as before. The results show that the decrease in smoking is driven by a significant increase in the group that had never smoked before pregnancy and a corresponding decrease in the group that continued smoking as before. This result suggests that instead of mothers changing behaviour in response to a decrease in income, it is the type of mothers who choose to get pregnant during periods of high unemployment that differs from those who have children when unemployment is low.

Smoking in general and especially smoking during pregnancy has been found to correlate with low SES (see, for example, reviews in Cutler and Glaeser, 2005; or Cutler and Lleras-Muney, 2006). Since we cannot control for SES directly, it is likely that our smoking variable also partially captures differences in SES. In that case, these results are in line with our theoretical prediction that low SES mothers would reduce their fertility more than high SES mothers during economic downturns leading to an “improved” cohort composition. Moreover, this result is also in agreement with the previous literature that attribute a part of the positive effect of economic downturns on babies' health to changes in the type of mothers that give birth during recessions. In the following section we explore whether these improvements in the cohort composition lead to better health outcomes of the babies born during economic downturns.

Table 4

Birthweight and provincial unemployment level, effect by gender.

VARIABLES	(1) Birthweight	(2) Low birthweight	(3) Birthweight	(4) Low birthweight	(5) Birthweight	(6) Low birthweight	(7) Birthweight	(8) Low birthweight
Male* unemployment	−5.918* <i>2.856</i>	0.0017 <i>0.0014</i>	−5.682 <i>3.045</i>	0.0016 <i>0.0014</i>	−7.579** <i>2.869</i>	0.0021 <i>0.0014</i>	−7.126* <i>2.959</i>	0.0020 <i>0.0014</i>
Female*unemployment	−3.641 <i>2.726</i>	0.0020 <i>0.0014</i>	−3.585 <i>2.740</i>	0.0020 <i>0.0014</i>	−5.158 <i>2.719</i>	0.0024 <i>0.0014</i>	−4.904 <i>2.680</i>	0.0024 <i>0.0014</i>
Male	203.3*** <i>13.25</i>	−0.0110* <i>0.0049</i>	202.1*** <i>13.51</i>	−0.0102* <i>0.0047</i>	201.2*** <i>12.68</i>	−0.0109* <i>0.0045</i>	200.2*** <i>12.88</i>	−0.0100* <i>0.0043</i>
Age of mother 25–35			68.82*** <i>7.180</i>	−0.0085*** <i>0.0018</i>			60.55*** <i>6.646</i>	−0.0069*** <i>0.0017</i>
Age of mother 35+			97.47*** <i>10.83</i>	0.0067** <i>0.0019</i>			83.07*** <i>10.72</i>	0.0095*** <i>0.0020</i>
Mother smoked					−108.2*** <i>8.524</i>	0.020*** <i>0.0029</i>	−99.27*** <i>8.194</i>	0.0196*** <i>0.0030</i>
Observations	54,853	54,853	54,306	54,306	54,334	54,334	54,334	54,334
<i>Imbens-Kolesar (IK) data-determined degrees of freedom:</i>								
male*unemployment	6.7	6.7	6.7	6.7	6.8	6.8	6.7	6.7
female*unemployment	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6

Note: OLS regression results. CR2VE standard errors clustered at the province level are reported in italics under the coefficients. The Imbens Kolesar degrees of freedom used in the *t*-tests for the key variables are reported at the bottom of the table (*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$). The reference group for age of mother is mothers younger than 25. The specification includes birth year and province fixed effects.

Table 5

Birthweight and provincial unemployment level, nonlinearities by mother's age.

VARIABLES	(1) All	(2)	(3) Males	(4)	(5) Females	(6)
	Birthweight	Low birth weight	Birthweight	Low birth weight	Birthweight	Low birth weight
Unemployment	−0.0372 <i>2.869</i>	0.0009 <i>0.0015</i>	0.256 <i>13.01</i>	0.0033* <i>0.0015</i>	−0.764 <i>7.070</i>	−0.0004 <i>0.0019</i>
Age of mother 25–35 * unemployment	−5.309** <i>1.372</i>	0.0015** <i>0.0005</i>	−9.174* <i>4.348</i>	0.0017* <i>0.0008</i>	−3.196 <i>2.598</i>	0.0014* <i>0.0006</i>
Age of mother 35+ * unemployment	−9.233** <i>2.268</i>	0.0012 <i>0.0007</i>	−24.74** <i>7.215</i>	0.0025 <i>0.0017</i>	−1.347 <i>3.535</i>	0.0006 <i>0.0014</i>
Male	192.3*** <i>8.639</i>	−0.0122 <i>0.0019</i>				
Age of mother 25–35	93.20*** <i>12.31</i>	−0.0155*** <i>0.0033</i>	115.9*** <i>21.09</i>	−0.0125** <i>0.0041</i>	80.49*** <i>12.45</i>	−0.0172*** <i>0.0041</i>
Age of mother 35+	137.5*** <i>17.75</i>	0.0016 <i>0.0035</i>	273.3*** <i>40.65</i>	−0.0143 <i>0.0164</i>	68.33*** <i>13.56</i>	0.009 <i>0.0097</i>
Observations	54,306	54,306	19,354	19,354	34,952	34,952
<i>IK degrees of freedom:</i>						
unemployment	6.7	6.7	6.8	6.8	6.7	6.7
Age of mother 25–35* unemployment	4.7	4.7	4.7	4.7	4.8	4.8
Age of mother 35+* unemployment	4.9	4.9	4.8	4.8	4.9	4.9

