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A Multivariate Analysis of Socio-demographic Factors Associated with Sex Ratio at Birth among Natives and Immigrants in Greece, Based on Vital Registration Microdata

Authors: Georgia Verropoulou and Cleon Tsimbos

Affiliations: Dept of Statistics & Insurance Science University of Piraeus (Verropoulou); Dept of Statistics & Insurance Science University of Piraeus (Tsimbos)

Corresponding author/address: Cleon Tsimbos, Dept of Statistics & Insurance Science, University of Piraeus, 80, Karaoli & Dimitriou str., Greece; Email: cleon@unipi.gr

Abstract

This study uses restricted access micro-level information on 112,042 single live births registered for 2006 in Greece to assess effects of socio-demographic factors and ethnicity on the propensity to have a male birth, using logistic regression models. The sex ratio at birth in Greece is 106.3, but it is higher for immigrants (110.9) compared to natives (105.4). Odds ratios indicate that associations of maternal age and birth order with the sex of the newborn are strong. These variables are interdependent and relationships are non-linear and complex; hence, they become evident only once interactions are added in the models. Birth order has an independent effect but also affects the estimates through maternal age. Effects of ethnicity (Greek/Foreign citizenship) remain substantial throughout the analysis irrespective of other controls. Being an immigrant mother is significantly related to higher chances of a male birth. Maternal occupation and educational attainment have a strong positive effect on the chances of having a male birth among Greek women, while education has the opposite effect for immigrant mothers, though associations are tenuous.

Keywords

Sex ratio at birth, demographic characteristics, socio-economic status, occupation, Greece, education, immigrants

1. Introduction

The secondary sex ratio, defined as the number of male divided by female live births and referred to as the sex ratio at birth (SRB), is an important demographic component of a population. It determines, up to a point, the overall sex ratio, affecting reproduction through the number of potential mothers (Teitelbaum 1972) and the time needed for a population to double its size (Markle 1974). The SRB has usually the value of around 105 male to 100 female live births, but it varies across populations and may change over time (Allan et al. 1997; Chahnazarian 1988; Dubuc & Coleman 2007; Garenne 2008; James 1987; Teitelbaum 1972). It is considered a sensitive indicator of environmental conditions and of the reproductive health of humans, since it may be affected by certain chemicals, toxins and pollutants (Lloyd et al. 1984; Lloyd et al. 1985; Mackenzie et al. 2005; Van Larebeke et al. 2008; Whorton et al. 1994). In several instances, however, such effects seem negligible (Dodds & Armson 1997) or the evidence is inconclusive and other explanations may be forthcoming (Davis et al. 1998; James 1998; Vartiainen et al. 1999; Williams et al. 1995). Occupational exposure of father to reproductive hazards has also been linked to an imbalance in the SRB in several cases (Grant & Metcalf 2003; James 2004), though other analyses have found no association (Dickinson & Parker 1997).

The observed variability of the SRB may be related to differences in the sex ratio at conception (primary sex ratio) and to differential sex-specific fetal loss (Markle 1974; Tremblay et al. 2003). Measurement of factors directly affecting the primary sex ratio, however, is tricky and research often relies upon indirect evidence associated with underlying biological mechanisms. Several studies have shown that parental age and birth order are associated with the SRB. More specifically, increasing birth order and higher maternal age seem associated with a decrease in the proportion of male births (Chahnazarian 1988; Erickson 1976; Jacobsen, Møller & Mouritsen 1999; Mathews & Hamilton 2005; Teitelbaum 1972). It has been argued that these effects may be attributable to levels of female gonadotrophin which rise with age of mother, and also, independently, with increasing birth order. Analyses attempting to unravel the relative contribution of these factors indicate significant independent negative effects in most instances (Rostron & James, 1977). Erickson (1976), Garfinkel and Selvin (1976) and Teitelbaum et al. (1971) find a significant linear association with birth order. James and Rostron (1985) additionally detect significant non-linear effects of maternal age on the SRB while analysis of Japanese data revealed interaction effects regarding parental age and birth order (Imaizumi & Murata, 1979).

