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Impact of economic conditions on the secondary sex ratio in a post-communist economy

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ABSTRACT

According to the Trivers–Willard hypothesis the secondary sex ratio (SSR, the ratio of male to female newborns [M/F]) should be positively related to the parents' living conditions. This also means that if in some population parents experience environmental (e.g. economic) stress, the SSR should be relatively low. If this holds true, the fluctuations in the SSR of offspring could be one of the ways the human population reacts to environmental (and also socio-economic) changes. Although confirmed for many human populations, such a relationship was not observed in the populations living in the communist-era planned-economy countries until recently. We test the hypothesis that economic stress in Poland after the communist era is also related to the SSR decrease. Using quarterly data from the years 1995–2007 about the total number of live male (M) and female (F) newborns born in central Poland (sample size = 310,532), we calculated the time series of the SSR. The quarterly economic conditions of the studied population within the period under consideration constituted the time series of the percentage change in private consumption at constant prices of the year 2000. The relationship between the SSR and the economic conditions in the analyzed 47 quarters of the year was tested with the use of the ARMA models. We have found that four quarters (one year) after the occurrence of economic stress there was a decline in the SSR. This result is consistent with the Trivers–Willard hypothesis at the population level in a modern free-trade economy of a post-communist country.

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Introduction

Humans react to environmental conditions using their evolutionarily developed adaptive mechanisms that produce population-level phenomena. Environmental stress may include both a deficiency of nutrients essential for growth and development, and strong emotional or social stress which may also disturb physiological processes (e.g. Fukuda et al., 1998; Catalano et al., 1999, 2005; Zorn et al., 2002; McClure et al., 2009; Leslie and Pawloski, 2009).

Widely known physiological stress indicators in humans are for instance: fluctuating asymmetry, enamel hypoplasia, Harris lines in the long bones or height deficiency. All of the above are observed in already formed morphological structures. In recent years, however, increasing attention has been paid to one of the first indicators of potential environmental stress which may modify the population structure, i.e. changes in the *secondary sex ratio* (SSR). Most frequently, SSR is expressed as a quotient of live male births to live female births (male proportion). In modern human populations, it is usually remarkably constant (ca. 0.515) with 105–107 male births for every 100 female births (Martuzzi et al., 2001; Hesketh and Wei Xing, 2006; Kemkes, 2006; Davis et al., 2007; Żądzińska et al., 2007). The higher number of live male births constitutes a biologically founded, and evolutionarily shaped, counter-strategy of the human species against male over-mortality during the period of parental investment (first twenty years or so, Hassold et al., 1983; Byrne and Warburton, 1987).

The environmental stress factors responsible for a decline in the SSR include: parents' exposure to chemical pollutants such as dioxins, TCDD (Mocarelli et al., 2000; Jongbloet et al., 2002; Ryan et al., 2002), pesticides (Vartiainen et al., 1999; Figa-Talamanca et al., 2003), exhaust fumes (Pergament et al., 2002), radioactive substances (Peterka et al., 2004); mothers' heavy tobacco smoking (Dougherty and Jones, 1982; Kornafel, 1995; Żądzińska, 2003); stresses brought about by natural phenomena such as floods (Catalano, 2003) or earthquakes (Fukuda et al., 1996; Fukuda et al., 1998); wars (Graffelman and Hoekstra, 2000; Jongbloet et al., 2001; Zorn et al., 2002; Kemkes, 2006), terrorist attacks (Catalano et al., 2005, 2006), and socio-economic crises (Catalano, 2003; Catalano and Bruckner, 2005; Jongbloet et al., 2001), although there are some papers which present contradicting evidence for the association between economic stress and a lower sex ratio (Helle et al., 2009).

According to the Trivers and Willard (1973) hypothesis, natural selection should favor mothers that produce sons under favorable conditions and daughters in unfavorable, stressful environments. It is assumed that a lower consumption of goods and services than required can finally result in economic stress, which in consequence results in a reduction of the secondary sex ratio. Such an assumption implies that the monitored secondary sex ratio among live newborns will decrease (as a result of a decrease of male births and/or an increase in the number of girls being born) when the population consumes less goods and services than it should according to its needs. Although the described relationship is well documented (large cohorts, long periods) for a few human populations living in Europe (Catalano, 2003; Catalano and Bruckner, 2005), it was not confirmed in the time series analysis of SSR fluctuations for the large long-term Polish data covering almost the last 50 years (1956–2005) (Żądzińska et al., 2007). This period in Poland includes at least three different types of economy: the years of the centrally planned communist economy with the crisis of the eighties (1956–1988), economy based on the free market (1994–2005) and the period of political and economic transformation (1989–1993) between them (Krakowińska, 2007).

