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► **To cite this version:**

Gilles Pison, Agata V. d'Addato. Frequency of Twin Births in Developed Countries. *Twin Research and Human Genetics*, 2006, 9 (2), pp.250-259. 10.1375/183242706776382338 . hal-04006346

HAL Id: hal-04006346

<https://hal.science/hal-04006346>

Submitted on 27 Feb 2023

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This is the accepted manuscript of an article published in *Twin Research and Human Genetics* in 2006, whose reference is Pison, G., & D'Addato, A.V. (2006). Frequency of Twin Births in Developed Countries. *Twin Research and Human Genetics*, 9(2), 250259. <https://doi.org/10.1375/183242706776382338>

FREQUENCY OF TWIN BIRTHS IN DEVELOPED COUNTRIES

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Abstract

Twinning rates in developed countries have recently registered an increase. At the end of the 1970s, the change in mother's age structure has partially contributed to the growth in the proportion of multiple births. In fact, the evolution of twinning rates is related to the calendar of maternity since, comparatively to younger mothers, older women more frequently have twins. Moreover, the growing frequency of multiple births also depends on fertility treatments, which are largely used in the developed countries. National data from the civil birth registration systems are taken into account in order to describe, in a comparative study, the main trends of twinning rates in the 20th century.

Introduction

The proportion of twin births has varied during the last century, rising at times and falling at others. Are these variations similar in different countries, or do some countries show particularities? How can we explain the similarities and differences from one country to the next? Twenty developed countries are compared here for which detailed statistics on multiple births are available going back to a century ago. In the first part, an overview of secular changes in twinning rates in these countries is provided. In the second part, we focus on the period around World War I during which there was a peak in twinning in many countries, although not in all. In the third and fourth part, we examine two long-term trends that are common to nearly all the countries : the decline in the twinning rate during the first three quarters of the 20th century, and the recent reversal upward trend since the 1970s or 1980s.

The twinning rate is the proportion of twin deliveries out of the total number of deliveries, expressed per 1000 deliveries. It was computed for each given year using the total number of confinements as the denominator and the annual number of twin confinements as the numerator. Data were drawn from the civil birth registration systems of the National Statistical Offices and from earlier studies where data from official registers had been collected and compiled.

The twinning rates presented are based on the total number of twin births, including both dizygotic (DZ ; or fraternal) and monozygotic (MZ ; or identical) twins. It has been well documented (Astolfi et al., 2003 ; Bulmer, 1970; Imaizumi, 1998; Parazzini et al., 1993; Rachootin & Olsen, 1980; Steegers-Theunissen et al., 1998), however, that the prevalence of MZ twins is relatively constant worldwide, that is, between 0.3 and 0.4%. However, the prevalence rates of DZ twins (and higher order multiples) vary considerably - ranging between 0.6 to 4.5% in different populations - because they are influenced by several determinants, including maternal age, parity and region of the world. In fact, the same variations according to mother's age and order of birth are observed everywhere, but the frequency of twinning differs by region. For instance, controlling for age and birth order, the fraternal twinning rate in sub-Saharan Africa is two times higher than in Europe and four to five times higher than in China or Japan. These variations among racial and ethnic groups are partly linked to hormonal differences and genetic origin (Pison, 2000).

Historical Trends in Twinning Rates

Worldwide changes have occurred in the pattern of twinning rates in recent decades. To gain a proper perspective, these variations in twin maternities should be seen in their historical context.

The longest available historical data are for Sweden (starting from the middle of the 18th century) and for Finland, Denmark and France (starting from the middle of the 19th century). Figure 1 shows the historical trends for Denmark and France since the middle of the 19th century. During the second half of the 19th century, the Danish twinning rate increased strongly, peaking in 1921 at 16.6 per mill, which is almost twice its level 70 years before. High values continued in the 1920s, with a twinning rate no less than around 16 per mille. After the 1930s the twinning rate progressively declined until the second half of 1970s, when it started to increase dramatically.

Variations are visibly less significant in France, however the observed trend follows the same general evolution as in Denmark. This can be summarized by the following: an increase in the twinning rate at the end of the 19th century and the beginning of the 20th century, a plateau from 1920 to 1960, a decline during the following 20 years, and a significant increase from 1972 onwards.

Similar downward and upward trends were observed in most developed countries, even if the overall levels of twinning rates vary among them (Figure 2)¹.

To summarize the trends over time observed, it can be noted that in the first half of the 20th century, the incidence of twin deliveries did not significantly vary, with a visible plateau generally kept until 1960. In the 1960s, the proportion of twin deliveries declined to a minimum in the 1970 or 1980s. The rate then began to increase again and, by the second half of 1980s, it had

¹ The figure shows trends for some representative countries only.

risen back to the level of the first half of the century, designing a U-shaped curve in most developed countries (Figure 2).

The general evolution reported in most developed countries clearly emerges calculating the medium twinning birth rates in three different quinquennial periods. The first selected 5 years correspond to the period of the plateau, the second period corresponds to the general decline and the third measure synthesizes the period of the important rise in the proportion of twins (Table 1).

In Europe there is a progressive decrease in the incidence of twinning rates from north to south. By European standards the twinning rate is low among the Latins, medium among the Slavs and relatively high among the Germanic people, particularly among the Nordic people, including the Finns (Astolfi et al., 2003 ; Eriksson et al., 1995). However, few data are available on the southern European countries (Parazzini et al., 1991).

Among people of east Asian countries, twin maternities are rare; in Japan for instance, the twinning rate varies between 3 and 9 per mille from 1920s to 1990s. The trend of twinning rates in Singapore and Hong Kong is comparable to that in Japan but of rather greater magnitude.