Note: OLS regression results. CR2VE standard errors clustered at the province level are reported in italics under the coefficients. The Imbens Kolesar degrees of freedom used in the *t*-tests for the key variables are reported at the bottom of the table (*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$). The reference group for age of mother is mothers younger than 25. The specification includes birth year and province fixed effects.

4.2. Provincial unemployment and babies' health

In this section, we investigate how provincial unemployment affects the birthweight of babies. Our main estimation results are displayed in Table 4. The first column provides the OLS estimate of the empirical model in Eq. (1). The first column reveals that provincial unemployment level has a statistically significant negative effect on birthweight in male babies. The result is significant at a 10% level. The effect in female babies has a negative coefficient, as expected, but is not statistically significant.¹

In the second column we consider whether an increase in unemployment leads to an increase in the probability of being born with low birthweight (below 2500 g). While the sign of the coefficients is in the expected direction (i.e., positive), we find that

higher unemployment levels are not associated with significantly increased probability of having clinically defined low birthweight in neither male or female babies. This indicates, that on average, the effect of unemployment level on birthweight is too small to cause medical issues for babies born in economic downturns.

Returning to Table 4, in columns 3 and 4 we enrich the model by controlling for mother's age at the time of birth. The results show that the age at which a mother gives birth has a significant effect on birthweight and on the probability of low birthweight. Interestingly, while older mothers on average have babies with higher birthweight, the probability of having a baby with low birthweight increases for older mothers. Naturally, the impact of maternal age on birthweight may reflect both biological and socio-economic factors—an issue that we do not pursue in this paper. Even though controlling for the age of the mother does not change the sign and the size of the effect of unemployment on birthweight or the incidence of low birthweight, the coefficients become insignificant. In the following sections we will investigate whether the loss

¹ Estimating the impact of provincial unemployment without stratifying by gender provides no significant results (available on request).

Table 6
Birthweight and provincial unemployment level, nonlinearities by mother's smoking behavior.

	(1) All	(2)	(3) Males	(4)	(5) Females	(6)
Variables	Birthweight	Low birthweight	Birthweight	Low birthweight	Birthweight	Low birthweight
Unemployment	−5.321 <i>2.920</i>	0.0022 <i>0.0014</i>	−10.46 <i>7.634</i>	0.0052*** <i>0.0014</i>	−3.040 <i>5.900</i>	0.0007 <i>0.0016</i>
Mother smoked* unemp	−6.819** <i>1.664</i>	0.001 <i>0.0006</i>	−7.536** <i>2.010</i>	0.0013* <i>0.0005</i>	−6.497* <i>2.553</i>	0.0007 <i>0.0008</i>
Male	189.7*** <i>8.666</i>	−0.0119*** <i>0.002</i>				
Mother smoked	−74.50*** <i>11.32</i>	0.0153*** <i>0.0029</i>	−65.87* <i>30.64</i>	0.0057 <i>0.0079</i>	−80.09*** <i>13.86</i>	0.0206*** <i>0.0032</i>
Observations	54,306	54,306	19,354	19,354	34,952	34,952
<i>IK degrees of freedom:</i>						
Unemployment	6.5	6.5	6.6	6.6	6.5	6.5
Mother smoked* unemp	4.6	4.6	4.5	4.5	4.6	4.6

Note: OLS regression results. CR2VE standard errors clustered at the province level are reported in italics under the coefficients. The Imbens Kolesar degrees of freedom used in the *t*-tests for the key variables are reported at the bottom of the table (*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$). The specification includes birth year and province fixed effects.

of significance happened because of a lack of statistical power or because maternal age is correlated to the unemployment levels.