There are a few studies (e.g. Bielicki and Szklarska, 1999; Kozieł et al., 2004; Kołodziej et al., 2007; Lipowicz et al., 2007) which also confirm that the period of political transformation in Central and Eastern Europe brought about changes in the causal relationships between the SES (*socio-economic status*) and selected biological features of human populations (e.g. body mass, body height, health status or mortality rate).

The political and economic transformation in Poland started in 1989, and therefore the assessment of the relationship between the fluctuations in the Polish secondary sex ratio (as a biological population parameter) and the socio-economic conditions (population stressors) should be made separately for two periods: the communist era between 1945 and 1989 and the beginnings of post-communist, free-trade economy between 1990 and 2008.

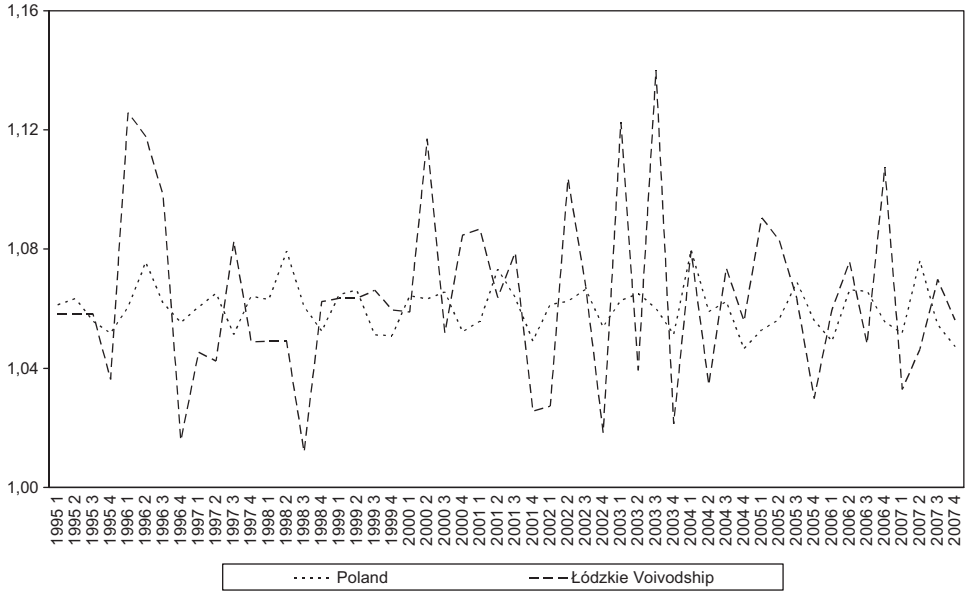

Fig. 1. The quarterly changes in the M/F ratio in the studied area against comparable data for the whole country.

Here we attempt to evaluate the significance of the impact of the economic conditions after the period of socio-economic transformation, measured by the consumption in year quarters, on the secondary sex ratio in central Poland.

Materials and methods

Statistical material and preparation of data for analysis

We used quarterly data about the total number of live male (M) and live female (F) newborns born between 1995 and 2007 in the Łódzkie Voivodship (the number of births per 1000 inhabitants: 10.2 in 1995 and 9.3 in 2007) (source: Demographic Yearbooks of the Central Statistical Office (GUS), population balance sheets of the Łódź Statistical Office). In terms of rural areas (93.8%) and the share of population living in these areas (35.4%), the Łódzkie Voivodship does not deviate from the national average (93.2% and 38.6% respectively), according to the National Official Register of Territorial Division of the Country—TERYT classification (GUS, 2006). The demographic situation of the Voivodship is definitely and largely influenced by population changes in the city of Łódź, which holds over 30% of the total population of the Voivodship and 45.7% of the urban population (Obraniak, 2007, 2008). The selected time frame includes the period of market economy stabilized after the economic and political transformation that took place in Poland in the very late 1980s and the early 1990s.

On the basis of the data gathered, time series for the values of the secondary sex ratio were calculated as the proportion of live male (M) to live female (F) births—M/F. Fig. 1 presents quarterly changes in the M/F ratio in the studied area against comparable data for the whole country.