Twinning Rates and World War I

The World War I represents an interesting scenario in the evolution of twinning birth rates. In particular, a peak can be observed just after the end of World War I in Italy, France, Germany and the Netherlands (Figure 3a). The differences between these countries concern above all the intensity and time of this peak: for instance, in Italy a very strong peak is reported in 1919 ; in France and Germany its intensity is a little less significant ; and in the Netherlands the increasing effect is postponed until 1920.

Several hypotheses have been suggested to explain this phenomenon. For instance, after deprivation women may have a higher polyovulation rate and better general conditions to carry through a multiple pregnancy. It is also conceivable that women with a short waiting time to conception are more prone to produce DZ twins. Consequently, early conceptions after separation may be more likely to be twins. The rise of twinning rates at the end of World War I may be mainly associated with this natural mechanism of selection (Pison & Couvert, 2004).

Similar trends have been reported in most developed countries, except for the Nordic ones, where the data are not homogeneous (Figure 3b). In fact, in Denmark, Sweden, Norway and Ireland, it seems that instead of a peak just after World War I, higher levels of twinning were reported in 1926. The explication may be linked to their neutral position during the war, which makes their history different from the other countries.

As for Finland, the historical events characterizing this country, in particular the war with the Russians during the observed period, determined a different evolution of twinning rates. The twinning rate declined between 1916 and 1918. After 1918, however, the rate starts to increase reaching a maximum value in 1923. Following this increase, a new decline is reported, which reached the lowest level in 1926.

The Declining Twinning Rates: Some Possible Explanations

As for the period around World War II, in Italy, Denmark, England and Wales, and even more visibly in Austria, higher twinning rates were observed between 1942 and 1944, as well a subsequent peak soon after the war. This phenomenon may, again, be explained by the fact that early conceptions after separation may be more likely to be twins. Indeed, the postdeprivation

peak observed in some countries between 1945 and 1946 is consistent with previous findings from other countries (for example, France) for World War I. In addition, it is interesting to note that this kind of trend is not the same everywhere during World War II. For instance, in France the twinning rate declined from 1920 and this decline continued during World War II without showing any visible peak (Pison & Couvert, 2004).

Besides showing interpopulation variability, it seems that, in most developed countries, a decline in twinning rates – in most cases a substantial decline – began at about the same time in the late 1950s. The temporal trend, which began to decrease in the early 1950s, displayed a reversal of tendency in the late 1970s, thereby reviving the interest of epidemiologists and geneticists in twinning and its possible causes.

Several complementary factors have played a role in the general phenomenon of declining twinning rates observed from around 1950 until the late 1970s. Firstly, maternal age is an important determinant in the variations of twinning rates, with a temporal trend toward earlier marriage and childbearing. In fact, as several studies have shown (Blondel & Kaminski, 2002 ; Eriksson & Fellman, 1973), there is a positive association between twinning incidence, in particular DZ, and maternal age and parity. Therefore, the decrease in mean maternal age at delivery and the reduction in the number of children have been considered to be at least partly responsible for the downward trend. Secondly, under the assumptions that (1) mothers of twins are more fecund than other women, and (2) such women constitute a subpopulation that is inherently twin-prone, the observed decline in twinning rates may be a reflection of the smaller family size chosen by these highly fecund, twin-prone women. In other words, the decline may be related to the voluntary limitation of deliveries (Pison & Couvert, 2004).

In addition to these two factors, a wide range of suggestions and hypothesis has been offered to further explain the general decrease of the twinning rates. A history of oral contraceptive use has been suggested to contribute to the decline in twinning by acting directly to reduce the probability of double-ovulation (Braken, 1979). However, it must be noted that birth rates in Denmark, for example, started to decline before oral contraceptives came into general use.

In addition, socioenvironmental factors, including increasing urbanization, may be acting to produce the observed changes. This has prompted the suggestion that an urban, sedentary lifestyle may increase the probability of spontaneous abortion in women expecting twins (Parisi & Caperna, 1981). On the other hand, it is hypothesized that mothers in rural regions may have a stronger genetic disposition for twinning and that mothers in the countryside with a good physical condition have a better chance of completing a gestation with multiple embryos than women in urban and industrialized areas (Eriksson et al., 1995).

The decline in twinning rates may also be influenced by a decrease in the probability of conception. Speculations on the cause of decreased sperm concentration include exposure to pesticides and stilbestrol, a growth hormone widely used for livestock (James, 1972). In support of this notion, it has been observed that workmen involved in the manufacture of pesticides have a lower than normal sperm count (Astolfi et al., 2003).

A higher frequency of multiple pregnancies in the lower classes has been reported in studies conducted in Nigeria and Scotland (Parazzini et al., 1994). It has been suggested that these differences might be explained in terms of the different reproductive or dietary habits of women in the lower social classes. However, this relation between social class and multiple pregnancies has not been consistently reported.

It seems therefore that no single factor can explain the trends observed. It is increasingly evident that the explanation of the variability of twinning rates is very complex and is not just of interest per se, but may disclose new insights into the role of genetic versus environmental factors in the reproduction of man.

As multiple births carry a high risk of fetal and infant mortality and long-term morbidity (Senat et al., 1998), population trends in these births, as well as the determinants of these trends and their consequences for infant and child health, are of major public health importance.

The Recent Evolution: The Influence of Sterility Treatments

The Figure 4 presents trends in the overall twinning rate on a worldwide scale during the period 1970 to 2003. Since the mid-1970s, rising twinning rates have been reported in most developed countries and, especially during the last two decades, a sudden increase in multiple births has been observed.

The rising multiple birth rates have been attributed to the higher proportion of mothers treated with ovulation-inducing hormones, and partially attributed to in vitro fertilization (IVF) practice, such as in Japan (Imaizumi, 2003), England and Wales (Murphy et al., 1997; Platt et al., 2001), Italy (Terzera, 2002), the Netherlands (Tas, 1994; Steegers-Theunissen et al., 1998), Denmark and Sweden (Eriksson et al., 1995), France (Blondel & Kaminsky, 2002 ; Pison & Couvert, 2004).