Another potential mechanism driving the relationship between unemployment and babies' health is changes in health-related behaviour. In this regard, Currie et al. (2009), amongst others, show that smoking during pregnancy increases the probability of low birthweight. In the previous section we discovered that the proportion of mothers who smoke decreases during periods of high unemployment. In columns 5 and 6 we explore how controlling for maternal smoking during pregnancy influences the effect of unemployment on birthweight. As expected, we find that smoking during pregnancy has a large and statistically significant negative effect on babies' health – lowering birthweight and elevating the probability of low birthweight. Also, controlling for smoking status increases the coefficient and significance of the effect of provincial unemployment on birthweight of male babies.

Finally, in columns 7 and 8 we include both, mother's age and smoking status in the regressions. Controlling for mother's age slightly reduces the coefficients of unemployment compared to columns 5 and 6. Nevertheless, the effect of unemployment on birthweight in males remains significant at a 10% level.

To sum up, in our sample economic downturns on average have a negative effect on male babies' health and no effect on female babies' health, which differs from the recent literature that found a positive effect in selected developed countries. Moreover, the size of the negative effect in male babies is too small to cause clinically low birthweight with all the medical consequences of it.

The next section discusses the heterogeneity in our results. In particular, we allow the effects of unemployment to depend on maternal age and mothers' smoking behaviour during pregnancy to identify any vulnerable groups.

4.3. Maternal age and smoking behaviour

In Table 5 we observe the heterogeneity revealed by the interaction between the age of the mother and the unemployment level at birth. Columns 1 and 2 show the results in the whole sample. First, we observe that, compared to Table 4, the effect of mothers' age on birthweight has increased. Second, for babies born to mothers under the age 25 (the reference category) unemployment has no effect on birthweight, while for babies born to older mothers, unemployment has a significant negative effect on birthweight and this effect increases with mother's age. Moreover, for boys born to a mother aged 25–35, unemployment significantly increases the probability of having clinically low birthweight.

In columns 3–6 we split the sample by gender. The results show that the effect of unemployment on birthweight is the most pronounced in boys born to older mothers, while in girls the effect is statistically insignificant.

In Table 6, we explore the heterogeneity in the effect of unemployment on birthweight revealed by including an interaction term between unemployment and maternal smoking in the regression. Columns 1 and 2 show the results for the whole sample. Even though mother's smoking and provincial unemployment both have a significant negative effect on birthweight, for babies born to smoking mothers, unemployment has additional negative effects on health. In columns 3–6 we again split the sample by gender. The results show that the effect of unemployment on birthweight does not statistically differ between boys and girls born to smoking mothers. However, controlling for smoking and the interaction terms reveals that high unemployment levels increase the probability of clinically low birthweight in boys born to non-smoking mothers and even more in boys born to smoking mothers.

5. Conclusions

In this paper, we revisit the relationship between the business cycle and babies' health using Lifelines—a large cohort study and biobank from the northern Netherlands. Our results show that in periods of high unemployment, health of male babies and fertility of mothers decrease. On average, the size of the effect we find is small and it causes birthweight fluctuations within the normal range. That is, if the unemployment rate increases by, say, 5 percentage points, male birthweight declines by about 30 g. Accordingly, an increase in the unemployment level on average does not lead to an increase in the probability of clinically low birthweight, which would cause a number of medical issues. In that sense, it seems that the generous Dutch unemployment benefits protect the health of the babies. Nevertheless, the sub-sample analysis reveals that in some population groups the negative effects are large enough to cause medical problems. Particularly, boys born to older women and to smoking women are at risk for low birthweight when unemployment levels are high at the time of birth. If the policy objective is to improve birth outcomes, these results clearly point to the groups that deserve particular attention during economic hardship.

Considering selection into pregnancy, we find evidence that fertility decreases when unemployment is high. This is in line with the prediction that, given the low female labour participation,

increases in unemployment levels do not affect women's wages and time value and therefore only the decrease in income plays a role in the fertility decision. We also find suggestive evidence that the less healthy, and likely more credit-constrained population groups decrease the fertility more when unemployment is high.

In sum, we establish that even though the mothers who give birth during recessions are healthier and possibly have higher SES, the negative income and environmental effects on babies' health outweigh the positive selection effects and the overall impact of economic downturns on babies' health is negative in the Netherlands.

Ethics approval

This analysis is based on the Lifelines Cohort Study data. The Lifelines Cohort Study is conducted according to the principles of the Declaration of Helsinki and in accordance with research code University Medical Center Groningen (UMCG). The Lifelines study is approved by the medical ethical committee of the UMCG, the Netherlands.

Originality

The authors confirm that this work is original and has not been published elsewhere, nor is it currently under consideration for publication elsewhere.

Conflict of interest

The authors have no conflicts of interest to report.

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