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**Family Stability and Labor Market
Gender Convergence**

**by
Ola Grytten
Arngrim Hunnes**

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Ola Grytten[*]   Arngrim Hunnes[†]

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Abstract

The present paper examines the historical development in the structure of the family in terms of marriage, divorce, fertility and labor 1886–2007 in order to map quantitative changes. The paper draws new information from novel Norwegian data. Along with the changing family relations we also quantify the closing of the gender gap by converging trends for both labor participation rates and wages. The paper concludes that there is a clear correspondence between gender convergence in the labor market and less stable family relations.

1 Introduction

During the last century the family as social and economic unit has experienced dramatic changes in the way it is organized and structured. 150 years ago it was common for a Norwegian or say European family to constitute the core unit both socially and economically. Marriage was the only established and accepted way of cohabitation. Divorce was extremely rare, fertility rates were very high. The family provided individuals with the necessary social network and social security. The family household, i.e. members of a family living in the same dwelling or related dwellings, in many ways was considered a production or labor unit. They were together responsible for a labor supply, which was sufficient to cover necessary expenses for their lives. Since that time the standard of living has been increasing dramatically. Women

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[*]Department of Economics, Norwegian School of Economics and Business Administration (NHH), Helleveien 30, N- 5045 Bergen, Norway. E-mail: `ola.grytten@nhh.no`

[†]Department of Economics, Norwegian School of Economics and Business Administration (NHH), Helleveien 30, N- 5045 Bergen, Norway. E-mail: `arngrim.hunnes@nhh.no`

are more engaged in paid work outside their home and the huge gender gap in income that existed 150 years ago has come down substantially, and is nowadays only of a minor significance.

Along with this development the stability of the family is considerably reduced. Marriage is not longer the only way of organizing the family, as cohabitation has been common. Divorce rates have rocketed during the last decades and fertility has dropped considerable, the number of provoked abortions and out of wedlock births have increased substantially. This has happened despite of considerable research showing that stable family life has a significant positive impact on the individual not only as a child but also later in life. For example family size, birth order and parents education influence children's acquisition of human capital and women taking longer education tends to delay their first birth. A shock to the family, for example a divorce, affects not only the parents but also the children in the family in the form of both financial and personal distress. For the society at large, family structure and stability affects for example the labor force participation rate and the financing and costs of social security services.

Modern economic theories of the family started with Becker's 1981 book *A Treatise on the Family*.[1] However, as Ermish points out, family economics can be traced back to "Thomas Malthus [who] believed that human fertility was determined by the age at marriage and frequency of coition during marriage. He contended that an increase in people's income would encourage them to marry earlier and have sexual intercourse more often."[2] Thus, fertility rates would increase.

In this paper we set out to describe aspects of the family structure in Norway from the last part of the nineteenth century until present, in order to quantify how this structure have changed over time and how the family interact with the labor market. In particular, we analyze five time series and the interaction between them. These series are the marriage rate, the divorce rate, the birth rate, the female labor force participation rate and the female to male wage ratio.

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[1]Becker, Gary S. (1981): *A Treatise on the Family*. Harvard University Press.

[2]Ermisch, John (2008): Family Economics. In Durlauf, Steven N. and Blume, Lawrence E., editors: *The New Palgrave Dictionary of Economics*. Palgrave Macmillan, The New Palgrave Dictionary of Economics Online, Palgrave Macmillan. 31 July 2008, DOI:10.1057/9780230226203.0550.

2 The trends

In this section we examine the trends in marriages, divorces, birth rates (fertility), female-male wage ratios and female labor participation rates for Norway 1886 to 2007. The first three of these time series picture dramatic changes in the Norwegian family structure, while the two latter time series describe large changes in women's economic lives and dependency.

2.1 Data sources

The data on family structure are basically drawn from Statistics Norway. In their historical statistics we find excellent data on births, marriages and divorces from 1769 and onwards. It is also possible to find older data in less available publications and unpublished archival sources. We basically compile these data from Statistics Norway's own historical statistics, which is partly published in printed series and partly electronically.[3] The data are compiled on the basis of registrations of births, marriages and divorces done by clergy and public records offices in all municipalities in the country and are very reliable indeed.

The data on labor participation rates are also basically drawn from Statistics Norway. For most of the post World War II period these data are easily drawn from data published by the bureau.[4] For the pre-war period, however, it is not a straightforward task to come up with stringent time series. In the first place, one has to adjust the labor force data collected at the population censuses taken every tenth year according to modern definitions of labor force participation. Secondly, one has to arrive at annual data by interpolation between the modified census data. This is done by using annual demographic, employment and unemployment data. These are available partly from Statistics Norway and partly from previous research.[5]

Finally, wage data are basically taken from a project on historical monetary statistics monitored by the Norwegian central bank. Here we find wage series by occupation, by industry and on aggregated levels.[6] As part of the

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[3]NOS 1969, Historical Statistics 1968, Statistics Norway, Oslo, pp. 42-47,
NOS 1978, Historical Statistics 1978, Statistics Norway, Oslo, pp. 44-49,
NOS 1994, Historical Statistics 1994, Statistics Norway, Oslo, pp. 63-71 and
URL: `http://ssb.no/emner/02/02/folkendrhist/tabeller/`
[4]NOS 1994, Historical Statistics 1994, Statistics Norway, Oslo, pp. 229-230 and
URL: `http://ssb.no/aku/tab-2009-01-28-01.html`
[5]Grytten, Ola Honningdal (1994): *An Empirical Analysis of the Norwegian Labour Market, 1918–1939*, NHH, Bergen, pp. 130-131.
[6]Grytten, Ola Honningdal (2007): Nominal wages in Norway by occupation 1726-1940, Eitrheim, Øyvind et al (eds), *Historical Monetary Statistics, Part II*, Norges Bank, Oslo,

occupational wage series we also find annual data sets for wages by gender from 1820 onwards. These series are basically constructed with data from the Professor Dr. Ingvar B. Wedervang's Archive on Historical Wages and Prices (until 1940) and data from Statistics Norway (chiefly from 1920).[7] The Wedervang Archive, kept at the Norwegian School of Economics and Business Administration in Bergen, is one of the richest manual archives on prices and wages for nineteenth century Europe. However, it also holds significant numbers of observations from the seventeenth and eighteenth century. All in all, some million observations on prices and wages 1641–1940 are kept in the records.

The archive was established by Professor Ingvar B. Wedervang in cooperation with Professor Ragnar Frisch, both from the Department of Economics at Oslo University in the 1930s. Some 40 part and full time staff assisted in collecting data from public and private records nationwide during the first decade of its existence. The price data are considered very good and reliable from 1815, when the wage data are considered good from 1820 and very good from 1850.[8]

Here we are able to split between female and male wages in agriculture, domestic services and some manufacturing industries 1820–1850. The gender specific data are richer from 1850, as they include additional private services and most manufacturing industries. The coverage increases towards 1940, and after World War II they represent gender specific wage data from most occupations and industries.