In the last 30 years of the 20th century, twinning rates were higher in European countries, Canada and Australia than in east Asian countries. Among Asian countries, twinning rates indicated similar values (5.5 - 8.9) except in Israel (9.7 - 17.4) during the entire period observed.

Of the western countries, the twinning rate was highest in Ireland until 1984 (the country with the highest total fertility rate in Europe). Afterwards, the highest twinning rates were observed in the Netherlands and in Denmark.

In Denmark, the first child from IVF was born at the beginning of the 1980s. It was only after the mid-1980s, however, that this treatment became common practice, and there has been a definite increase in its use in recent years. To reduce the increase in multiple pregnancies caused by fertility-enhancing treatment, the Danish National Board of Health recommended in 1991 that only two, and never more than three embryos should be transferred per treatment cycle (Imaizumi, 1998). However, it seems that the multiple birth rates did not decrease.

In the Netherlands, the twinning rate remained nearly constant between 1970 and 1980 (9.9 - 10.8). In the last two decades, however, the twinning rate increased significantly, significantly more strongly than could have been expected, according to quantitative estimations. It rose 64% in 25 years : from 9.9 per 1000 in 1970 to 16.3 per 1000 in 1995. Although ovulation-inducing agents were introduced into Dutch medical practice in the 1970s, a sharp increase in the use of these drugs, in particular gonadotropins, occurred just after 1986. The delay in achieving pregnancy and the use of fertility-promoting therapies profoundly affect the prevalence of multiple pregnancies in the Netherlands.

On the other hand, the lowest western European twinning rate was seen in Switzerland between 1970 and 1977, and in Austria between 1978 and 1988.

After the introduction of assisted reproductive techniques such as IVF, natural twinning rates have been changing depending on how popular these techniques have been in each country. Namely, the variations of these rates among countries were not only due to biological factors, but also to assisted reproductive techniques.

In the Czech Republic, for example, the twinning rate remained constant from 1972 until 1994 (8.7 - 9.6) and rapidly increased to 16.9 in 2003. This suggests that this country had not been affected by fertility drugs and assisted reproductive techniques until recently.

No data about subfertility treatments are analyzed here. This information in fact, is not collected at birth registration and data from other sources are not directly comparable.

Multiple Births and Age of Mother: The Case of France and the Case of England and Wales

In France, and in England and Wales, age-specific rates have been reported to obtain a better understanding of the role of mother's age.

The twinning birth rates presented here include both MZ and DZ twin deliveries. It is, however, a well-known that the frequency of identical twins is fairly constant, no matter the age of mother (Bortolus et al., 2001).

The rates for the youngest maternal age groups (under 20 years old) remained nearly constant during the examined period both in France (Figure 5) and in England and Wales (Figure 6). On the contrary, twinning and multiple rates for the age groups 35 to 39, 40 to 44 and 45+ significantly increased year by year.

The incidence of multiple births increases with the mother's age, up to ages 35 to 39 years², and in the last decade, it dramatically climbed among women aged up to 45. This sudden increase, already visible in France (Figure 5), has been even more striking in England and Wales (Figure 6).

In fact, this huge increase concerns not only twins but also triplets, quadruplets and higher order multiples, which are certainly more frequent in the oldest maternal age-groups.

Moreover, the strikingly high frequency of multiple deliveries among older women (Figure 6) suggests that ovarian stimulants and, from the late 1982s onwards, assisted conception, had a considerable impact on the rate of multiple births. In fact, older women are more likely to utilize infertility treatments. The finding of a dramatic increase in multiple rates mainly among older women, strongly supports the link to fertility-enhancing treatments. To quantify the impact, however, more appropriate data that explicitly relate the use of these procedures to their outcome are needed.

Another hypothesis to partly explain the recent explosion of multiple births in the oldest maternal age groups may be related to the increasingly observed number of second marriages, which may reasonably be linked with a significant rise in the mean maternal age at childbirth³.

Maternal age rose in recent decades in most countries. In France, the rise was from 26.5 years of age in 1977 to 29.6 in 2004. The quantitative contribution of rising maternal age to the increase in multiple pregnancies has been estimated in several countries. These estimates exclude the influence of infertility treatments, which are more frequently used by older women. In England and Wales, France, the Unites States and Sweden, one fourth to one third of the

² It has been attributed to the rise in the level of gonadotropin with age, with maximum stimulation of follicles occurring between ages 35 and 39 (Danforth, 1990).

³ However, the strong impression that twinning rates increase with the women's age is only partly confirmed by a recent publication focusing on Sweden (Hoem & Strandberg, 2004). The authors of this study show that there is a simple but nonmonotonic association between age and twinning rates when one controls for parity, and also a nonmonotonic association between parity and twinning rates when one controls for the mother's age.

increase in twin or triplet pregnancies is attributable to the increase in maternal age (Blondel & Kaminski, 2002).

Some Conclusions

To summarize, the recent rise in twinning incidence reflects a change in the age distribution of women at childbirth, with more women giving birth at older ages, and an increased use of fertility drugs which greatly increase the risk of multiple ovulation and subsequent delivery of multiple births. Other possible contributing factors can be the use of pesticides and food additives, and the increased pollution in general. Further studies are needed to allow significant conclusions concerning these factors to be drawn, especially comparisons between countries and areas, which marked differences in the mentioned environmental factors.

The increase in multiple births represents an important public health issue because of its large socioeconomic, physical and psychological impact. To halt the increase in multiple births, it is important to raise awareness as to the seriousness of these trends.

In the last few years, the beginning of a weak contraction in the proportion of twin deliveries has been observed in several countries, such as the Netherlands, Germany, Norway, Finland, Switzerland, England and Wales. This is an important aspect, which will hopefully be of increasing interest to more developed countries in the near future.