Another important correlate of the SRB is socio-economic status (SES), albeit rarely considered in such analyses due to the difficulty of finding reliable indicators in vital registration data. It has been suggested that SES, in its own right or in conjunction with psychological factors, may play a part in determining the gender of a birth by influencing hormone levels around the time of the conception (Grant 1996, 2003, 2007; James 1987, 1996, 2004). Results of past research, however, are often ambiguous, based on small sample surveys while other factors affecting SRB (i.e. birth order, etc.) are not controlled for (Teitelbaum 1972). Moreover, most analyses consider paternal characteristics. Teitelbaum and Mantel (1971) using a multidimensional index of SES found a non-linear positive relationship with SRB; proportion of male births increased substantially from low to middle levels of social status but not thereafter. Chahnazarian (1988) also suggests that parents in higher socio-economic classes are more likely to have sons. Rostron and James (1977), on the other hand, using the husband's occupation, do not find any effect. Similarly, Erickson (1976) does not find any significant association of SRB with paternal education when controlling for parental ages and birth order. Regarding maternal characteristics Almond and Edlund (2007) find a higher proportion of male births among better educated women.

Finally, an important source of differentiation in the proportions of male offspring seems related to race and ethnic origin. Studies of the US population have shown that black

American mothers have consistently a lower sex ratio at birth compared to white Americans, while the ratio seems slightly higher in Asian populations (Dubuc & Coleman 2007; Erikson 1976; Garenne 2002; James 1984, 1985; Mathews & Hamilton 2005; Teitelbaum & Mantel 1971). Substantial differentials between populations of the same race have also been observed. For instance, SRB ranges from about 100 to 107 among African populations (Garenne, 2002). Such variability has been attributed to hormonal and physiological differences but also, in some occasions, in the practice of sex-selective abortion in countries such as China and India (Dubuc & Coleman, 2007).

The present study employs data at individual level, on the live births recorded by the vital registration system of Greece for 2006, to address three main research questions: First, using multivariate analysis, what are the associations among gender of the newborn, maternal age and birth order? Second, controlling for these confounders, what are the possible relationships with the socio-economic status of the mother? Third, are there any differentials between natives and immigrants in Greece? This is the first time that such an analysis, based on nation-wide micro-level data and a wide range of covariates, is undertaken for Greece.

2. Data and Methods

2.1 Data

The data used in the study are based on the 112,042 live births recorded by the national vital registration system of Greece for 2006. Multiple births, which represent 4.6% of the total, have been excluded from the multivariate part of the analysis, as it has been shown that SRB is lower than for single births (Jacobsen et al. 1999). Hence, regression models are based on 106,527 records of single live births to women resident in Greece. Of this number, 87,816 (82.4%) are births to native mothers while 18,711 (17.6%) are births to immigrant women.

For administrative and legislative purposes, immigrants in Greece are identified by citizenship (Hellenic Migration Policy Institute 2007; Ministry of the Interior 2007), a criterion used also by the National Statistical Service of Greece (NSSG). The present study employs this definition, too. The available information is at micro-level and includes live birth order and sex of the newborn, maternal age at birth in single years as well as educational qualifications, occupation, place of usual residence and citizenship of mother. Birth registration in Greece is complete and since the vast majority of births (99.9%) for native and immigrant women occur in maternity wards and hospitals, the information collected is considered reliable.

2.2 Measures

In the regression models maternal age is represented by a three-category variable, distinguishing between women aged below 25, those aged 25-34 and those aged 35 or more. In the analysis the youngest age group is considered as reference category. Live birth order ranges from 1 to 16 while immigrant status is indicated by a dummy showing whether the mother is a foreign (=1) or a Greek citizen (=0).

