

The Japanese Decline in Secondary Sex Ratio Correlates with Percentage Change in GDP/Annum

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Background: Male births occur in excess of female births. The ratio of male:female births is commonly referred to as M/F and is expected to approximate 0.515. Stress has been shown to decrease M/F due to an increased rate of male spontaneous abortions. Since Japan's economy declined after the mid-1970s, this study was carried out in order to ascertain whether there was any relationship between M/F and annual change in percentage gross domestic product (GDP) in Japan.

Methods: Annual male and female live births were obtained from a World Health Organisation Mortality database. GDP data was downloaded as an Excel sheet from the website of the World Bank. Data for both variables was available for the period 1961-2009.

Results: This study analysed 71878631 total live births. There was an overall and abrupt decline in M/F which commenced in 1975 (0.5149, from 0.5155 in 1974), one year after the decline in percentage annual GDP growth which fell from 8.0% to -1.22 from 1973 to 1974. M/F correlated with percentage annual GDP growth ($r=0.4$, $p=0.005$).

Conclusion: M/F is increasing overall in Asia, but decreasing in Japan, as is the trend in developing countries. This country exhibits a rise in GDP change along with M/F in boom years, followed by a progressive fall in both values, which occurs almost in parallel, especially after 1980. To the author's knowledge, this is the first time that M/F has been linked with percentage annual GDP.

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1. INTRODUCTION

Male births occur in excess of female births [1]. The ratio of male to female live births is generally expressed as the ratio of male live births divided by the total live births. This would be more accurately abbreviated as M/M+F or M/T (male divided by total births), but it is widely (and technically incorrectly) abbreviated as M/F. The latter will be used throughout. For humans, M/F is anticipated to approximate 0.515 [2].

The reason for this discrepancy is uncertain. Moreover, a plethora of factors have been shown to influence M/F [2]. For example, long duration warfare increases M/F [2] while stress lowers it [3]. It has also been shown that stress in the form of economic shock may abruptly lower M/F. For example, in East Germany, M/F was at its lowest in 1991, the year after reunification when economic conditions in this region were at their worst [3].

The Japanese period of economic growth up to the 1970s has been called the Japanese post-war economic miracle. Growth averaged 7.5% per annum in the 1960s and 1970s [4]. However, Japan faced severe economic challenges after the global oil crisis in 1973 since the country was almost totally dependent on imported petroleum. This led to the first post-war decline in percentage annual gross domestic product (GDP) growth. The eventual recovery was followed by the Japanese asset price bubble from 1986 to 1991, with high inflation rates in real estate and stock prices. Growth averaged less than 3% per annum. This bubble burst in 1991-2, leading to many difficulties in several Japanese financial institutions. The 1990s in particular are known as the "Lost Decade" following the country's economic collapse [4].

In Asia, it has been shown overall the M/F is increasing [5]. In Japan, M/F has been shown to be declining since the 1970s, [6-8] and between 1950-2009. This overall trend was statistically highly significant (chi for trend 15.6, $p < 0.0001$) [5].

A country's economic growth is measured by changes in goods produced and services

provided with time. It is conventionally cited as the annual percentage rate of increase/decrease in real gross domestic product (GDP), which is adjusted for inflation.

This study was carried out in order to ascertain whether there is any relationship between M/F and annual change in percentage GDP in Japan. In this context, the latter is used as a measure for economic hardship or wellbeing within the populace.

2. METHODS

Data about annual male and female live births were obtained from a World Health Organisation Mortality database. This was imported into Microsoft Excel, which was then used for collation and analysis. GDP data was downloaded as an Excel sheet from the website of the World Bank [9]. Data for both variables was available for the period 1961-2009.

The quadratic equations of Fleiss were used for exact calculation of 95% confidence intervals for ratios [10]. Chi tests were applied using the Bio-Med-Stat Excel add-in for contingency tables. Spearman correlation was carried out using SPSS.

The null hypothesis was that annual change in percentage GDP was unrelated to M/F. A p value ≤ 0.05 was taken to represent a statistically significant result.

3. RESULTS

This study analysed 71878631 total live births (males: 36971799, females: 34906832). Annual M/F and percentage annual GDP growth are shown in Fig. 1. 5-yearly averages are shown in Fig. 2.