To assess the economic conditions of the population within the analyzed period, we used the values of quarterly private consumption in the Łódzkie Voivodship. For further statistical analysis (models), quarterly time series for the percentage change in the value of private consumption (relative increase in the consumption value $\Delta C/C$) expressed in constant prices of the year 2000 were chosen as variables describing the economic conditions of the population of the studied environment. Fig. 2 presents the quarterly private consumption increases estimated for the examined period in the Łódzkie Voivodship against the whole of Poland.

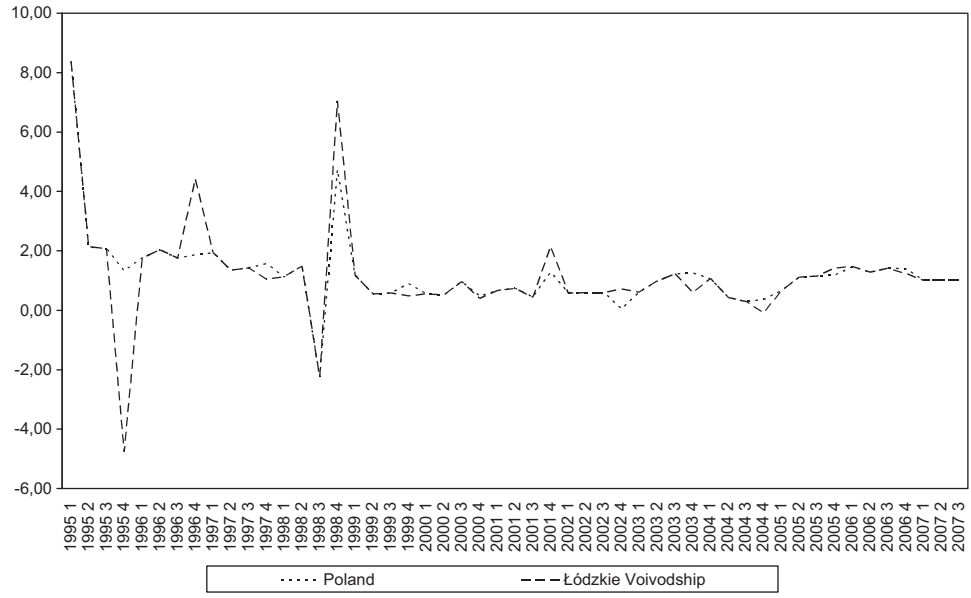

Fig. 2. The quarterly private consumption increases estimated for the examined period in the Łódzkie Voivodship against the whole of Poland.

Outline of the applied method of statistical analysis

For the statistical modeling we used the method suggested by Catalano and Bruckner (2005). If the consumption of goods and services is lower than needed (below expectations), economic stress appears, and this should result in a secondary sex ratio decline. This implies that the observed SSR should decrease (as a result of the falling number of live male births and/or the growing number of live female births) when the consumption of goods and services by a population is lower than its potential needs.

In the statistical procedure employed, the null hypothesis (H_0) that has been formulated implies that there is no increase of the secondary sex ratio when economic conditions (private consumption) improve whereas the alternative hypothesis (H_1) says that the SSR increases when the economy improves.

In the first stage, having identified and analyzed the stationarity of the series $\Delta C/C$ with the augmented Dickey–Fuller test (ADF), and following the approach proposed by Box and Jenkins (1983), a model was constructed by the use of the autoregressive process (AR), the moving average process (MA) or the autoregressive moving average processes (ARMA), which would provide a statistically significant explanation of $\Delta C/C$ consumption changes.

Next, from the $\Delta C/C$ model, residuals ($e\Delta C/C$) were calculated, which constitute the unexplained part of consumption variation (i.e. uncorrelated differences between the theoretical values calculated from the constructed model and the empirical values).

At the subsequent stage, after the identification and analysis of the M/F time series stationarity, by means of AR or MA processes or of the mixed approach (ARMA), a model describing the M/F ratio value was created. Furthermore, the $e\Delta C/C$ residuals obtained from the consumption model were used as an additional dependent variable. Thus, a model was acquired which explains the variation in the SSR on the basis of private consumption fluctuations.

In the final step of the analysis, an assessment of the parameter values obtained for the M/F model was carried out with the objective to reject the null (H_0) hypothesis in favor of the alternative one (H_1), which indicates the existence of the effect of economic stress.