2.2 Decomposition of the time series

To estimate the trend we have decomposed the time series into a trend and a cyclical component using the Hodrick-Prescott (HP) filter. The HP-filter is an algorithm for finding smoothed values, i.e., trends of a time series. The filter separates an observed time series, $\{y_t\}_{t=1}^{T}$, into a smoothed or a trend

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pp. 231–342 and

Grytten, (Ola Honningdal 2007): Norwegian wages 1726-2006 classified by industry, Eitrheim, Øyvind et al (eds), *Historical Monetary Statistics, Part II*, Norges Bank, Oslo, pp. 343–384.

[7]Grytten, Ola Honningdal (2007): Nominal wages in Norway by occupation 1726-1940, Eitrheim, Øyvind et al (eds), *Historical Monetary Statistics, Part II*, Norges Bank, Oslo, pp. 271–342.

[8]Grytten, Ola Honningdal (2007): Professor Dr Ingvar B Wedervang's Historical Archive on Wages and Prices, Eitrheim, Øyvind et al (eds), *Historical Monetary Statistics, Part II*, Norges Bank, Oslo, pp. 203–230.

component, g_t, and a cyclical component, c_t. That is,

$$y_t = g_t + c_t. \tag{1}$$

In the filtering (detrending) of y_t, the trend component g_t is determined by

$$\min \quad \sum_{t=1}^{T}(y_t - g_t)^2 + \lambda \sum_{t=2}^{T-1}[(g_{t+1} - g_t) - (g_t - g_{t-1})]^2. \tag{2}$$

Here T is the sample size and λ is the smoothing parameter, specifying the smoothness of the trend. A normal value for λ is 100 for annual data, 1600 for quarterly and 14400 for monthly, depending on the use of the data. Thus, we apply $\lambda = 100$ in our analysis.

2.3 Changing family structure

In order to investigate the impact of changes in the economic life and the labor market on marriage, divorce and fertility it is important to examine structural changes in the family as an socio-economic institution. Norwegian archival sources on wages very much reflect the family as an economic unit throughout the last centuries.

By looking at wage records from two of the pioneer industrial plants in Norway, the Baasland and Næs iron mill (from 1726) and Alvøen paper mill (from 1797) we find that the labor force was basically connected to the companies by individual contracts. These were chiefly made between the manager of the plant and the bread-winners of the household. Wages were paid both as a cash component, but also in natura, i.e. housing and subsidized food and clothing. This was representative for manufacturing plants, agriculture and to a large extent crafts and construction. The payment was dependent on the labor effort of the family household. The employers often demanded work from both parents and the children able to work on the plant. The families were paid both according to their total working capacity and their need for life support. In other words, the employers considered the family both as a labor unit and an economic and social unit.[9]

This pattern was significant until the mid-19th century, and still remained strong at the end of the nineteenth century, despite that the individual labor contract had become dominant at that time. One example can be taken from one of the foremost textile companies in Norway, O.A. Devold, formally

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[9]Fløystad, Ingeborg (1979): *Arbeidsmandens Lod, det nødtøftige Brød: Arbeiderlevekår ved Baaseland and Næs Jernverk 1725–1807.* University of Bergen, Bergen, pp. 595-596. Goksøyr, Matti (1982): *Fra tjener til arbeider? En undersøkelse av Alvøen-arbeidernes rekruttering og lønnsforhold 1801–1865.* University of Bergen, Bergen, pp. 7-61.

founded in 1853, but with roots from 1818. The company was funded by Christian puritans, which was very common for companies in the Western world, also in Norway. Devold was a pioneer company internationally within production technology, hydro-electricity, telecommunication, wool products, health, and labor welfare and community building. As late as in the middle of the twentieth century, they still considered the families of their labor force as their responsibility, building kinder gardens, granting scholarships for sons and daughters of their employees, building the local hospital, church, mission hall and dwellings for their working force and their families. On the other hand the family households stayed faithful to the company, and its work force was recruited internally.

During the inter-war crises of the economy the old system of considering the family household as the basic labor force and economic unit had a short revival generally, before it ceased after World War II.[10]

Marriage   Historically, marriage was a contract between a man and a woman, which had important economic, social and juridical implications.[11] Quite often the marriage contracts were set up by others than the two individuals. According to Coontz p. 145 it was not until the end of the 1700s that in Europe "personal choice of partners had replaced arranged marriage as a social ideal, and individuals were encouraged to marry for love." This is for example reflected in the historical practice that clergy and other civil servants often had to marry the widows of their predecessors.

From a neoclassical economic view the benefit from marriage is increased specialization. The woman staying at home (at least traditionally) and the husband working outside the home. This specialization has potentially huge productivity effects, which will increase the family's economic well-being. Other economic explanations for marriage, and in broader sense the family, are economics of scale, public goods, risk pooling and credit and coordination of investment activities.[12] On the personal level, there are of course other benefits to marriage. For example, married people have better health, lower risk of mortality at any point in life, more pleasure, higher wages and better

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[10]Lerheim, Kr (1952): Historikk - Devold, Manuscript, Ålesund, pp. 1-86 and Wedervang Archive, file 417.

[11]Coontz, Stephanie (2005): *Marriage, a History*. Penguin Books.

[12]Blau, Francine D., Ferber, Marianne A. and Winkler, Anne E. (2006): *The Economics of Women, Men, and Work*. 5th edition. Pearson Prentice Hall.

Weiss, Yoram (1997): The Formation and Dissolution of Families: Why Marry? Who Marries Whom? and What Happens upon Divorce? In Rosenzweig, Mark R. and Stark, Oded, editors: *Handbook of Population and Family Economics*. Volume 1A, Elsevier. North Holland. Chapter 3, pp. 81–123.

private economy.[13]   From this is seems clear that marriage has a positive effect on well-being. However, the direction of the casuality is not entirely clear.

Figure 1 shows the *trend* in the birth, marriage and divorce rates in Norway from 1886 to 2007. The numbers are quoted as percentage of the annual mean population. The number of marriages was relatively stable with about six marriages per 1,000 inhabitants until the mid 1930s. From then on there was a sharp increase of about 35% to 1950. However, looking at the raw data (the data before applying the HP filter) there was a sharp decline in marriages during World War II. Surprisingly, this decline was reversed during a few years after World War II. Then the trend is significantly negative with a few exceptions only. Today, we have about five marriages per 1,000 inhabitants annually. Hence, the fall in the number of marriages is not very large looking at the entire time period from 1886 to 2007. Having said that, it should be noted, as already stated, that the trend since 1950 is clearly negative.