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Figure 1 – *Twinning rates, historical trends*
(number of twin deliveries per 1,000 total deliveries)

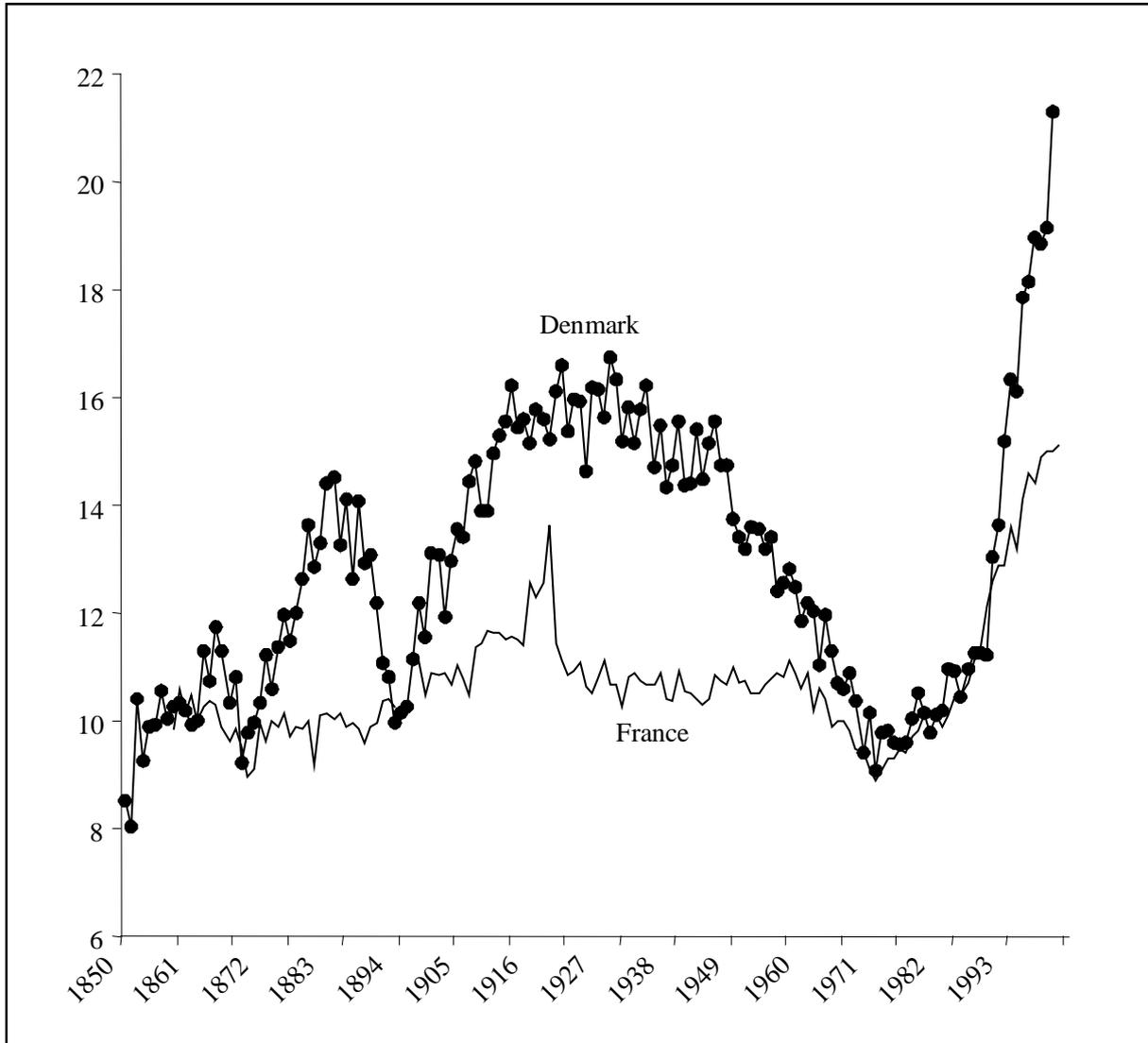


Figure 2 – Trends of twinning rate over the 20th century in seven developed countries
(number of twin deliveries per 1,000 total deliveries)