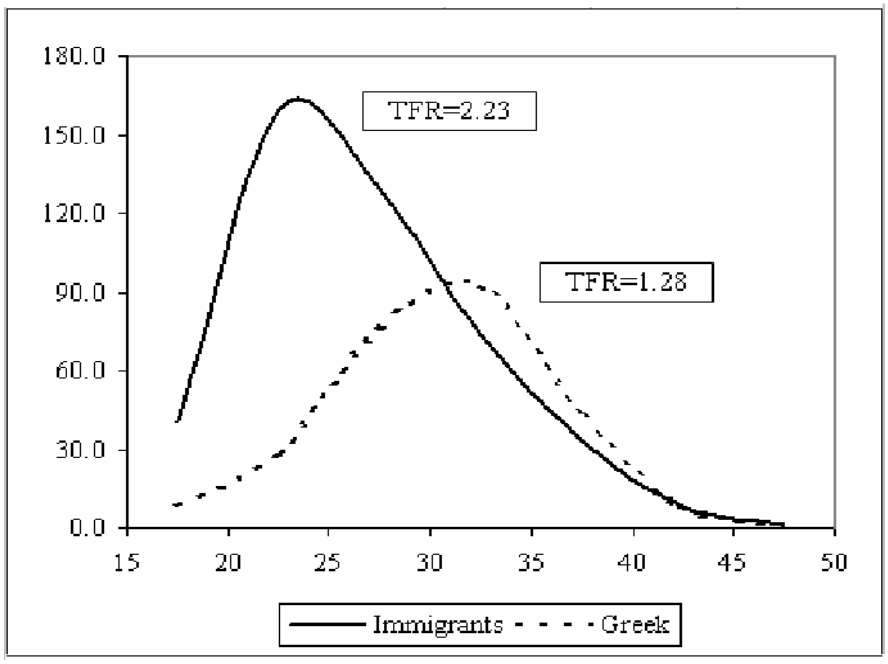
Socio-economic status (SES) is represented by educational attainment and occupation. Educational level is based on the highest qualification attained; a four-category variable was constructed denoting whether the mother had at the most completed primary (6 years of schooling), lower secondary (9 years), upper secondary (12 years) or tertiary education (at least 13 years of schooling). A binary variant of that variable is also used in the analysis for foreign women, distinguishing between primary schooling and all other categories. Occupation is based on the Greek census classification ISCO-88 codes (Elias & Birch, 1994); these were grouped initially into three categories, one including all economically inactive women, mostly housewives, another including women with high occupational profile

(managerial and professional occupations) and a third including all other occupations. However, housewives and women with middle and low occupational profiles were eventually grouped together since, in exploratory analysis, no significant differences were found. Additionally, a very high proportion of immigrant women (82.7%) were reported as housewives which seems suspect and may be partly attributable to these women working as domestic servants or being in informal/illegal employment.

2.3 Statistical Analysis

Apart from the descriptive part of the analysis, where levels of SRB by different characteristics of the mother are examined, logistic regression models are employed to assess the odds of a male over a female birth, controlling for various factors. This is the most appropriate method as the dependent variable is binary (Ruder 1985), the sex of the newborn, taking the value of 1 if that is a boy and 0 otherwise. To explore associations with maternal age and birth order further, and to appraise their nature, interaction effects are also included in the models while predicted odds ratios of having a male birth are produced to better illustrate the combined effects of these factors. To contrast effects of socio-economic indicators, certain models were run separately for immigrant and Greek mothers. All models, apart from those estimated exclusively for foreign women, disregard births to mothers under age 20 (3.1% of the total) as educational attainment usually extends beyond that age among better educated women; such a cut-off point has been used before in similar analyses (Acevedo-Garcia et al. 2007; NCHS 2005). A further justification is provided by the shape of the age-specific fertility rates for foreign and Greek mothers (Figure 1).based on the live births registered in 2006 and population estimates obtained for that year (Tsimbos 2008a; 2008b). It is evident that fertility under age 20 is trivial for Greeks while it is quite substantial for immigrants.

Figure 1 Estimated age-specific and total fertility rates for Greek and immigrant mothers: Greece 2006



The overall goodness of fit of the logistic regression models is assessed on the basis of the Hosmer-Lemeshow Chi-square test (Hosmer & Lemeshow 2000), which produces robust and

reliable results in large samples (Hosmer et al. 1997) and the log-likelihood statistic. The models have been estimated using STATA 10.0.

3. Results

3.1 Descriptive Analysis

Sex ratios at birth, mean age of mother and mean birth order by citizenship of mother for legitimate, illegitimate, multiple and single births are presented in Table 1. The SRB stands at 106.3 for the overall population of Greece in 2006; the ratio is somewhat lower among Greeks (105.4) while it is substantially higher among immigrants (110.9). SRB is fairly high

Table 1 Sex ratio at birth, mean age of mother and mean birth order for legitimate, illegitimate, multiple and single births by citizenship of mother.