Men were historically and still are normally older when entering into their first marriage than women. This has been a stable pattern throughout the period of investigation here. Until around 1920 the average age was about 28-29 years for men and 26-27 years for women. Then it started to increase until 1946 when the average age was about 29 for men and 26.5 years for women. After 1936 it dropped considerably until 1970 when the average age had come down to 26 and 23. Since then, average age at first marriage has increased steadily and has reached approximately 32.5 for men and 29.5 years for women. In other words, men are today about four years older and women about three years older when entering into their first marriage compared to 150 years ago. The age difference between men and women when entering into their first marriage is today about three years, which is about one year increase since 1850.

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[13]Waite, Linda J. (1995): Does Marriage Matter? *Demography*, 32, Nr. 4, pp. 483–507.

Stutzer, Alois and Frey, Bruno S. (2006): Does Marriage Make People Happy, or do Happy People Get Married? *The Journal of Socio-Economics*, 35, pp. 326–347.

Zimmermann, Anke C. and Easterlin, Richard A. (2006): Happily Ever After? Cohabitation, Marriage, Divorce and Happiness in Germany.*Population and Development Review*, 32, Nr. 3, pp. 511–528.

Mastekaasa, Arne (1995): Age Variations in the Suicide Rates and Self-Reported Subjective Well-Being of Married and Never Married Persons. *Journal of Community & Applied Social Psychology*, 5, No. 1, pp. 21–39.

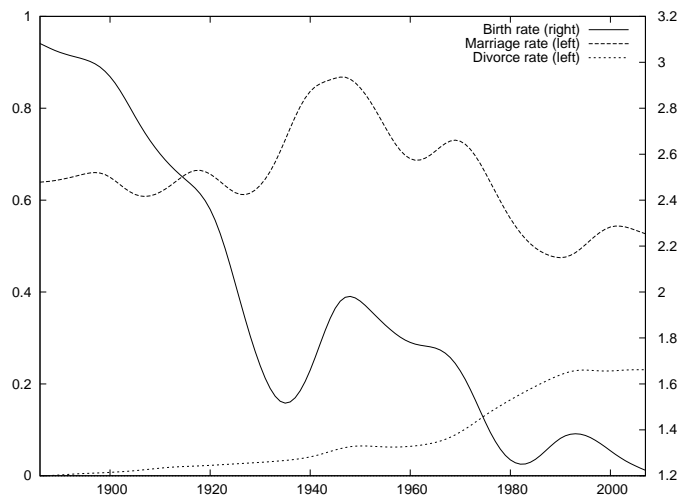Frey, Bruno S. and Stutzer, Alois (2002): *Happiness and Economics.* Princeton University Press.

Figure 1: Birth, marriage and divorce rates (HP-filtered with $\lambda = 100$). The rates are defined as births, marriages and divorces as percentages of the population.

Divorce   Divorce tends to rise when the traditional division of labor is weak, that is, the gains from one specializing in domestic production and the other person working outside the household are small. Since World War II women have experienced the possibility of higher education and work outside the home, and as such, women's outside possibilities are larger than before, making it easier for them to break out of marriage. Hence, the costs associated with marital dissolution are smaller than before, at least, in economic terms. But the probability of divorce also depends on other factors. Weiss and Willis show that an unexpected increase in the husband's earning capacity reduces the probability of a divorce, while an unexpected increase in the wife's earning capacity raises the divorce probability.[14] Further, sorting into marriage on the basis of educational attainment at the point of marriage, similarity in religion and ethnicity, reduce the probability of divorce.[15]

Before 1900 divorce was practically non existing. In fact, it was not until about 1970 that there was one divorce per 1,000 inhabitants annually. In Norway there has been a steady increase in divorces as showed in Figure 1.

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[14]Weiss, Yoram and Willis, Robert J. (1997): Match Quality, New Information and Marital Dissolution. *Journal of Labor Economics*, 15, No. 1, Part 2, pp. S293–S329.

[15]Weiss, Yoram (1997): The Formation and Dissolution of Families: Why Marry? Who Marries Whom? and What Happens upon Divorce? In Rosenzweig, Mark R. and Stark, Oded, editors: *Handbook of Population and Family Economics.* Volume 1A, Elsevier. North Holland. Chapter 3, pp. 81–123.
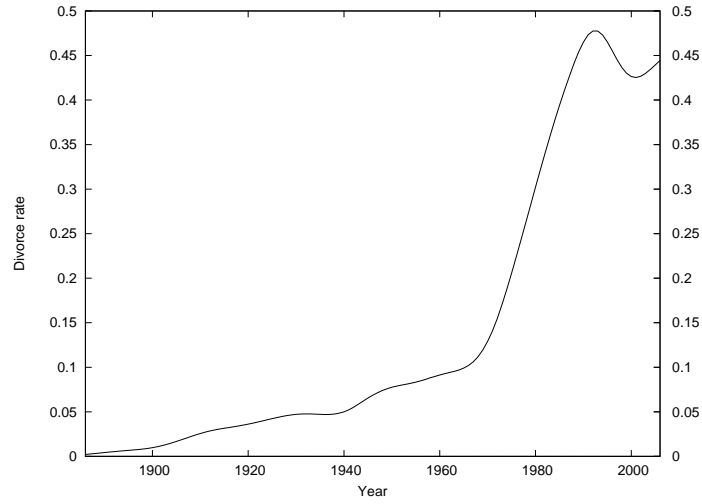
(a) Number of divorces divided by the number of marriages in a given year.
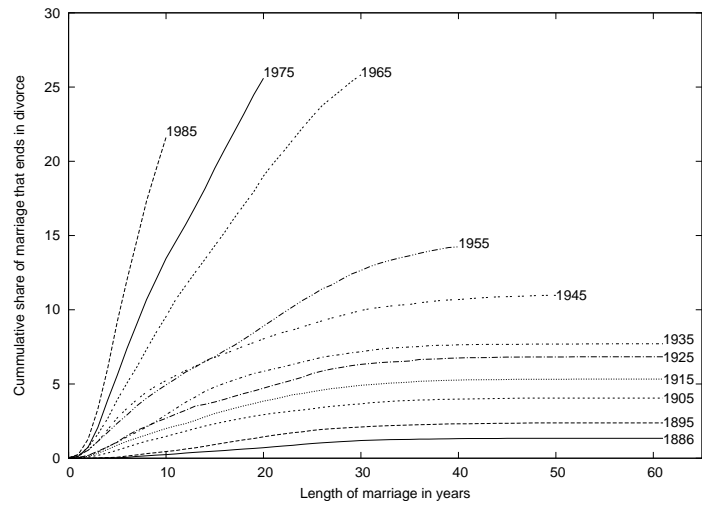
(b) Cummulative share of marriage that ends in divorce for a given cohort. *Source:* Mamelund, Brunborg and Noack, 1997.

Figure 2

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Since 1970 the increase has been stronger than in earlier time periods. The number of divorces per 1,000 people is today approximately 2.5 per annum, that is, about half of the number of marriage conducted annually. This is also confirmed in Figure 2a which shows the divorce rate defined as the number of divorces divided by the number of marriages in a given year. The divorce rate has had a steady increase since 1970 with a peak around 1990. Thereafter it decreased until the late 1990s due to less frequent marriages and an increasing number of cohabitations not covered by the statistics. In the 1990 the relative number of divorces started to raise again.