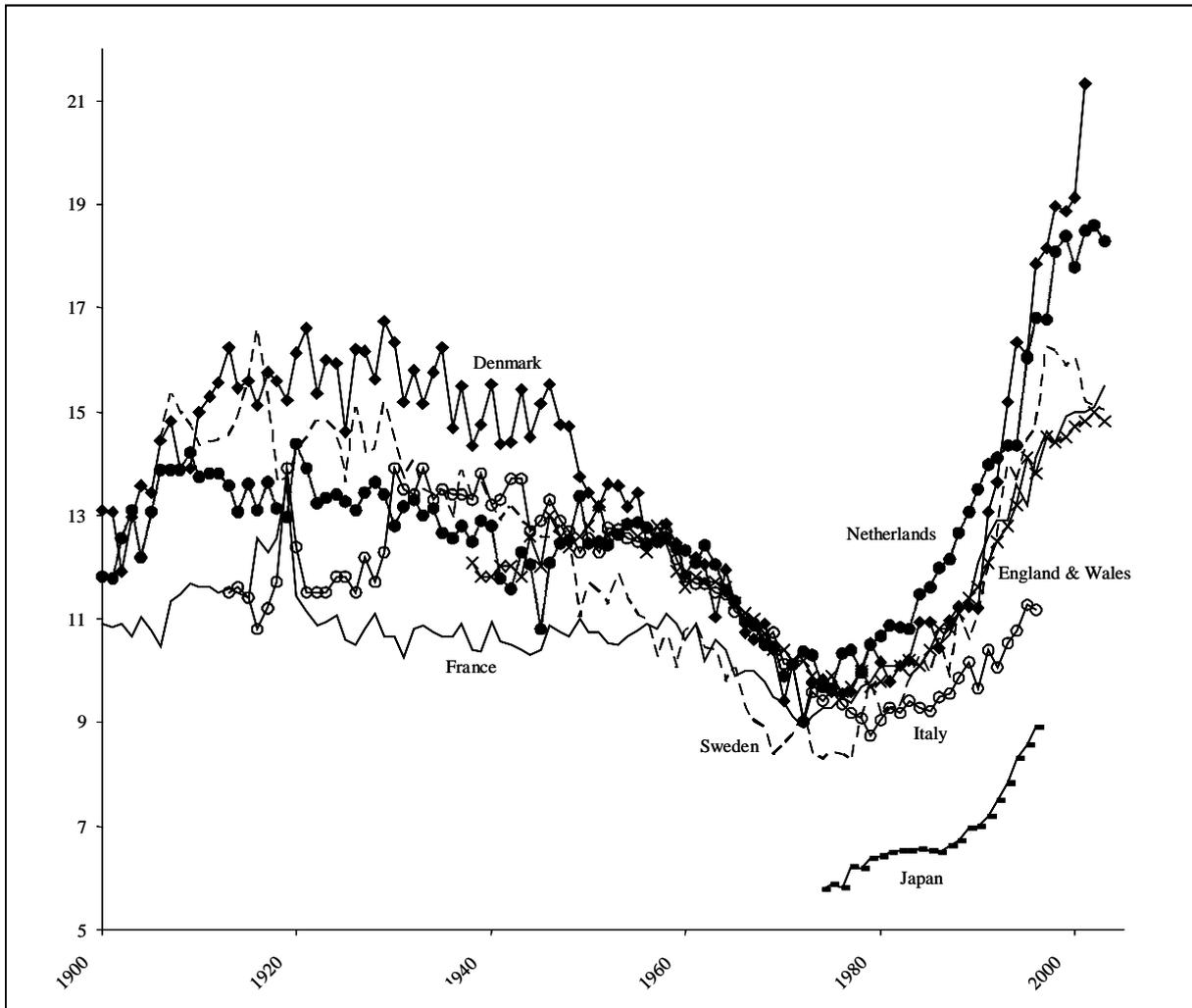


Figure 3a – Twinning rates per 1,000 births, the peak of World War I

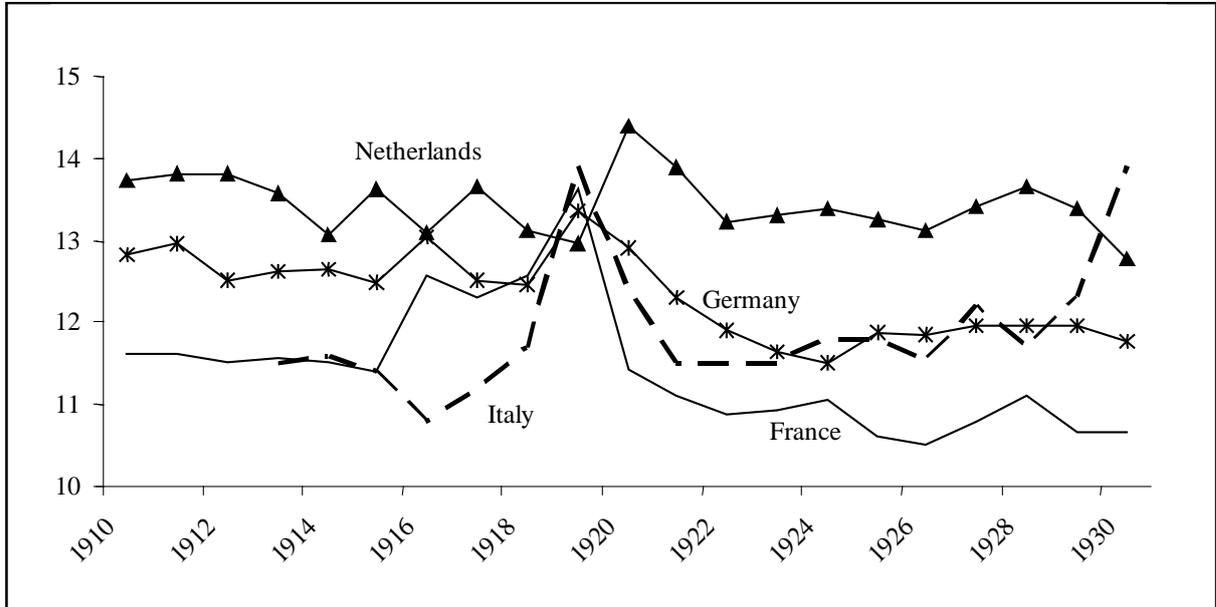


Figure 3b – *Twinning rates per 1,000 births, Nordic countries*

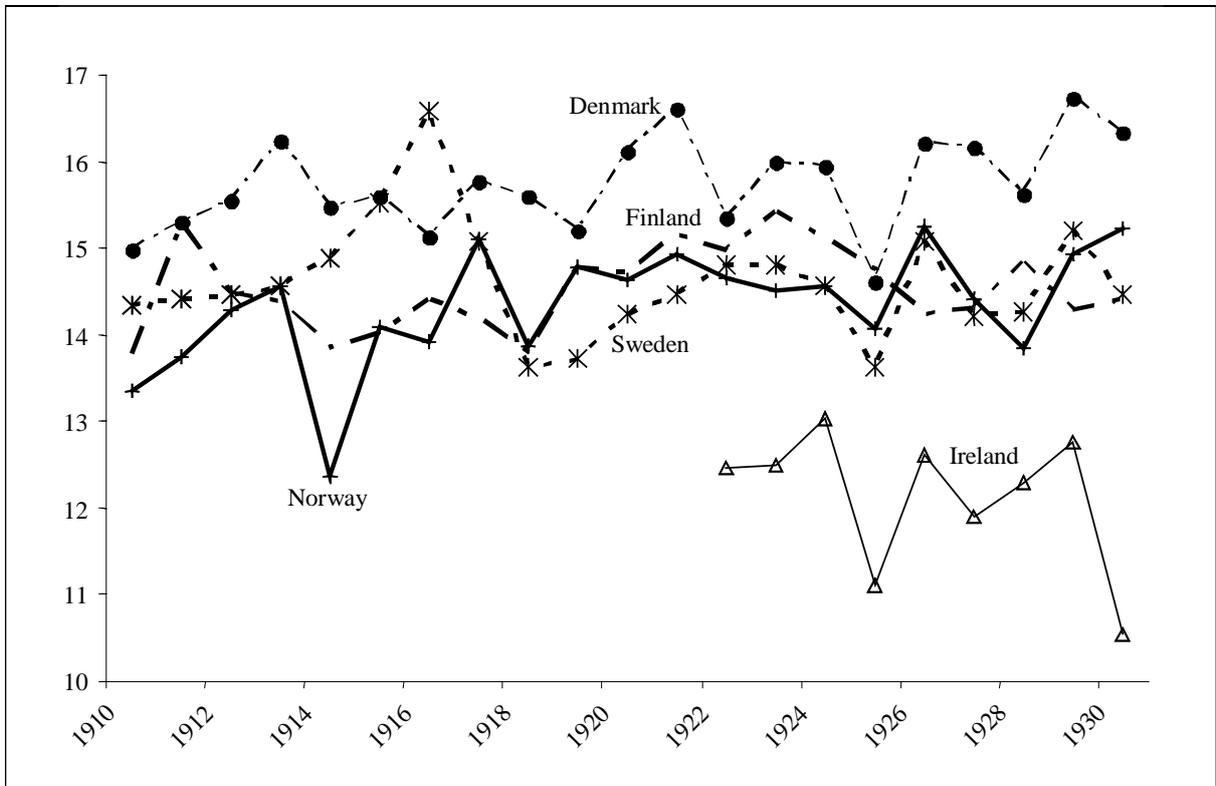