Table 1
AR(2) estimation using 51 observations (1995.2–2007.4). Dependent variable: $\Delta C/C$.

Variable	Coefficient	Standard error	*t*-Statistics	*p*-Value
Const	1.1632	0.2445	4.7578	<0.00001
$\Delta C/C(1)$	0.4423	0.1308	3.3820	0.00072
$\Delta C/C(2)$	0.3549	0.1358	2.6132	0.00897
ZJ_1996_1	−6.7524	0.3335	−20.2488	<0.00001
ZJ_1995_2	6.4637	0.3987	16.2136	<0.00001
ZJ_1999_1	5.9649	0.3405	17.5164	<0.00001
ZJ_1997_1	2.6795	0.3317	8.0774	<0.00001
ZJ_1998_4	−3.4598	0.3398	−10.1822	<0.00001

Mean of the dependent variable = 1.1861; standard deviation of the dependent variable = 1.7784; average of random disturbances = −0.0221; variance of random disturbances = 0.1438; log-likelihood = −23.36; Akaike Information Criterion (AIC) = 64.73; Schwarz Bayesian Criterion (BIC) = 82.11; Hannan-Quinn Information Criterion (HQC) = 71.37.
Dependent variable $\Delta C/C$ – relative consumption value rate (percentage rate of the consumption value in constant prices of the year 2000); $\Delta C/C(1)$, $\Delta C/C(2)$ – two autoregressive parameters of the consumption equation, relative consumption value rate with one-quarter and two-quarter lags, respectively; ZJ_ – dummy variables to explain atypical values in the time series and to increase model fit (coefficient of determination).

The rejection of the H_0 hypothesis is carried out on the basis of the evaluation of the average value, the standard deviation (model stability), and the sign of the parameter (positive/negative) estimated with the $e\Delta C/C$ variable of the M/F model (occurrence of a causal relationship). If the value of the estimated parameter is two times higher than its standard deviation, it means that the solution is stable. A positive $e\Delta C/C$ parameter is interpreted as a relation described in the following way: "an increase in consumption brings about an increase in the M/F ratio", and the result is correct. Consequently, one may reject the null hypothesis in favor of the alternative one, which states that economic factors do impact the SSR, and the result is deemed statistically significant. If the $e\Delta C/C$ parameter is negative, the relation is interpreted in the following manner: "an increase in consumption brings about a decrease in the M/F ratio", and the result indicates that there is no reason to reject the null hypothesis proposing the lack of a causal relationship between economic stress and the SSR. If the estimate of the $e\Delta C/C$ parameter is less than two times higher than the standard deviation, the solution is regarded as unstable, statistically insignificant.

In addition, the final M/F model may be transformed so that the variable M (number of live male births) is the dependent one, with the F variable (number of live female births) as the explanatory one, and with the other explanatory variables of the model unchanged. Given the average (expected) value of consumption increase, the re-estimation of the parameters of an "identical" model (perhaps without a constant term) makes it possible to estimate the number of live male births (M) induced by the good socio-economic situation of the parents (i.e. an increase in consumption above expectations) in the analyzed period.

Estimations of the parameters of particular models were conducted using the statistical program GRETL 1.6.0 (Kufel, 2004)—licensed by GNU, http://www.kufel.torun.pl.

Results

The M/F and $\Delta C/C$ time series were stationary (ADF test). On the basis of the total and partial autocorrelation functions (ACF and PACF, respectively) as well as the Ljung–Box correlation test, parameters for the $\Delta C/C$ model were identified (Table 1).

The parameters of the $\Delta C/C$ model (Table 1) were identified by means of the total (ACF) and partial (PACF) autocorrelation functions as well as the Ljung–Box correlation test. After the residual of $e\Delta C/C$ was calculated on the basis of the consumption model, it was included as an explanatory variable in the M/F equation, and then the model parameters were identified for the M/F series of the SSR (Table 2).

The assessment of the parameter with the $e\Delta C/C(4)$, i.e. residuals from the consumption model (with a four-quarter lag), showed both the stability and the significance of the constructed model. The value of the parameter (0.0229) was nearly 2.9 times higher than its standard deviation (0.0080). This

Table 2
ARMA(2,2) estimation using 47 observations (1996.2–2007.4). Dependent variable: M/F.