Figure 2b shows that there are large cohort effects with respect to divorces.[16] There is an unambiguous trend that the cumulative share of marriages that end in divorce increases with younger cohorts. This clearly shows that marriages are becoming less stable. Further, not only do younger cohorts divorce more frequently, but they also divorce earlier, i.e., they are married fewer years before terminating their marriage compared to older cohorts.

Overall, the trends in Figures 1, 2a and 2b are unambiguously: marriages are slowly declining and divorces are increasing rapidly, implying that other types of commitments between two people, for example cohabitation, are preferred before marriage, and, additionally, if two people are married the threshold for breaking the marriage is lower compared to earlier times.

Fertility   Today it is more than ever a choice for a woman or a couple to have children since the separation between sex and childbearing is stronger than ever before. Hence, it is appropriate to talk about the demand for children. Already Thomas Malthus in his *Essay on the Principle of Population* in 1798 analyzed the population dynamics within an economic framework. Becker's paper from 1960 is the first analysis within a neoclassical economics framework.[17] Children are associated with providing utility for their parents, income and costs. Further, the parents must make a trade-off between the quantity (how many children) and the quality of children (benefits). More children means less resources per child for a given basket of resources.

Figure 1 shows the birth rate in Norway from 1886 to 2007 and Figure 3a shows the total fertility rate from 1846 to 2005.[18] From the beginning

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[16]Cohort refers here to the year a couple enter into marriage. The source for the figure is Mamelund, Svenn-Erik, Brunborg, Helge and Noack, Turid (1997): *Divorce in Norway 1886–1995 by Calendar Year and Marriage Cohort.* Report no. 97/19 Statistics Norway.

[17]Becker, Gary S. (1960): An Economic Analysis of Fertility. In *Demographic and Economic Change in Developed Countries.* Princeton University Press for the National Bureau of Economic Research, pp. 209–231.

[18]Total fertility rate is by Statistics Norway defined as: "The average number of live-born children born to a woman passing through the child-bearing period exposed at each

of the period and until present there has been a sharp decline in the birth rates from around 3.1% to 1.25%. From the beginning of 1900 until the 1930s there was a sharp decline in the fertility rate from around 4.5 to less than 2 live-born children born to a woman passing through the child-bearing period. The fertility rate increased rapidly from the end of World War II to the beginning of the 1970s (baby boom), when it started to decrease again and it is now approximately 1.8 child per woman. This is smaller than the reproduction rate of 2.1 child per woman, but significantly higher than the rate for average Europe, which is about 1.5.

The transition from high to low levels of fertility and mortality is explained by the "theory of the demographic transition":

> "Socioeconomic forces are seen to play a central role in this process: urbanization, the movement of work outside the home, increased population mobility, the increased importance of the nuclear family, the increased importance of education and human capital, declining infant and child mortality, changing roles of women, and increased rationality in individual and family decision making."[19]

Until 1960 about seven percent of all children were born outside a marriage. After 1960 this percentage has increased dramatically. Today, only half of all children born in Norway are born by parents who are married, see Figure 3b which shows the ratio of children born out-of-wedlock and the total number of children born in a given year.

2.4 The converging economic lives of men and women

After having quantified the development of marriage, divorce and fertility we are in a position to compare the development in these variables against labor market statistics, i.e. participation rates and gender specific wage ratios, i.e. female to male wage ratios. Relevant questions would be: did female participation rates increase? Was the gender gap in terms of wages closed? If the answer on these two questions are both yes, women became more independent of male bread-winners. If this development correlates with the trends in family structure, this can naturally be taken as indication of more fragile family relations along with the trend that women become less economic dependent on their spouse.

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age to the existing fertility but not exposed to mortality. Total of one-year age-specific fertility rates 15-49 years."

[19]Haines, Michael (2003): Fertility. In Mokyr, Joel, editor: *The Oxford Encyclopedia of Economic History*. Volume 2, Oxford University Press, pp. 284–291.
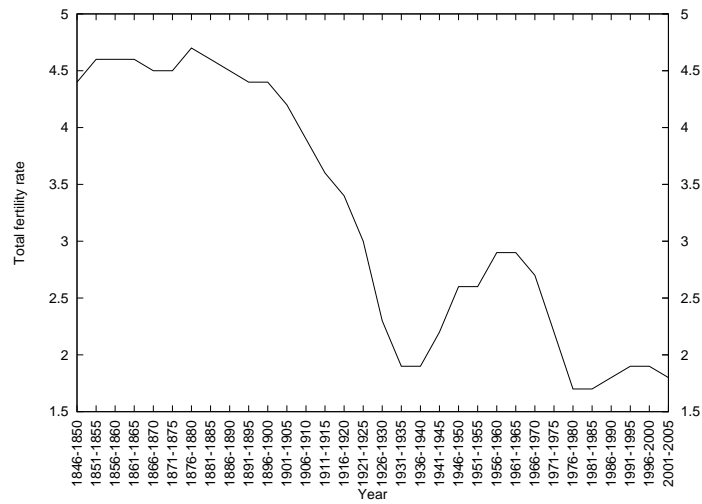
(a) Total fertility rate in Norway 1846 to 2005.
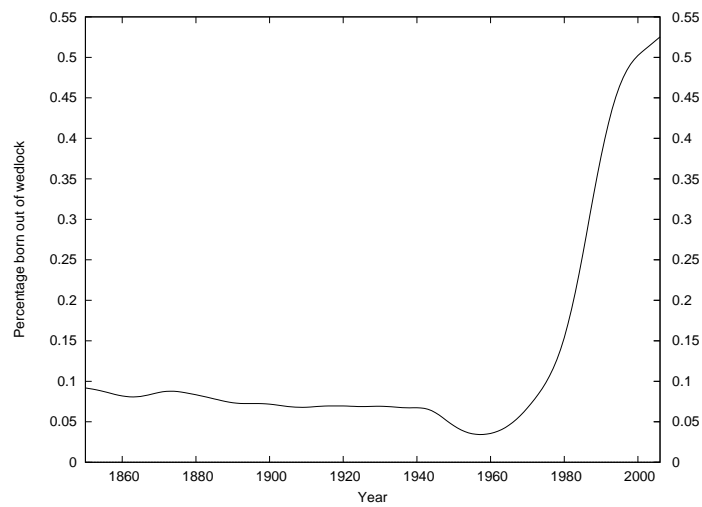
(b) Ratio of born out-of-wedlock and total born (HP-filtered with $\lambda = 100$). Norway 1886 to 2007.

Figure 3

The labor force participation rate According to Figure 4a the female labor force participation rate showed a minor increasing trend until the turn of the nineteenth century when it fluctuated around 54 per cent for women beteween 15 and 74, against 90 per cent or higher for men. This came as a consequence of the relatively rapid industrialization process in Norway at the time, when more women were involved in manufacturing. The fastest growing female intensive sub-industries were among others food processing and textile.