Figure 4 - *Twinning rates per 1,000 births, 1970-2003*

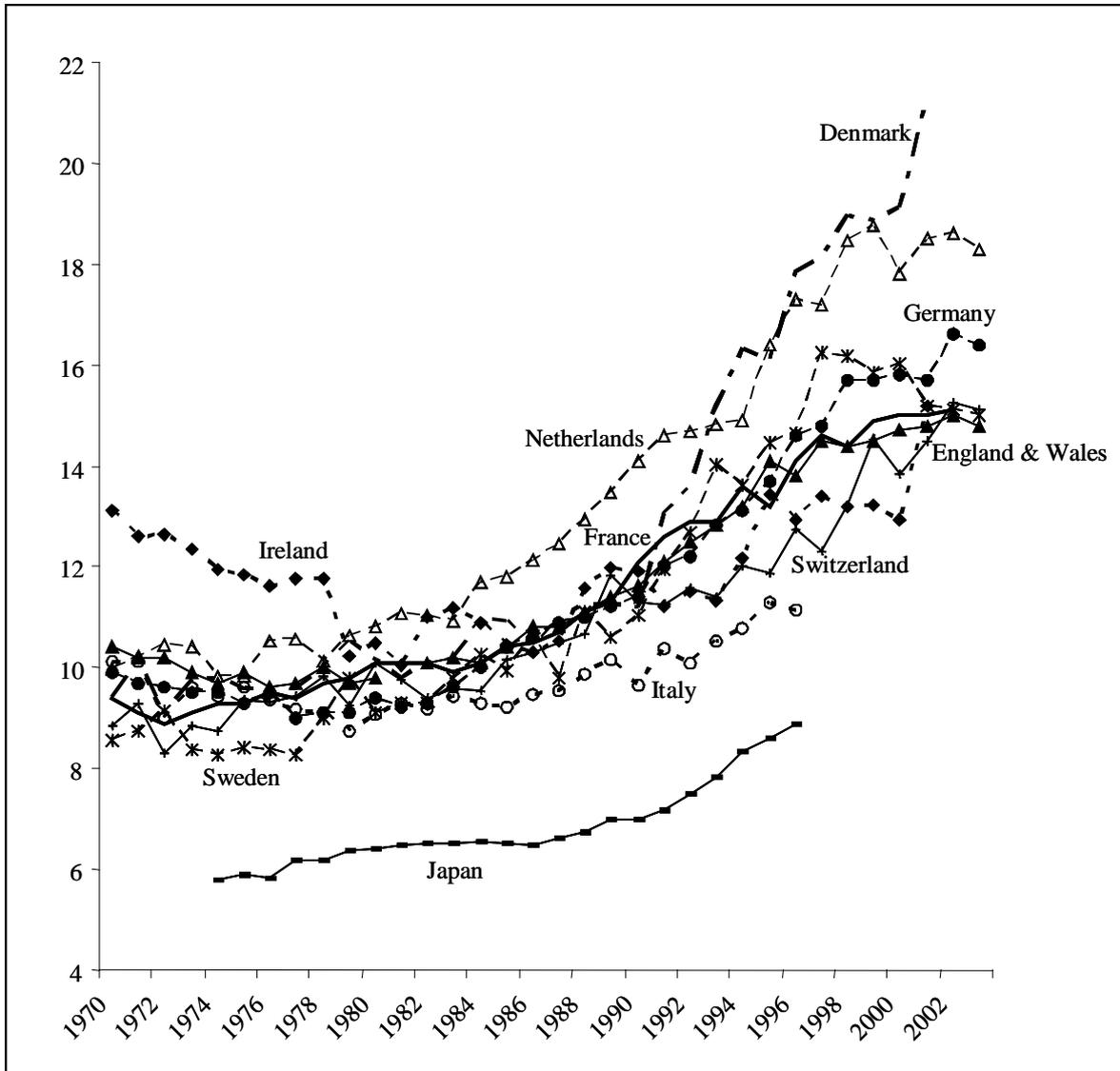


Figure 5 – Twinning rates per 1,000 births by maternal age, France
(for the age group 45+, moving averages over three years are shown)