There is an overall and abrupt decline in M/F which commenced in 1975 (0.5149, from 0.5155 in 1974), one year after the decline in percentage annual GDP growth which fell from 8.0% to -1.22% from 1973 to 1974.

M/F correlated significantly with percentage annual GDP growth ($r=0.4$, $p=0.005$).

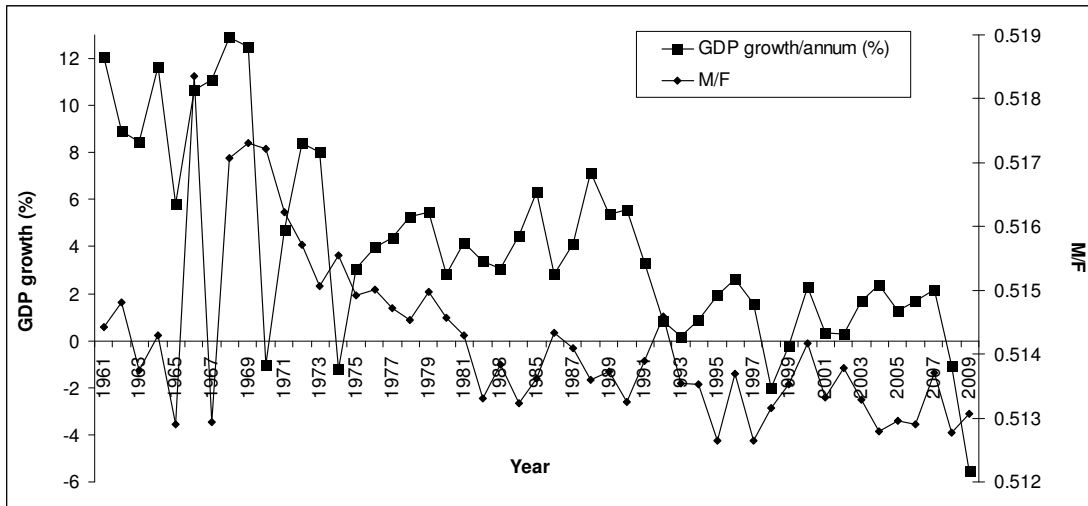


Fig. 1. Annual M/F and percentage annual GDP growth

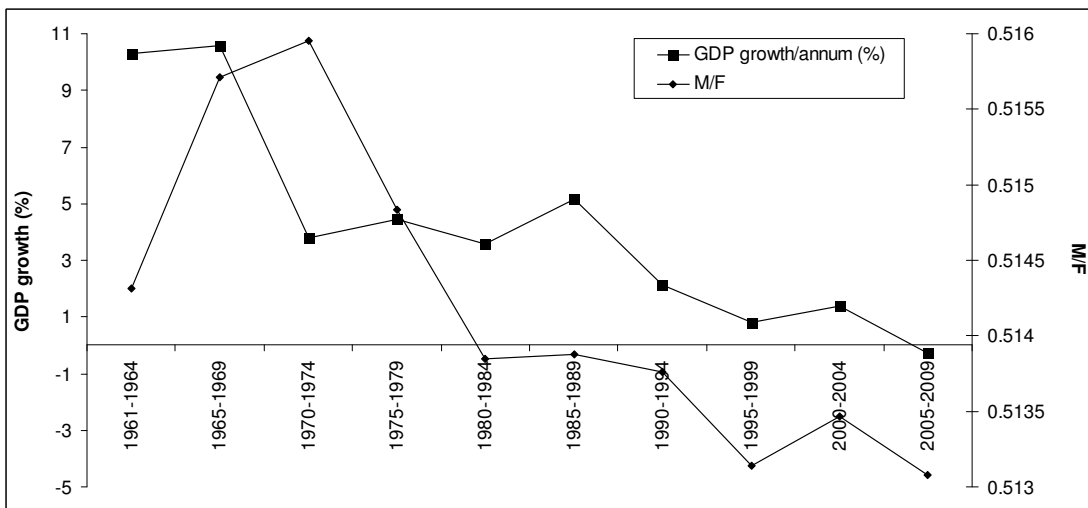


Fig. 2. 5-yearly M/F and percentage annual GDP growth

4. DISCUSSION

M/F is increasing overall in Asia [11]. This is in contrast with developed countries where M/F is in decline [11]. The drop has been blamed on the increasing chemical contamination of the environment, and indeed, M/F has been mooted as a possible sentinel health indicator [12]. For example, Japan's declining M/F has been possibly attributed to environmental dioxin, but it must be noted that these hypotheses are speculative [6].