From the turn of the century the participation rate for women started to decrease significantly. This can basically be explained by the rapid productivity growth in agriculture, causing the labor force in this industry to fall rapidly. Thus, many women went out of the labor force, when most men remained in the labor force. The development was speeded up during the unemployment crisis of the interwar period, when women were forced out of the labor market due to political decrees by the labor party backed by the trade unions in order to give priority to male bread-winners before dependent married women in job application processes. In local boroughs governed by the social democrats married men were given priority to married women in the public sector.[20] This attitude was also mirrored in the private sector. At the end of the 1930s the female labor participation rate fell to well 42 per cent per cent against close to 87 per cent for men between 15 and 74 years.

During the German occupation 1940–1945 lack of labor force again made the participation rate to increase, before steady economic growth and improvement in the standard of living after the war made more women enter the role as housewives, considered a status symbol for a family until the 1960s. Thus female participation rates reached an all-time low 36 per cent.[21] From the middle of that decade, modern feminism and rapid increase in demand for labor caused female participation rates increase dramatically until present days. In 2008 they were over 70 per cent for women and more than 77 per cent for men.

In other words, we see a dramatic movement towards labor force participation in Norway from the middle of the 1960 onwards, due to less participation by men and substantially higher participation by women. In addition, in Figure 4b we draw the estimated cycle deviations from HP-filtered labor participation rate-series. The chart informs us that the female labor force participation rate fluctuated significantly more among women then among men and was considerably more sensitive to business cycles. An implication

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[20]Grytten, Ola Honningdal and Camilla Brautaset (2000): Family households and unemployment in Norway during years of crises, *The History of the Family*, no 1, pp. 23–53.

[21]Hodne, Fritz and Ola Honningdal Grytten (2002): *Norsk økonomi i det 20. århundre, Fagbokforlaget*, pp. 198-199.

of this is that female labor participation historically fell more than the corresponding male labor participation during years of crises in the economy. However this difference of pattern seem to have been wiped out during the last 15–20 years.

The female-male wage ratio   Polynomial trends of the female to male wage ratios are plotted in Figure 4c. They are calculated as female wages as shares of male wages for similar occupations within industries. As shown in the graph the gender gap was closed almost persistently. The only exception was during the years of devastating crises in the economy in the 1920s and 1930s, when the development was temporarily reversed.

Obviously, the substantial interwar crisis in the labor market did not only force women to give way to male bread-winners in the labor market, but also, wage differences did increase significantly. This development took place after a period of rapid decrease in the gender wage differences during the postwar World War I boom.[22] Thus, the divergence trend during most of the 1920s and 1930s can be seen not only as a result of years of crises, but also as a consequence of very high convergence rates during the economic upturn before the interwar crises.

From 1940 onwards the HP-filtered series of female to male wage ratios have increased rapidly until present days, when the gender differences have come down to about ten percent, compared to about 55 per cent in the 1880s. In order to close the last part of the gap, women have to more often enter senior positions than they have had the opportunity and have been willing to do up until now. Anyway, the development during the last 120 years clearly tells us that women have become less economic dependent on husbands, and can nowadays afford to carry family responsibilities on their own shoulders, contrary to their abilities in the nineteenth and well into the second part of the twentieth century.

Summing up the descriptive analysis   From the above descriptive analysis we can conclude: historically the divorce rate has been increasing and the fertility rate declining significantly for almost all periods since the late nineteenth century. Marriage rates have been declining substantially during the last four decades, due to the new trend of cohabitation. The female labor participation rate was decreasing until 1960, and has thereafter shown

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[22]Grytten, Ola Honningdal (2007): Nominal wages in Norway by occupation 1726–1940, Eitrheim, Øyvind et al (eds), *Historical Monetary Statistics, Part II*, Norges Bank, Oslo, pp. 271–342.
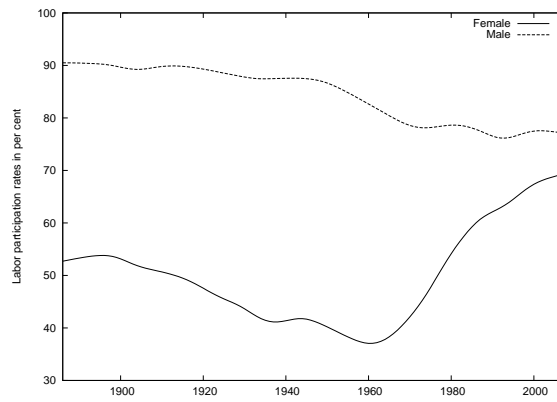
(a) Female and male labor participation rates 1886–2007 (HP-filtered with $\lambda = 100$).
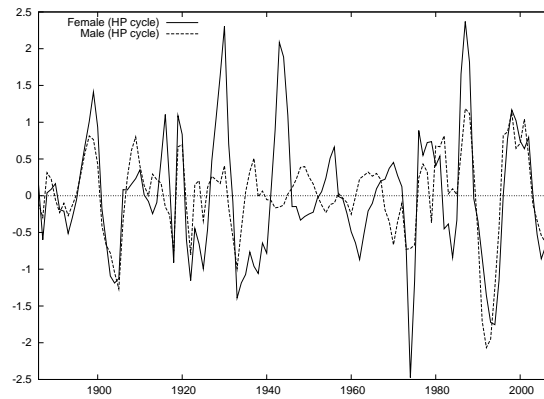
(b) HP cycles female and male labor participation rates 1886–2007 (HP-filtered with $\lambda = 100$).
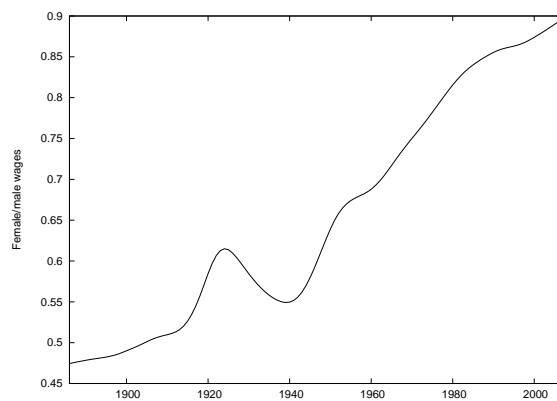
(c) The ratio of female to male wages 1886–2007 (HP-filtered with $\lambda = 100$).

Figure 4: The changing economic lives of women.

rapid growth. The purchasing powers between men and women have been converging as measured by the ratio of female to male wages.