Variable	Coefficient	Standard error	*t*-Statistics	*p*-Value
Const	1.0607	0.0032	329.2125	<0.00001
M/F(1)	−1.8076	0.1246	−14.5040	<0.00001
M/F(2)	−0.8693	0.1217	−7.1446	<0.00001
MA(1)	1.8917	0.1049	18.0286	<0.00001
MA(2)	1.0000	0.1051	9.5168	<0.00001
e$\Delta C/C(4)$	0.0229	0.0080	2.8568	0.00428
ZJ_2003_3	0.0792	0.0230	3.4397	0.00058
ZJ_2002_2	0.0629	0.0215	2.9265	0.00343
ZJ_1996_4	−0.0497	0.0213	−2.3303	0.01979
ZJ_2000_2	0.0524	0.0207	2.5347	0.01125

Mean of the dependent variable = 1.0636; standard deviation of the dependent variable = 0.0296; average of random disturbances = −0.00001; variance of random disturbances = 0.0004; log-likelihood = 115.53; Akaike Information Criterion (AIC) = −209.06; Schwarz Bayesian Criterion (BIC) = −188.71; Hannan-Quinn Information Criterion (HQC) = −201.40.
Dependent variable M/F – values of secondary sex ratio; M/F(1), M/F(2) – two autoregressive parameters of the M/F equation with one-quarter and two-quarter lags, respectively; MA(1), MA(2) – two parameters of the moving average, the estimated random term of the M/F equation with one-quarter and two-quarter lags, respectively; ZJ_ – dummy variables to explain atypical values in the time series and to increase model fit (coefficient of determination); e$\Delta C/C(4)$ – residuals from the consumption model with one-year lag (four-quarter lag).

Table 3
ARMA(2,2) estimation using 47 observations (1996.2–2007.4). Dependent variable: male births.

Variable	Coefficient	Standard error	*t*-Statistics	*p*-Value
M(1)	−1.8368	0.1189	−15.4507	<0.00001
M(2)	−0.9012	0.1142	−7.8891	<0.00001
MA(1)	1.9072	0.1165	16.3731	<0.00001
MA(2)	1.0000	0.1170	8.5450	<0.00001
e$\Delta C/C(4)$	70.5987	24.0943	2.9301	0.00339
ZJ_2003_3	240.423	69.3248	3.4681	0.00052
ZJ_2002_2	135.133	66.4094	2.0348	0.04187
ZJ_1996_4	−141.495	61.3609	−2.3059	0.02111
ZJ_2000_2	157.143	61.8969	2.5388	0.01112
F	1.0609	0.0032	326.8849	<0.00001

Mean of the dependent variable = 3031.06; standard deviation of the dependent variable = 254.94; average of random disturbances = −0.0777; variance of random disturbances = 3401.90; log-likelihood = −259.00; Akaike Information Criterion (AIC) = 540.00; Schwarz Bayesian Criterion (BIC) = 560.35; Hannan-Quinn Information Criterion (HQC) = 547.66.
Dependent variable M – number of live male births; M(1), M(2) – two autoregressive parameters of the M equation with one-quarter and two-quarter lags, respectively; MA(1), MA(2) – two parameters of the moving average, the estimated random term of the M equation with one-quarter and two-quarter lags, respectively; ZJ_ – dummy variables to explain atypical values in the time series and to increase model fit (coefficient of determination); e$\Delta C/C(4)$ – residuals from the consumption model with one-year lag (four-quarter lag); F – number of live male births.

result means that there is a relationship between the economic factor and the secondary sex ratio. The positive value of the estimated parameter indicates that a decrease in consumption results in an SSR decline with a one-year lag.

The next step was to convert the original equation, which included the division of the M/F variable into an independent variable, i.e. the number of live female births (F), and a dependent variable representing the number of live male births (M) (Table 3). As with the Catalano and Bruckner (2005) method, the transformation of the equation made it possible to estimate the number of male newborns whose birth was the result of a "favorable socio-economic situation" (i.e. they were born in a period without economic stress).

Our results indicate that an increase in individual consumption by 1% over its expected level (an average quarterly increase in this respect amounted to 1.1632, Table 1) resulted in an average quarterly increase in the number of live male births vs. live female births by 70–71. In the entire studied period, there was a 14.8-basis-point increase over the expected consumption level in the studied population.

This means that such an improvement of the socio-economic conditions resulted in 1050 boys being born over the expected number of live male births.