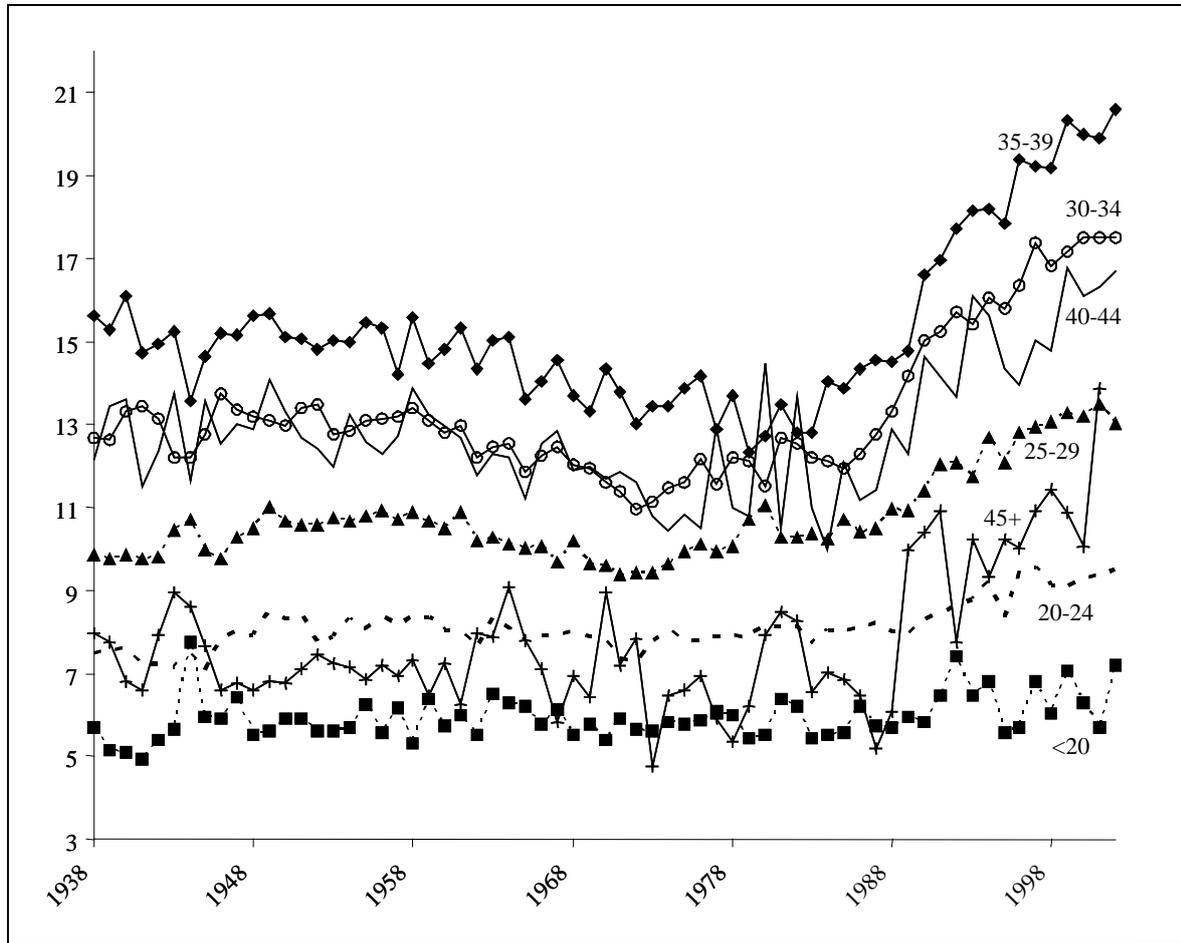


Figure 6 – Multiple rates per 1,000 births by maternal age, England and Wales
(for the age group 45+, moving averages over three years are shown)