In the rest of this paper we focus on the divorce and birth rates on one side and the female labor participation rate and the female and male wage ratio on the other side. In addition to analyzing the whole time span we also look at a sub-sample covering the years 1945 to 2007 when most of the dramatic changes in family structure and labor market gender convergence took place. From looking at the above graphs there seems to be shifts in trends relatively close to 1945. Formally, the Zivot and Andrews test as described in the next section identifies structural breaks within plus / minus 30 years from 1945. The time around World War II in many ways seem to mark a change of paradigms both in family life and in the gender specific wage gap.

3   Unit roots and cointegration

3.1   Unit root

It is not uncommon for a time series to be nonstationary. A nonstationary time series $\{y_t\}$ do not have the properties of time invariant first and second moments, i.e., the mean $E(y_t)$ and variance $Var(y_t)$ is not constant. Another important property with a stationary time series is that the covariance $Cov(y_t, y_{t\pm s})$ between two time periods t and s depends on the time period between them s and not on the actual time t that the covariance is computed. Investigating possible relationships between two nonstationary time series may lead to results that are spurious.

Looking at the time series in Figure 5 it seems plausible that the variables in levels are nonstationary when the first differences seem to be stationary. To formally test for a unit root we employ the Augmented Dicky-Fuller (ADF) test.[23] The number of lags is chosen as the highest significant lag out of a maximum of five lags. The test statistics are reported in Table 1. For the years 1886–2007, the test statistic for the birth, divorce and participation rate is larger than the critical values, hence we are not able to reject the null hypothesis on nonstationarity. Wages are barely significant at a 10% level. Overall, the evidence supporting stationarity is weak and we conclude that the time series are not stationary in levels. But, from the same table it is clear that the times series are stationary in first differences. Hence, all four

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[23]Most estimations is this paper is computed using the statistical package *gretl 1.7.5* (Gnu Regression, Econometrics and Time-series Library). In addition we use Stata 10.1 (mainly for the Zivot and Andrews test) and for graphics we use *gnuplot 4.2.*
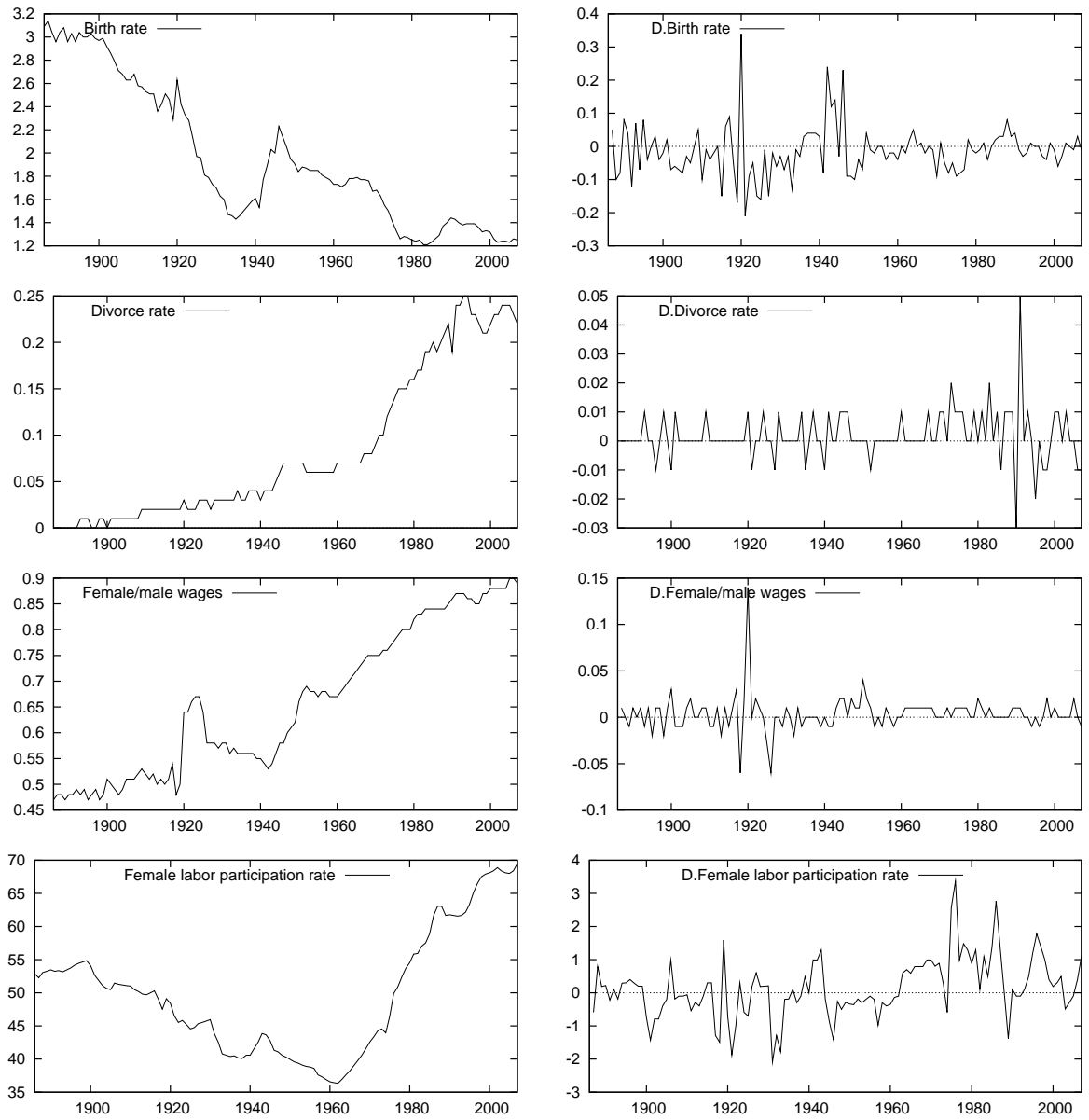
Figure 5: Birth rate, divorce rate, female male wage ratio, female labor participation rate 1886–2007 in levels (left column) and first differences.

time series are integrated of order 1, $I(1)$. For the sub-sample period, i.e. 1945–2007, this conclusion still holds.

A weakness with the ADF test is that it does not allow for any structural breaks in the series. To allow for this we apply the Zivot and Andrews test procedure[24] as implemented in the `zandrews` command for Stata by Christopher F. Baum.[25] The Zivot and Andrews test allows for one structural break in the time series. The break can be in the intercept, the trend or both. We test for all three types of breaks, and the results are reported in table 2. The test results give the same overall conclusion as for the ADF. That is, the time series in levels are nonstationary.

3.2 Cointegration

Having established that all four time series are integrated of order 1, $I(1)$, it is natural to ask if there exists any long term equilibrium relationship between the two series. Or is there a spurious relationship only? In order to answer this we examine if the time series are cointegrated, i.e., if the series share a common stochastic trend. To formally test for this we apply the Johansen cointegration test. In the test we apply a two time period lag for the sample and one lag for the sub-sample, and in both cases we use an unrestricted constant allowing for a linear time trend in the levels of the data. Optimal lag structure is determined by looking at the Akaike Information Criterion (AIC), the Schwartz Bayesian criterion (BIC) and the Hannan-Quinn criterion (HQC) estimated in a Vector Autoregressive (VAR) model framework. For both the full sample and the sub-sample all three information criteria give the same conslusion, i.e. they have their minimum value at the same length of lags. Table 3 presents the results for both the trace and maximum eigenvalue test statistics.