All live births	Male	Female	Both sexes	SRB	Mean age of mother	Mean birth order
Total	57739	54303	112042	106.3	29.80	1.73
Greek	47512	45078	92590	105.4	30.37	1.74
Immigrant	10227	9225	19452	110.9	27.08	1.66
Albanian	6208	5667	11875	109.5	25.90	1.65
Romanian	554	547	1101	101.3	27.75	1.58
Bulgarian	545	492	1037	110.8	27.22	1.73
Ukrainan	264	239	503	110.5	30.37	1.62
Russian	263	234	497	112.4	29.12	1.63
EU (excl. Greece)	636	604	1240	105.3	31.88	1.74
Asia	698	541	1239	129.0	28.53	1.73
Africa	279	258	537	108.1	28.58	1.87
Legitimate						
Total	54659	51469	106128	106.2	29.99	1.72
Greek	45542	43177	88719	105.5	30.56	1.73
Immigrant	9117	8291	17409	110.0	27.09	1.68
Illegitimate						
Total	3080	2834	5914	108.7	26.44	1.75
Greek	1970	1901	3871	103.6	26.14	1.89
Immigrant	1110	934	2043	118.8	27.00	1.48
Single						
Total	55169	51753	106922	106.6	29.68	1.69
Greek	45198	42756	87954	105.7	30.26	1.70
Immigrant	9971	8997	18968	110.8	27.00	1.64
Multiple						
Total	2570	2550	5120	100.8	32.28	2.44
Greek	2314	2322	4636	99.7	32.46	2.43
Immigrant	256	228	484	112.3	30.48	2.50

among most Eastern European populations, with the exception of Romanians, while it is exceptionally high (129.0) among mothers from Asia. The relevant numbers, however, are rather small. Mean age of Greek mothers (30.4 years) is higher by about 3 years compared to immigrants (27.1 years). Considering the different citizenships, Albanian mothers are the youngest (25.9 years) while women from other EU countries (Central, Western, Southern and Northern Europe) are the oldest (31.9 years). Mean birth order is slightly lower for immigrants on average (1.66) compared to the natives (1.74), though it is somewhat higher among African mothers (1.87).

Comparing births outside the wedlock to legitimate births, Greek married women have more male offspring than single women while the reverse is true regarding immigrants. Nevertheless, numbers of illegitimate births are very small, corresponding to 5.3% of the total (4.2% for natives and 11.7% for immigrants). Greek unmarried mothers are 4 years younger compared to their married counterparts while the figures for immigrants are virtually identical. The SRB for multiple births is much lower for Greeks (99.7) in comparison to single births, a fact in accordance with the literature (Jacobsen 1999). Mean age of mother in that group is higher by about 2 years for Greek mothers and 2.5 years for foreigners. This is consistent with the notion that a high proportion of multiple births is due to infertility treatment, which is more prevalent among older women.

The numbers and the percentage distribution of births by birth order and broad age-group of mother are presented in Table 2. The age-groups included in the table are those used in the regression analysis, too. The figures indicate that overall, the SRB differentiates by birth order but the trend does not seem consistent. However, when age of mother at birth is taken into account, a pattern emerges. The ratio follows a decreasing trend with increasing birth order for women below age 25 while the opposite is the case for older women. These figures seem to suggest that the SRB is associated with birth order but the direction of the association differs according to age of mother. This is an indication that in the multivariate analysis, apart from the main effects of maternal age and birth order on the chances of a male birth, interaction effects should also be considered.

Means, standard deviations and relative distributions for the variables used in the regression models are presented in Table 3. The figures are shown for the overall population, by citizenship and for Albanians, separately. Mean live birth order is marginally higher for Greek women, 1.70 compared to 1.64 for foreigners. This difference might be related to the fairly young age distribution of immigrant women in Greece, who represent mostly recent arrivals in the country (Tsimbos 2006). The main bulk of births (64.4%) occur between ages 25 and 34; for foreign mothers, however, that proportion is lower (53.1%) and a considerable percentage of births (36.8%) occur also below age 25. This tendency is more pronounced for Albanians for whom 45% of births correspond to women aged less than 25 and 49% to the 25-34 age group. Births to women aged 35 or higher represent 20% of the total for natives but only 10% for immigrants and 6% for Albanians.

Regarding the socio-economic characteristics of mothers, 26.0% of Greek women have managerial or professional posts compared to only 3.2% of foreign women and to 1.0% of Albanians. Greek women are also, on average, better educated than immigrants. For instance, while 28.7% of Greeks have a degree or an equivalent qualification, that applies only to 7.1% of foreigners and to 2.1% of Albanian mothers.