We also conducted the same analysis for the city of Łódź, thus only for the urban population, and the results were similar (a decrease in consumption results in a SSR decline with a four-quarter lag). This means that the results that we have obtained for the entire region could not have been driven by the rural population only.

Discussion

Our results indicate that within the studied period, there was a positive relationship between economic growth in post-communist Poland and the increase observed in the secondary sex ratio, which may support the hypothesis that natural selection should favor mothers that produce sons under favorable conditions and daughters in an unfavorable, stressful environment (Trivers and Willard, 1973). This also confirms the results obtained by the authors who studied the influence of economic stress on the SSR in a longer period in European countries, based on, e.g. 163 annual birth cohorts in Sweden, 79 in Denmark and 72 in England and Wales (Bruckner and Catalano, 2007). It is interesting that Żądzińska et al. (2007), who studied the whole Polish population in a longer period (1956–2005; 50 annual birth cohorts), did not find a relationship between consumption rate and SSR fluctuations. Helle et al. (2009), who studied the effect of economic stress on the sex ratio in Finland in 1865–2003, also found no evidence to confirm the relationship between economic crises and an SSR decline. This result was explained by Zilko (2010), who assessed the quantity, validity and consistency of empirical evidence supporting the hypothesized connection between economic contraction and alterations of the secondary sex ratio. He argued that the inconsistency of the published results in this field might exist because some authors estimated the total effect of measures of economic contraction on the sex ratio (Catalano, 2003; Catalano et al., 2005, 2006), whereas others estimated the direct effect, controlling for several factors that might be on the casual pathway, such as famine or mortality" (Helle et al., 2009, p. 11).

For the Polish population, the lack of support for the hypothesis that economic stress is associated with a lower secondary sex ratio demonstrated in the study based on the ARIMA decomposition method (Żądzińska et al., 2007) could also be explained by an additional factor which was not considered by Zilko (2010)—the diversity of the analyzed period, which includes at least three different types of economy: centrally planned communist economy (1956–1988), free-market economy (1994–2005) and the period of political and economic transformation (1989–1993) between them. It is also possible to use this explanation for other populations living in the post-communist countries.

In literature, there is only one other publication based on a birth cohort from another communist country – East Germany (Catalano, 2003), but in this publication, the author did not analyze the interrelation between the time series of the two variables (the value of annual consumption and the sex ratio), but he examined only one variable – the secondary sex ratio in East Germany during the economic collapse of 1991 – and found that it was 1.5% lower than the expected value of 1.059 based on history and on the West German sex ratio in the same period.

According to economists of the former centrally planned communist economies (1945–1989), such factors as consumption rate could not adequately represent the real household budgets and the economic situation in Poland and in other communist countries (not to mention the fact that they were manipulated or even counterfeited by the communist party governing the country at that time) (Krakowińska, 2007).

We therefore suggest that under the political and economic conditions characteristic for the communist countries (as in Poland between 1945 and 1989), the indices of consumption rates are not reliable enough (if true at all) to reveal the subtle effect of the influence of the relatively small fluctuations of economic conditions on SSR changes at the population level. It is also possible that such a relationship can be detected only in the period of free-trade economy.

There seems to be no reason to seek the explanation for different relationships between economic stress and the secondary sex ratio only in a disparate distribution of variables characterizing the prenatal environment of children born in Western and Eastern Europe. In Poland between 1985 and 2006, the analysis of distribution of variables modifying the prenatal environment (and subsequently pos-

sibly influencing the sex of offspring) only confirmed important changes in maternal age distribution (observed in all European populations). According to demographic data collected for the biggest Polish cities, the highest fertility rate, which was still characteristic of women under 25 years of age in the 1970s, in the 1980s and at the beginning of the 1990s, has been gradually moving up the age scale (Obraniak, 2007).

In Łódź in 1993, the most numerous group of patients of maternity clinics was constituted by mothers ≤25 years of age (52%, now 34%), and ten years later (in 2003) by women 26–30 years of age (an increase from 28% to 41%). The proportion of mothers >30 years of age also increased (from 20% to 25%). At the same time, no significant changes in the number of women with a particular parity were observed (Rosset, 2008).