We start by considering the full sample. The trace statistics reject the null hypothesis of no cointegrating vector with a test statics of 52.303 which is larger than the 5% critical value of 47.21. But, we are not able to reject the null hypothesis that the number of cointegrating vectors is a most one. Hence, based on the Johansen trace statistics there exists one cointegrating vector. Turning to the maximum eigenvalue statistic, we see that the hypothesis stating no cointegrating vector is rejected. The test statistic for the null that there is at most one cointegrating vector and the alternative that there is two

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[24]Zivot, Eric and Andrews, Donald W. K. (1992): Further evidence on the great crash, the oil-price shock, and the unit-root hypothesis. *Journal of Business & Economic Statistics*, 10, Nr. 3, pp. 251–270.

[25]Baum, Christopher F. (2001): Stata: The language of choice for time series analysis? *The Stata Journal*, No. 1, pp. 1–16.

Table 1: Unit root tests.

Variable	ADF	Critical values			Asymptotic
		1%	5%	10%	p-value
Years 1886–2007					
Birth	−2.29412 (5)	−4.035	−3.448	−3.148	0.43660
Divorce	−1.59041 (1)	−4.033	−3.447	−3.147	0.79710
Wages	−3.16415 (3)	−4.034	−3.448	−3.148	0.09174
Participation	−0.30368 (1)	−4.033	−3.447	−3.147	0.99060
D.Birth	−3.89845 (4)	−2.598	−1.950	−1.611	0.00000
D.Divorce	−6.80764 (1)	−2.597	−1.950	−1.611	0.00000
D.Wages	−5.15995 (5)	−2.598	−1.950	−1.611	0.00000
D.Participation	−5.72128 (0)	−2.597	−1.950	−1.611	0.00000
Years 1945–2007					
Birth	−1.67691 (5)	−4.168	−3.508	−3.185	0.7617
Divorce	−1.62408 (0)	−4.168	−3.508	−3.185	0.7723
Wages	−2.42625 (1)	−4.168	−3.508	−3.185	0.3657
Participation	−2.89491 (1)	−4.168	−3.508	−3.185	0.1641
D.Birth	−2.28547 (5)	−2.616	−1.950	−1.610	0.0215
D.Divorce	−4.52567 (1)	−2.616	−1.950	−1.610	0.0000
D.Wages	−5.09153 (0)	−2.616	−1.950	−1.610	0.0000
D.Participation	−3.34687 (0)	−2.616	−1.950	−1.610	0.0012

Notes: ADF = Augmented Dicky-Fuller test. Number of lags in parenthesis is chosen as the highest significant lag out of a maximum of 5 lags. The test includes a constant and a trend. In first differences there are no constant and no trend included.

Table 2: Zivot and Andrews unit root test.

Variable	Break	t-statistic	Break year	Critical values	
				1%	5%
Birth	intercept	$-4.099\ (3)$	1921	-5.43	-4.80
Divorce	intercept	$-4.727\ (1)$	1973	-5.43	-4.80
Wages	intercept	$-4.549\ (3)$	1925	-5.43	-4.80
Participation	intercept	$-3.660\ (1)$	1975	-5.43	-4.80
Birth	trend	$-3.845\ (3)$	1928	-4.93	-4.42
Divorce	trend	$-2.249\ (1)$	1953	-4.93	-4.42
Wages	trend	$-4.063\ (3)$	1941	-4.93	-4.42
Participation	trend	$-4.666\ (1)$	1958	-4.93	-4.42
Birth	both	$-5.384\ (3)$	1942	-5.57	-5.08
Divorce	both	$-2.887\ (1)$	1973	-5.57	-5.08
Wages	both	$-4.573\ (3)$	1931	-5.57	-5.08
Participation	both	$-4.247\ (1)$	1956	-5.57	-5.08

Notes: Number of lags in parenthesis is chosen as the highest significant lag out of a maximum of 5 lags.

Table 3: Johansen cointegration test.

H_0	H_1	Test statistic	1%	5%	p-value	Eigenvalue
			Years 1886–2007			
			Trace statistic			
$r = 0$	$r \geq 1$	52.303	54.46	47.21	0.0166	0.21042
$r \leq 1$	$r \geq 2$	23.952	35.65	29.68	0.2091	0.12712
$r \leq 2$	$r \geq 3$	7.6371	20.04	15.41	0.5120	0.055385
$r \leq 3$	$r \geq 4$	0.79979	6.65	3.76	0.3712	0.0066428
			Maximum eigenvalue statistic			
$r = 0$	$r = 1$	28.351	32.24	27.07	0.0364	0.21042
$r \leq 1$	$r = 2$	16.314	25.52	20.97	0.2153	0.12712
$r \leq 2$	$r = 3$	6.8373	18.63	14.07	0.5169	0.055385
$r \leq 3$	$r = 4$	0.79979	6.65	3.76	0.3712	0.0066428
			Years 1945–2007			
			Trace statistic			
$r = 0$	$r \geq 1$	59.326	54.46	47.21	0.0024	0.44106
$r \leq 1$	$r \geq 2$	22.678	35.65	29.68	0.2708	0.17064
$r \leq 2$	$r \geq 3$	10.890	20.04	15.41	0.2220	0.13101
$r \leq 3$	$r \geq 4$	2.0435	6.65	3.76	0.1529	0.03192
			Maximum eigenvalue statistic			
$r = 0$	$r = 1$	36.648	32.24	27.07	0.0016	0.44106
$r \leq 1$	$r = 2$	11.788	25.52	20.97	0.5806	0.17064
$r \leq 2$	$r = 3$	8.8464	18.63	14.07	0.3062	0.13101
$r \leq 3$	$r = 4$	2.0435	6.65	3.76	0.1529	0.03192

cointegrating vectors is not rejected. Hence, both the trace and maximum eigenvalue test statistics give the same conclusion. Examining the trace and maximum eigenvalue statistics for the sub-sample, we conclude that there is one cointegrating vector for the years 1945 to 2007.

Since both the full sample and the sub-sample have a cointegrating vector we can estimate a Vector Error Correction (VEC) model with one cointegrating relationship in the specification. However, for both samples we are not as interested in the parameter estimates as in the ability to estimate the Impulse Response Functions (IRF).

4 Impulse response functions

The impulse response functions show how the variables within a system react to a one-standard-deviation innovation (shock) in one equation at time t, while there are no innovations in the other variables at time t. The left column in Figure 6 shows the IRFs for the full sample (1886–2007) while the right column shows for the sub-sample (1945–2007).