Table 2 Sex ratio at birth and percentage distribution of single live births by birth order and broad age groups of mother

	Numbers			Distribution (%)			
All ages	**male**	**female**	**both sexes**	**male**	**female**	**both sexes**	**SRB**
b.o. = 1	27598	25809	53407	50.0	49.9	49.9	106.9
b.o. = 2	19991	18967	38958	36.2	36.6	36.4	105.4
b.o. = 3+	7580	6977	14557	13.7	13.5	13.6	108.6
Total	55169	51753	106922	100.0	100.0	100.0	106.6
15-24	**male**	**female**	**both sexes**	**male**	**female**	**both sexes**	**SRB**
b.o. = 1	6461	5966	12427	68.8	67.1	68.0	108.3
b.o. = 2	2307	2293	4600	24.6	25.8	25.2	100.6
b.o. = 3+	620	635	1255	6.6	7.1	6.9	97.6
Total	9388	8894	18282	100.0	100.0	100.0	105.6
25-34	**male**	**female**	**both sexes**	**male**	**female**	**both sexes**	**SRB**
b.o. = 1	17625	16556	34181	49.6	49.7	49.6	106.5
b.o. = 2	13648	12871	26519	38.4	38.7	38.5	106.0
b.o. = 3+	4291	3868	8159	12.1	11.6	11.8	110.9
Total	35564	33295	68859	100.0	100.0	100.0	106.8
35+	**male**	**female**	**both sexes**	**male**	**female**	**both sexes**	**SRB**
b.o. = 1	3512	3287	6799	34.4	34.4	34.4	106.8
b.o. = 2	4036	3803	7839	39.5	39.8	39.6	106.1
b.o. = 3+	2669	2474	5143	26.1	25.9	26.0	107.9
Total	10217	9564	19781	100.0	100.0	100.0	106.8

3.2 Regression Results

Odds ratios of having a male over a female birth are shown in Table 4. According to the Hosmer-Lemehsow test all models fit the data reasonably well. Model 1 includes all births to women aged 20 or higher and demographic predictors only. Birth order and maternal age are very significant but only once an interaction term is added in the model. Increasing birth order is related to about 6% lower chances of having a male birth, a result significant at the 1% level. Similarly, chances of a male birth are lower, by about 8%, among mothers over age 25 compared to younger women. The interaction, on the other hand, indicates that higher birth order within the 25-34 and the 35+ age groups of women is associated with a higher excess of male births compared to women below age 25. Hence, to quantify the overall effect of birth order the interaction has to be taken into account, too (see Table 5 and relevant discussion).

The model further includes a binary indicator of whether the mother is of foreign citizenship. The indicator is significant at the 1% level and shows 5% higher chances of having a male birth for immigrant women even when controlling for mother's age.

Table 3 Sex ratio at birth, means and standard deviations (in parentheses) and relative distribution for the variables used in the analysis by citizenship of mother: Greece 2006.

	Greek citizens	All Foreign citizens	Albanians	Total
Demographic characteristics				
Mean live birth order	1.70 (0.9)	1.64 (0.8)	1.63 (0.7)	1.69 (0.9)
Age of mother (%)				
<25	12.9	36.8	44.9	17.1
25-34	66.8	53.1	49.3	64.4
35 or more	20.3	10.1	5.8	18.5
[(<20)	2.4	6.0	6.9	3.1]
Socio-economic status				
Occupational classification				
Low [a] - Middle [b] - Housewife	73.9	96.8	99.0	77.9
High [c] (managerial & professional)	26.1	3.2	1.0	22.1
Educational attainment				
Primary (ref. cat.)	7.7	35.9	43.3	12.6
Lower secondary	9.7	26.5	32.5	12.6
Upper secondary	53.9	30.5	22.2	49.8
Tertiary	28.7	7.1	2.1	25.0
Citizenship of mother				
Greek				82.4
Foreign (all)				17.6
Albanian				10.8
N	87,816	18,711	11,530	106,527

[a] agricultural workers, lower supervisory and technical occupations, semi-routine and routine occupations, unemployed and economically inactive
[b] intermediate occupations, clerks, own account workers
[c] managerial and professional occupations

All other models in Table 4 explore associations with socio-economic factors while controlling for the aforementioned demographic characteristics. In Model 2 (all citizenships) effects of the demographic predictors remain strong and significant while the magnitude and direction of the associations are not affected by the inclusion of socio-economic variables. Foreign citizenship of mother also maintains its importance as a predictor of more male births. Regarding SES, educational attainment of mother does not produce any significant results. By contrast, occupation of mother is significant; women with high occupational profiles, in managerial and professional posts, seem to have 6% higher chances of a male birth.