According to our results, there was a four-quarter lag between a consumption decline and an SSR decrease, i.e. a decrease in consumption being associated with later SSR was measured 3 months before the time of conception. Cameron (2004) performed a meta-analysis on previous studies, investigating sex ratios in all mammalian taxa (except humans) to determine if studies that measured condition near the time of conception showed more support for the Trivers–Willard hypothesis than studies using condition measured at other times of the reproductive cycles. Her analysis suggests that SSR adjustment occurs at near implantation (the results were most robust and reliable if the variable being associated with later SSR was measured at the time of conception). On the basis of our set of data, we are unable to suggest the precise mechanism of this one-year lag. Possible mechanisms that can be considered are the following:

(1) James (1999) and Lazarus (2002) suggested that the frequency and the timing of sexual intercourses within the menstrual cycle could influence the primary, and in consequence also the secondary, sex ratio. It is then possible that a deterioration of the economy of households can cause either a decline in sexual activity or changes in the distribution of this activity within the cycle. This mechanism would, however, work with some delay (ca. 3 months after the consumption rate decrease).
(2) Depleted energy and other depleted resources important for the pregnancy (and/or some stress) can cause a deterioration of women's biological condition and an increase of the risk of miscarriages of the more eco-sensitive, i.e. fragile, male fetuses. In that case, the biological effect (SSR) of a disruption of the economy would also take place after more than 3 months (Catalano and Bruckner, 2005). Since most miscarriages take place in the first trimester (Boklage, 2005), the delay could be between 3 and 6 months. It is, however, also possible that this delay is longer than 6 months. As some authors indicate (Owen and Matthews, 2003), the second peak of miscarriages is predominantly related to spontaneous abortion of male fetuses that takes place between the 16th and the 20th week of pregnancy.

The biological mechanism influencing the SSR can be different after a dramatic event or a shock (e.g. a war, a great economic crisis), and yet different after only mild economic changes (such as the changes considered in the present paper). This can be the reason why, contrary to our results, Catalano et al. (2006) detected a drop in the SSR only 3–5 months after a shock to the population. In such shock cases, one can postulate the selective male fetal loss and therefore the mechanism suggested above in hypothesis 2.

Another interesting question is why despite the increasing economic trend for the whole post-war period (also including the majority of the period studied here), there was in fact a decline in the SSR in Poland (Żądzińska et al., 2007). Furthermore, this decline appeared to be much stronger in rural than in urban environments. This decline is, however, not only specific for the Polish population. The SSR recently declined in many Western countries irrespective of social class (Catalano, 2003; Catalano and Bruckner, 2005) and in Japan (Davis et al., 2007).

The contradictory results between temporary SSR increases under better economic conditions for the studied population and the generally declining SSR in many countries despite the economy increase in the previous years (before the 2008 crisis) can be explained by factors influencing this almost worldwide decrease in the SSR different from the consumption rate changes. It is possible that it is the increase of environmental contamination (Mocarelli et al., 2000; Pergament et al., 2002; Ryan et al.,

2002;) and changes in sexual habits, e.g. longer birth intervals, coital activity, maternal age (Brewis, 1993) that are potential factors responsible for the worldwide decline in the SSR. The fact that we observe a decline in the SSR in many countries in spite of an increasing consumption rate indicates that at the population level, the factors related to the SSR decline are stronger than the economic prosperity (measured here by the consumption rate).

It is worth noting that there are known reactions of the Polish population to economic stress depending on political conditions which "create" specific living conditions (e.g. Bielicki and Szklarska, 1999; Szklarska et al., 2007). Increased social stratification at the onset of free-trade economy that was established in the early nineties in Poland can be observed for instance in the distribution of deficiency and excess in body mass in children and adults (Kozieł et al., 2004). It is also exemplified by the distribution of the mortality of adults (Kołodziej et al., 2007; Lipowicz et al., 2007). Social stratification is accompanied by new kinds of environmental stresses which may have an impact on many biological factors. Pregnant women, for instance, quote job loss (theirs or their partners') as a stressful experience which may result in the decreased body weight of a newborn (Catalano et al., 1999). This factor has also proved a significant explanatory variable in a model which characterizes the relation between the level of fluctuating cephalometric structure asymmetry in male children and external environmental factors (Żądzińska, 2003).

To sum up, the secondary sex ratio decrease with a one-year lag after a private consumption rate decrease proves the potential of applying SSR fluctuations as an economic stress indicator at the population level. In addition, the results obtained seem to confirm the rule that the reactions of human populations to stressogenic factors may vary depending on the political system.

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