The two top figures show the response of the female labor participation rate to an innovation in the female to male wage ratio, the birth rate and the divorce rate. Comparing the full sample with the sub-sample we observe that the effects of the innovations are quite the opposite. For the sub-sample, an innovation in the female to male wage ratio increases the female labor participation rate. When women's wages increase, their incentives to work increase. Or, the costs of not working become higher. Hence, this response is as expected and is in line with the standard view in the economics literature. The participation rate also increases if there is an innovation in the divorce rate. A divorced woman who in her marriage has been financially dependent on her husband must after a divorce generate income on her own. In other words, she will join the labor force. However, the increase in the participation of an innovation in the divorce rate is not as large as the effect of a shock in the female to male wage ratio. An increase in the birth rate will, as expected, decrease the female labor participation rate.

The impulse response functions for the birth rate show that an increase in the female to male wage ratio has an initial positive effect on the birth rate in the first two periods. Then the effect becomes negative as we would expect. In fact, for the years 1945–2007 the effects start off and remain negative. An innovation in the female labor participation rate decrease the birth rate, but only temporarily for the whole time span. For the sub-sample there is a permanent negative effect of participation rate on the birth rate, while there is more or less no effect of shocks in the divorce rate. Both
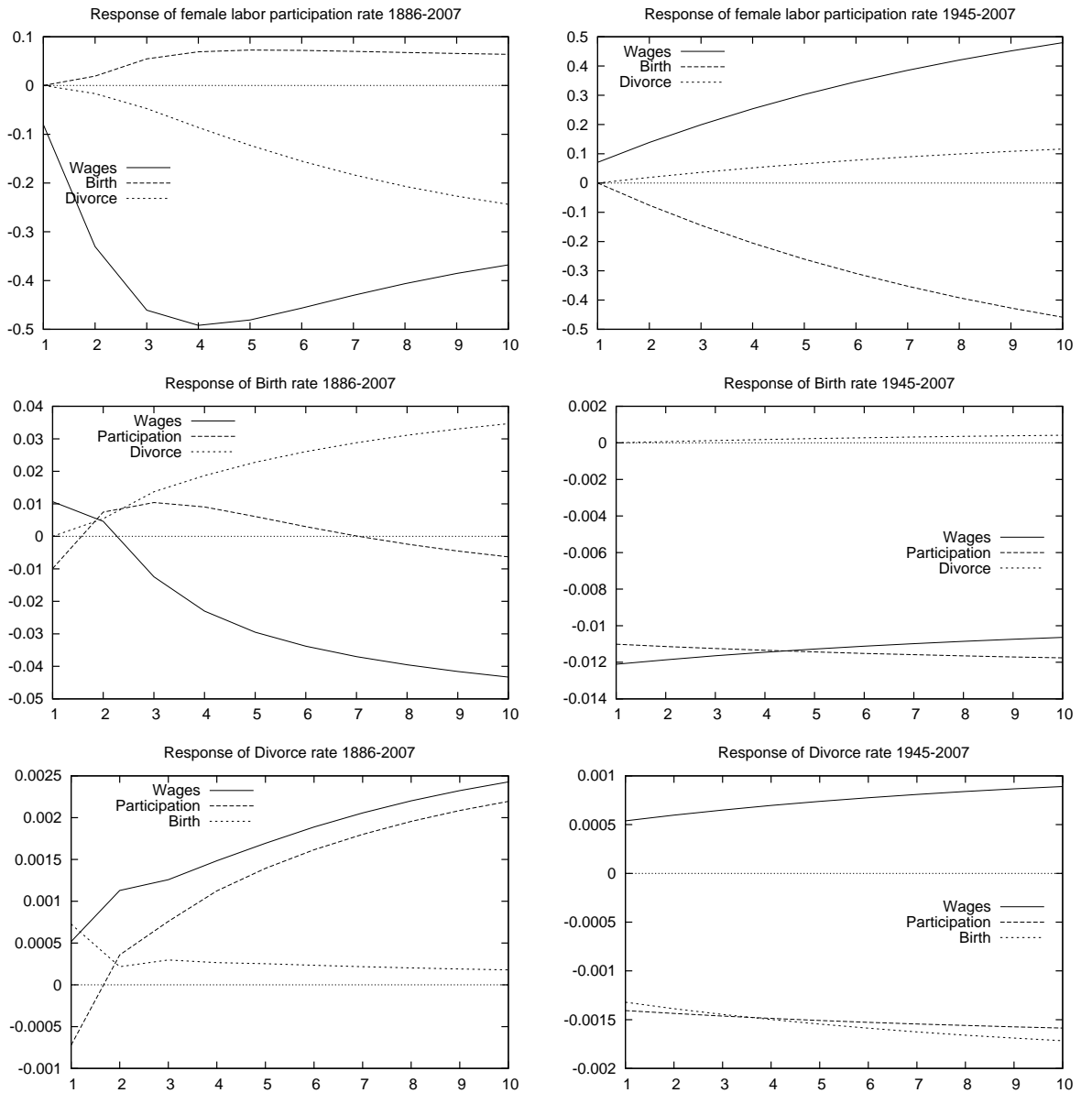
Figure 6: Impulse response functions for the full sample 1886–2007 (left column) and the sub-sample 1945–2007.

the female participation rate and the wage ratio between women and men have a negative effect on the birth rate. This is not surprising since better conditions in the labor market increase the costs of not taking advantage of higher pay. In other words, the cost of having children measured in foregone income increases.

When women get larger economic freedom measured as their wages relative to men, the divorce rate increases. And the increase is permanent, but with a decreasing rate. When women enter the labor market it seems to stabilize the marriage, i.e. the divorce rate decreases. However, this is only partial true for the full sample where this effect is vanished after one period and the divorce rate is increasing because of a innovation in the female participation rate. For the years 1945–2007, innovations in the birth rate also tend to reduce the divorce rate.

5 Summary and concluding remarks

Most writers on family history would agree that converging wages and higher female labor participation rates along with a more generous welfare system has contributed to significant changes in the family structure, e.g. lower birth and fertility rates and more frequent divorces. This paper tries to quantify these historical changes for Norway from the late 1800s until present days. This is done by calculations on the basis of family and labor force data from Statistics Norway and new wage data put together as part of the historical monetary statistics project ran by the central bank.

We quantify that the family structure has changed dramatically when it comes to marriage, divorce and fertility. We also give evidence of the magnitude of labor participation rate and wage convergence between genders. For the entire period we find that birth rates fell along with increasing standards of living and the closing of the gender wage gap. We also find that divorce rates increased along this development in the labor market. The development speeded up after World War II. Increasing female labor participation rates from the mid 1960s also gave fuel to the development towards lower fertility rates and less stable family relations.

It is also interesting to note that the effects of the demographic changes in family structure seem to be smaller for the recent time period than they are in the full sample, especially the responses of the birth and divorce rates. This we would explain by the fact that family life and the economic lives of men and women are more separated today than earlier.

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