To further investigate these relationships, the analysis was also performed separately for Greek and foreign citizens as well as for Albanian mothers who represent the majority of immigrants. The findings reveal differences between these ethnic groups. With respect to demographic variables, associations for Greek women (Model 3) remain very strong and essentially unchanged. Associations for Albanian mothers (Model 5) also point to the same direction though they are only borderline significant (probably due to the small numbers) while for all foreign citizens (Model 4) odds ratios are rather inconsistent and non-significant. Regarding socio-economic status for Greek women, high occupational profile is significantly related to higher chances of a male birth; that holds for educational qualifications as well, though relationships are not as strong. In fact, if occupational class of mother had been excluded from the analysis (results not shown here) the effect of educational attainment would have been stronger since these variables are strongly correlated; for example, the correlation coefficient between high occupational class and tertiary education for Greek women is 0.93.

Table 4 Results of logistic regression: odds ratios estimated for response variable (male birth) and socio-demographic predictors.

Predictors	All citizenships		Greek citizens	Foreign citizens	Albanian citizens
	Model 1	Model 2	Model 3	Model 4	Model 5
Demographic variables					
Live birth order	0.938***	0.936***	0.935**	0.949	0.952
Age of mother					
<25 (ref. cat.)	1.000	1.000	1.000	1.000	1.000
25-34	0.922**	0.916**	0.884***	1.018	0.877
35 or more	0.919*	0.908**	0.879**	0.999	0.686*
Interaction:					
Birth order by age of mother					
<25 (ref. cat.)	1.000	1.000	1.000	1.000	1.000
25-34	1.077***	1.080***	1.088***	1.033	1.114*
35 or more	1.077**	1.081***	1.087***	1.032	1.172*
Socio-economic variables					
Occupational classification					
Low [a] - Middle [b] - Housewife (ref. cat.)		1.000	1.000		
High [c] (managerial & professional)		1.059**	1.067***		
Educational attainment					
Primary (ref. cat.)		1.000	1.000		
Lower secondary		1.004	1.063*		
Upper secondary		0.983	1.030		
Tertiary		0.968	1.014		
Primary (ref. cat.)				1.000	1.000
Secondary - Tertiary				0.937**	0.939*
Citizenship of mother					
Greek (ref. cat.)	1.000	1.000			
All Foreign	1.050***	1.050***			
Log likelihood	-71,516.3	-71,511.5	-59,339.5	-12,940.6	-7,974.3
Hosmer-Lemeshow test	3.00	9.45	1.69	9.39	2.89
(significance level)	(0.81)	(0.31)	(0.98)	(0.23)	(0.89)
N	103,266	103,266	85,676	18,711	11,530

Note: Models 1, 2, 3: mothers aged 20 or higher. Models 4 and 5: births to women below age 20 are included

* p<0.1, ** p<0.05, *** p<0.01

[a] agricultural workers, lower supervisory and technical occupations, semi-routine and routine occupations, unemployed and economically inactive

[b] intermediate occupations, clerks, own account workers

[c] managerial and professional occupations

Occupation for foreign women was not included in the models, due to their very small proportions in high occupational class and the unreliable figures for housewives. Educational attainment is included in two categories, as numbers in upper secondary and tertiary education are rather small; had the four-category variable been used instead, results would have been similar but less significant. The odds ratios in Table 4 indicate that among foreign women higher educational attainment is related to more girls; this finding is the opposite compared to Greeks.

To clarify further the complex interrelationships of birth order with age of mother, predicted odds ratios of having a male birth for women of all citizenships have been estimated based on

Model 1 and are presented in Table 5. More specifically, these odds ratios are predicted values which take into account the independent effects of birth order, age-group of mother as well as the outcome of their interaction. Hence, keeping age-group of mother fixed, one may observe how odds vary across birth order. Conversely, keeping birth order fixed, it is possible to see how odds change across age-group of mother. For instance, for mothers below age 25, chances of having a male birth are highest for birth order 1 and decrease monotonically as birth order increases. By contrast, chances of a male birth among older mothers increase monotonically with increasing birth order. Considering now first births only (which represent about 50% of births in 2006), chances of having a male offspring are highest for women below age 25. For second births, on the other hand, chances of a male birth are highest for the 25-34 age group.

Table 5 Predicted odds ratios of having a male birth by age-group of mother and birth order, based on Model 1 of Table 4.