However, the M/F decline clearly parallels Japan's economic collapse, in accordance with

the economic stress hypothesis [13]. This is particularly evident when five year averages are examined in Fig. 2, which shows a rise in GDP change along with M/F in boom years, followed by a progressive fall in both values. This descent occurs almost in parallel, especially after 1980.

Adverse environmental conditions encourage stressed females to spontaneously abort male fetuses in excess of female foetuses [14]. Declining economies have also been associated with an elevated incidence of very low birth weights (<1500 g) in Sweden and Norway, but this data for Japan was not available for analysis [15].

Other phenomena have also stressed the Japanese population. For example, the January 1995 Great Hanshin (Kobe) Earthquake was shown to have reduced sperm motility [16] as well as fertility (by 6%) in the Hyogo Prefecture [17]. This was accompanied by a significant decline in M/F in this region [17]. However, no effect was noted on Japan's overall M/F (Fig. 1). This contrast is interesting as it was observed that after the terrorist attacks of September 11, M/F fell not only in New York [18] but also in California [19] and in the rest of the United States [20].

All of this in accordance with the Trivers-Willard hypothesis which proposes that a male who reaches reproductive age in good condition is expected to out-reproduce a sister in similar condition. Conversely, if both are in poor condition, a female is expected to out-reproduce a brother. This is because a weak son would compete poorly with stronger males for the same cohort of females, thus producing fewer offspring than a weak female daughter would [21].

This theory implies that natural selection has favoured females who, when pregnant and subjected to environmental stressors, manipulate M/F by culling male fetuses that are least likely to eventually sire grandchildren. Males are specifically selected for abortion as a male in poor condition is likelier to die before reaching reproductive age than a female in similar condition, despite receiving a greater maternal investment [21].

Male vulnerability is manifest in premature births, as well as in term babies, with higher morbidity and mortality rates that persevere into early childhood. It has therefore been suggested that postnatally, malnutrition, interacting with infection, is a precipitant for male loss. Furthermore, because of this innate male vulnerability, despite advances in medical care, male loss always exceeds female loss [22].

Partial support for this theory is provided by the rise in M/F that occurred with improvement in living conditions, education, and reproductive hygiene in the developed world around and after the turn of the 20th century. These factors would tend to reduce conceptopathology, thereby theoretically increasing the survival rate of male foetuses [23].

The Trivers-Willard hypothesis is further reinforced by the finding that M/F and caloric availability per capita in over two hundred

countries were positively correlated. The same study demonstrated that increases or decreases in caloric availability were associated with corresponding changes in countries' M/F [24].

Besides stress, it has been theorised that nutritionally deprived mothers are likelier to produce daughters since these are less costly from the nutritional point of view and are therefore less likely to be frail and likelier to survive a harsh environment [25]. Indeed, under such circumstances, increased male foetal attrition in pregnancy may be inevitable since women who gestate a male embryo require a 10% higher daily energy intake than women who gestate a female embryo, consuming on average 8% more protein, 9.2% more carbohydrates, 10.9% lipids of animal origin and 14.9% lipids of vegetable origin. Male embryos may therefore be more susceptible to energy restriction and thus more likely to be aborted spontaneously [26].

This study is naturally limited by potential confounders since the data available only included male and female live births by year. For example, monthly M/F data has been shown to exhibit seasonality as evidenced by a recent Chinese study which showed that summer and winter pregnancies had a lower M/F than those occurring in spring [27]. Seasonality and changes therein could not be taken into account due to the nature of the available data.

Furthermore, a very recent Japanese study has also shown that climate change along with its inherent abnormal temperature fluctuations is linked with a lower M/F due to increased male foetal losses [28].

5. CONCLUSION

To the author's knowledge, this is the first time that M/F has been linked with percentage annual GDP. It would be interesting to observe whether GDP is related to M/F in other countries that have experienced rapid economic changes.

CONSENT

Not applicable.

ETHICAL APPROVAL

Not applicable.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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