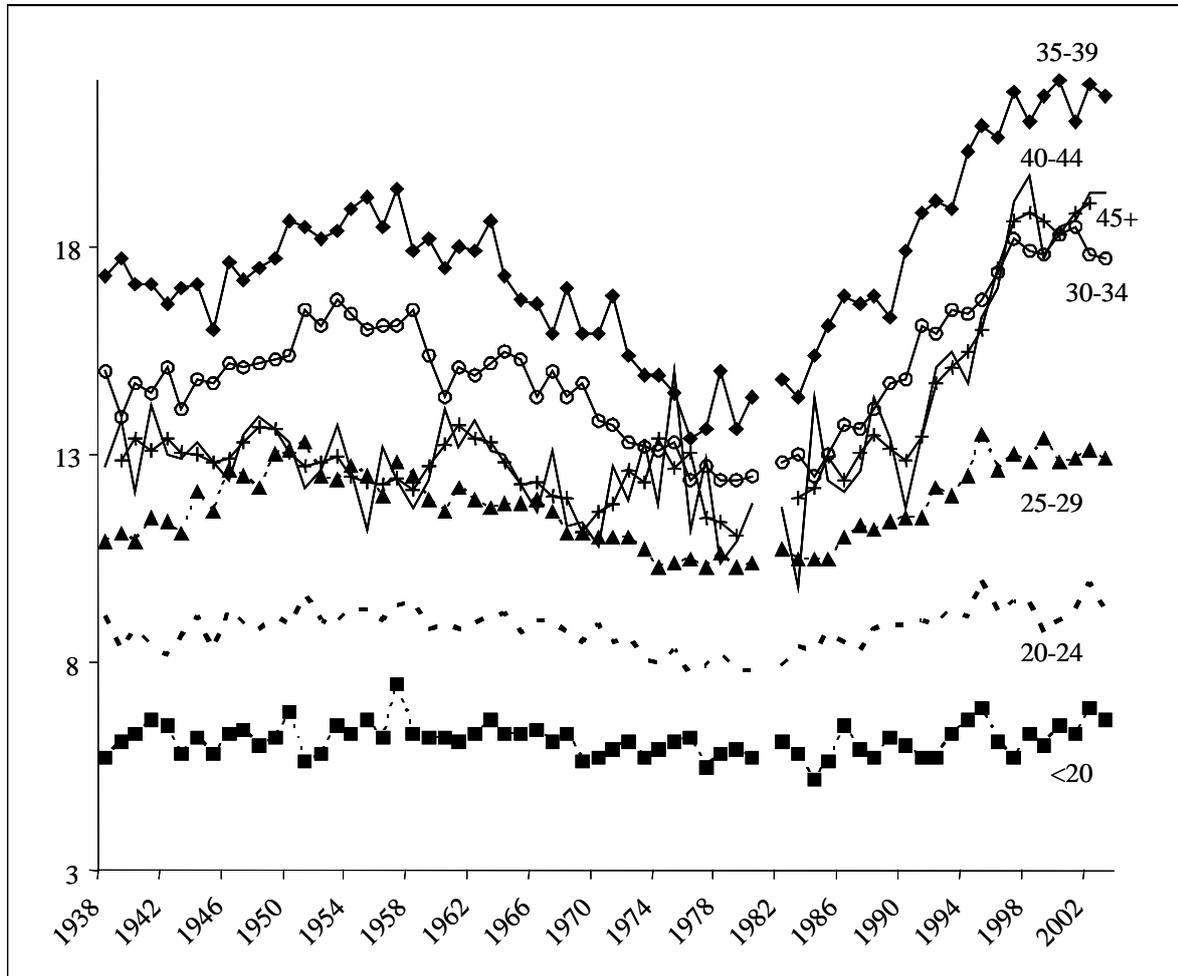


Table 1 - *Medium twinning rates per 1,000 births*

| Countries | Medium twinning rate period | | | Years with estimates available (in Figure 2) | Sources |
|-------------------|-----------------------------|-----------|-----------|---|--|
| | 1925–1929 | 1972–1976 | 1995–1999 | | |
| Australia | 10.68 | | 14.08 | 1907–1936; 1985–1996 | Bunle, 1954 (from 1907 to 1936); Imaizumi, 1998 (from 1985 to 1996) |
| Austria | 12.16 | 9.04 | 12.08 | 1906–1913; 1920–1924; 1928–1929; 1931–1934; 1937–2002 | Bunle, 1954 (from 1906 to 1934); National Statistical Office (from 1937 to 2002) |
| Canada | 12.31 | 9.02 | 11.40 | 1921–1936; 1972–1996 | Bunle, 1954 (from 1921 to 1936); Imaizumi, 1998 (from 1972 to 1996) |
| Czech Republic | 12.46 | 9.34 | 13.32 | 1920–1923; 1925–1935; 1949–2003 | Bunle, 1954 (from 1920 to 1935); National Statistical Office (from 1949 to 2003) |
| Denmark | 15.87 | 9.55 | 17.98 | 1850–2001 | National Statistical Office |
| England and Wales | — | 9.86 | 14.26 | 1938–2003 | National Statistical Office |
| Finland | 14.49 | 11.01 | 15.69 | 1906–1936; 1975–2003 | Bunle, 1954 (from 1906 to 1936); Imaizumi, 1998 (from 1975 to 1996); National Statistical Office (from 1997 to 2003) |
| France | 10.74 | 9.22 | 14.24 | 1906–2003 | Pison & Couvert, 2004; Beaumel et al., 2004 (from 2001 to 2003) |
| Germany | 11.93 | 9.48 | 14.90 | 1906–1936; 1950–2003 | Bunle, 1954 (from 1906 to 1936); National Statistical Office (from 1950 to 2003) |
| Hong Kong | — | 6.21 | 8.40 | 1972–1996 | Imaizumi, 1998 |
| Ireland | 12.14 | 12.07 | 13.24 | 1922–2001 | National Statistical Office |
| Israel | — | 10.03 | 17.40 | 1972–1974; 1977–1991; 1993–1996 | Imaizumi, 1998 |
| Italy | 11.90 | 9.40 | 11.22 | 1913–1996 | National Statistical Office (from 1913 to 1949); Astolfi et al., 2003 (from 1950 to 1996) |
| Japan | 3.21 | 5.83 | 8.74 | 1923–1936; 1974–1996 | Bunle, 1954 (from 1923 to 1936); Imaizumi, 1998 (from 1974 to 1996) |
| Netherlands | 13.36 | 10.08 | 17.22 | 1900–2003 | National Statistical Office |
| Norway | 14.50 | 9.29 | 15.81 | 1906–1955; 1974–2003 | Bunle, 1954 (from 1906 to 1936); Imaizumi, 1998 (from 1973 to 1976); National Statistical Office (from 1937 to 1955 and from 1977 to 2003) |
| Singapore | — | 6.72 | 8.37 | 1972–1996 | Imaizumi, 1998 |
| Sweden | 14.48 | 8.52 | 15.47 | 1906–2003 | Bunle, 1954 (from 1906 to 1936); Eriksson et al., 1995 (from 1937 to 1960); Hoem & Strandberg, 2004 (from 1961 to 1998); Imaizumi, 1998 (from 1972 to 1995); National Statistical Office (from 1999 to 2003) |
| Switzerland | 12.68 | 8.90 | 12.94 | 1906–1936; 1970–2003 | Bunle, 1954 (from 1906 to 1936); National Statistical Office (from 1970 to 2003) |