	Age of mother		
Birth order	Below 25	25-34	35 or higher
1	1.083	1.060	1.056
2	1.013	1.073	1.068
3	0.948	1.085	1.079
4	0.887	1.098	1.091
5	0.829	1.111	1.103
6	0.776	1.125	1.115
7	0.726	1.138	1.127
8		1.151	1.140
9			1.152

4. Discussion and Conclusion

This paper uses restricted access records of legitimate single live births for 2006 at micro-level, provided by the National Statistical Service of Greece, to assess effects of socio-demographic factors and ethnicity on the propensity to have a male birth. This is the first time that such an analysis, based on nation-wide individual data, is undertaken for Greece. The data are detailed enough to allow multivariate statistical techniques to be applied. In addition, there is available information on the mother's occupation and educational attainment which enables exploration of associations with maternal SES, a rare occurrence in analyses involving vital registration data. The assessment of the odds of a male over a female birth is performed using logistic regression models while to unravel the complex effects of the demographic factors predicted odds ratios by age of mother and birth order have been estimated.

4.1 Demographic effects

Exploration of the effects of demographic factors indicates strong non-linear associations with maternal age which become evident only once interactions are added in the models. Birth order has an independent effect but also significantly affects chances of a male birth dependent on the age of the mother. These associations point mostly to the expected direction (i.e. higher ages and birth order are associated with a lower proportion of male births) and persist even when controlling for SES indicators and ethnicity (Greek/foreign origin mothers). The interaction of maternal age with birth order, on the other hand points to the opposite direction. Hence, effects of demographic factors are complex.

Several studies dealing with effects of parental ages and birth order have also found non-linear associations with maternal age and interaction effects with SRB which point to the opposite direction compared to main effects (Imaizumi & Murata 1979; James & Rostron

1985, Novitski & Kimball 1958). A few analyses, including this study, find an independent negative effect for birth order (Chahnazarian 1988; Erikson 1976; James & Rostron 1985) while other research could not detect any significant relationship once other factors were controlled for (Jacobsen et al. 1999; Teitelbaum & Mantel 1971).

To delineate these composite relationships in the present study, predicted odds ratios based on the logistic regression models were computed, showing the odds of having a male birth, taking into account the independent effects of the demographic factors in addition to their interaction. The figures illustrate clearly that while chances of having a boy decrease with increasing birth order for women below age 25 the opposite holds for older women. Similarly, age-group of mother has a differential effect on chances of having a male birth dependent upon birth order; in particular, effects differ for first births and all others. These results, however, cannot be compared to other research since, to the best of our knowledge, predicted odds ratios showing the composite effects of the demographic factors have not been presented before.

A few studies have considered effects of both paternal and maternal age (Erickson 1976; Imaizumi & Murata 1979; Novitski & Kimball 1958; Ruder 1985). Results in these instances are variable, though mostly significant, non-linear and complex. The present study also examined such effects (results not shown here) but the associations were especially complicated with interactions of both paternal and maternal age with birth order being very significant.

4.2 Socio-economic Status

With respect to socio-economic characteristics, the analysis indicates a strong positive non-linear effect of maternal occupation and educational attainment on the chances of having a male birth for Greek women. The differentiation is observable when comparing mothers in high occupational class to all others; also, between low and all other educational levels. A negative non-linear effect of the educational attainment of foreign women is also estimated which, however, points to the opposite of the expected direction.

Teitelbaum and Mantel (1971) found a positive association of SRB with socio-economic status, using a composite index based on the father's characteristics, while controlling for birth order and race. The effect was non-linear, showing a greater differentiation between low and medium status. Erickson (1976), however, found no association with paternal education while Rostron and James (1977) could not detect any relationship with social class (based on the husband's occupation) either. Models including paternal socio-economic characteristics run by the authors (not shown here) came up also with non significant results. Maternal characteristics have rarely been used in similar analyses; Almond and Edlund (2007) find a higher proportion of male births among better educated women. Hence, these results are mostly in agreement with the findings of the present study for Greek women for whom higher educational attainment and high occupational profile had an important effect increasing chances of having a boy.

4.3 Differentials by citizenship

Effects of ethnicity (Greek/Foreign citizenship) remain substantial throughout the analysis. Being an immigrant mother is related to higher chances of a male birth in spite of controlling for age and socio-economic characteristics of mother. Strong differentials by race and ethnicity, which persist in spite of the addition of socio-demographic controls, have been found also by a multitude of studies (Dubuc & Coleman 2007; Erikson 1976; Mathews & Hamilton 2005; Teitelbaum & Mantel 1971).

Examining the importance of demographic factors separately for foreign-origin and native women differentiations are observed. Effects for Albanians point to the same direction as for Greek women though associations are less significant; estimates for all foreign citizens, on the other hand, are less consistent and not significant. Associations with SES differ more substantially; the apparent negative association of the proportion of male births with educational attainment of foreign mothers, which contrasts with results for Greek women, raises the issue of comparability of qualifications between these populations (different educational systems). Further, it is questionable that educational level truly represents socio-economic status among immigrants, since the vast majority of them are recent arrivals and their occupation and income are unlikely to reflect their actual qualifications. Similar reservations have been put forward before, regarding education of Latino US-born and foreign-born mothers (Acevedo-Garcia et al. 2007). It should be noted that the foreign-origin population, apart from including a large group of Albanian mothers (65%), constitutes a highly heterogeneous group comprising persons of different ethnic origins, backgrounds and behaviours; hence, no firm conclusion can be drawn.

4.4 Other effects and implications

SRB depends mainly upon the sex ratio at conception and rates of foetal loss (Markle 1974; Chahnazarian 1988; Tremblay et al. 2003). It has been suggested that the primary sex ratio has a minimum value of 110 or even 120 but the SRB is lower due to the excessive vulnerability of male foetuses (Lerner 1968; McMilles 1979). Data on foetal loss, however, are virtually non-existent in most countries. Thus, socio-demographic factors may serve up to a point as proxies of the unobservable biological processes which affect the primary sex ratio during conception and throughout pregnancy.

The findings of the study for the native population provide indirect evidence supporting the thesis that parental hormone levels around the time of the conception may affect the sex of the foetus. In particular, the observed associations of demographic factors with chances of having a male birth are compatible with the hypothesis that increasing age of mother and increasing birth order, independently of each other, are related to higher levels of gonadotrophin, which favours birth of female children (James & Rostron 1985; James 1996, 2004). These results are also in accordance with the Trivers and Willard hypothesis (1973), according to which the SRB may deviate from the norm in response to parental circumstances: parents in good condition (i.e. younger parents) would have more sons while parents in poor condition would have more daughters. All the expected associations hold clearly for mothers below age 25 and for first births. The rather unexpected significant positive relationship between birth order and chances of a male birth among older women, however, is more difficult to explain in biological terms; maternal age and birth order are interdependent and the resulting associations are complex, as is apparent in other similar analyses as well (Imaizumi & Murata, 1979).

The observed positive association of the proportion of male births with mother's socio-economic characteristics among natives may be partly attributable to reduced male prenatal mortality, correlated with better health, accessibility to healthcare and proper diet among women of higher socioeconomic position (Chahnazarian 1988; Markle 1974; Teitelbaum & Mantel 1971). Maternal hormone levels may provide another plausible explanation as it has been proposed that stress and dominant position causes females to produce high levels of adrenal androgens and testosterone which would result in a high proportion of sons (Grant 1996, 2003, 2007; James 2008). More male offspring among women of higher SES is consistent also with the Trivers and Willard hypothesis (Almond & Edlund 2007). It has been suggested that predominance of lower birth orders among persons of higher SES, who tend to have on average lower fertility, may influence the estimates resulting thus, in spurious associations (Siegel & Swanson 2004; Teitelbaum & Mantel 1971). However, this does not

apply to this case, as models control for birth order which, additionally, does not differentiate much across occupational classes.

Some limitations of the present study should be mentioned. A reliable indicator of socio-economic status among immigrant women is lacking, since educational status seems inadequate while occupation was very likely misstated. Nevertheless, these variables work well for native women. Another point to reflect on is that effects of all factors included in the analysis are fairly small in magnitude; hence, there are a number of unobservable factors influencing the sex of a baby which are not included in the analysis.

4.5 Concluding remarks

Some important points have emerged from the present study. First, associations with demographic variables are strong. Second, the demographic variables are interdependent and relationships are non-linear and complex; hence, for the effects to come to light interactions have to be included in the models. Third, maternal age is significant while birth order has an independent effect but also affects the estimates through maternal age. Fourth, socio-economic status of mother is important while it seems that conventional measures such as occupation and educational qualifications represent poorly SES among immigrants, particularly if these arrived only recently in a new-receiving country such as Greece. It is worth noting that the analysis is based only on births that occurred in 2006; it may be of interest therefore to re-estimate the models using data for a longer period, to examine whether associations hold.

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