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Parental Status and Gender Preferences of Children: Is Differential Fertility Stopping Consistent with the Trivers-Willard Hypothesis?

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Abstract: Based on evolutionary reasoning, Trivers and Willard (1973) predict status-biased sex composition and parental investment with son-preferencing effects in higher, and daughter-preferencing effects in lower status groups. Previous research shows mixed results. Using event-history methods and Swedish register data, we study one possible mechanism in isolation: Do parents in different status groups vary in their proclivities to continue fertility based on the sex composition of previous offspring? Results show no support for the Trivers-Willard hypothesis on a wide range of different status indicators. We recommend that future research on the stated hypothesis focuses on physiological rather than behavioral mechanisms.

INTRODUCTION

Based on evolutionary reasoning, Trivers and Willard (1973) proposed the hypothesis that in certain species, including humans, sex composition of children and sex-selective parental investment is affected by parental resource levels: For parents with high resource levels, the expectation is that sex composition and parental investment benefit male offspring, whereas for parents with low levels of resources, sex composition and parental investment benefit female offspring. On an aggregate level, these forms of discrimination in sex composition and parental investment—to the degree the latter contributes to a sex differential in mortality—are predicted to lead to biased sex ratios by social status (Trivers and Willard 1973). Here we focus on testing this prediction with regard to parental investment. We argue that previous studies were based on single investment indicators that cannot be easily compared. Instead, we propose a central role for (unconscious) parental gender preferences in steering parental investment. In order to test whether we find the pattern predicted by Trivers and Willard (1973) in parents' gender preferences, we analyze fertility stopping based on parental status and sex composition among previous offspring.

If indeed existent, the stated relationship between parental resource levels and offspring sex determination as well as sex-selective parental investment has implications not only for evolutionary theory but also for many core sociological issues, both on the micro and macro level: In societies in which parents can inherit their resource levels to their children (and this has been the case in most known human societies), sex-ratio biasing based on parental resource-rank leads to a gendered wealth and status distribution in society. This in turn suggests ramifications for the incentive structure in mating and career decisions as well as for gender norms and the gendered power distribution in couples as well as in society at large (Guttentag and Secord 1983). Sex-selective parental investment can lead to different starting chances and affect later-life outcomes by affecting psychological well-being and academic achievement.

Previous research has shown that individual and social conditions can affect sex composition at birth (e.g., R. A. Catalano, Ahern, and Bruckner 2007; R. A. Catalano et

al. 2010; Ellis and Bonin 2002; James 2009; Margerison Zilko 2010; Ruckstuhl et al. 2010), yet it remains open exactly which mechanisms are responsible for producing the detected effects (Grant and Irwin 2009; cf. Grant 2007; James 2006). With regard to the Trivers-Willard (TW) hypothesis specifically, researchers from both a biological and a sociological perspective have contributed to testing the stated relationship. Yet until today, the empirical results remain mixed and it cannot be finally decided whether the TW effect is to be found, both with regard to biased sex composition and parental investment (Almond and Edlund 2007; see also Brown and Silk 2002; Festa-Bianchet 1996; Freese and Powell 1999, 2001; W.C. Mackey and Immerman 2008; Pollet et al. 2009; Schnettler 2010).

Given this inconclusive evidence with regard to the TW hypothesis, it seems therefore important to take a more analytical approach that helps to dissect the physiological and behavioral mechanisms and the biological, cultural, and social influences thereon that may be at play in shaping sex composition of children and sex-biased parental investment (cf., Hedström 2005; Runciman 2009). Researchers studying the hormonal pathways responsible for sex determination have made important advances in narrowing down the pool of potential physiological mechanisms playing a role in producing the TW effect (Grant and Irwin 2005; Grant et al. 2008; James 2008). Other scholars have resorted to testing the TW hypothesis more generally in a correlational sense (W.C. Mackey and Immerman 2008; e.g., Wade C. Mackey and Coney 1987). But whereas this approach enables researchers to test whether the data behave consistently with the TW prediction, it tells us little about the underlying mechanisms. Specifically it tells us little about whether the observed pattern is truly an effect of a TW mechanism or rather a byproduct of other mechanisms.

We know even less about potential mechanisms when it comes to sex-selective parental investment as compared to biased sex ratios. Some evolutionary psychologists assume that our mind consists of thousands of domain-specific mechanisms (Barkow, Cosmides, and Tooby 1992; Buss 1995). According to this view, a number of mechanisms steering parental investment in response to child characteristics, parental status, and investment domain are theoretically conceivable. But the emerging consensus

among psychologists seems to be that a domain-general architecture that allows humans to be rational and reflexive agents is coupled with a smaller number of domain-specific mechanisms that can, under certain conditions, bias the outcomes of the domain-general architecture (Baumeister 2005). According to this view, it seems plausible to assume that, if at all, one rather crude mechanism influences parental investment through parents' (unconscious) gender preferences.

In this paper, we aim to study status-based parental gender preferences in isolation. A good way to measure parental gender preferences is to look at fertility stopping in response to parental status and the gender composition of previous offspring. This approach is superior to asking parents about their gender preferences in a survey as it does not imply social desirability biases. By means of examining differences in parity progressions, both cross-nationally and over time, sociologists and demographers have provided increasing evidence that parents adjust their overall number of children to accommodate offspring gender preferences (e.g., Andersson et al. 2006; Hank and Kohler 2000). In populations like pre-modern China parity progression ratios could differ by as much as 18% dependent on sex composition of previous children (Zhao 1997). Fertility stopping based on a particular set of sex and family preferences gives parents a limited means of affecting the sex composition among their offspring¹. In fact, it is the only available way for parents to influence the sex composition of their children in Western societies where sex selective abortion is absent and modern sex selection techniques are not (yet) practiced.

Whereas existing social science research thus indicates that parents generally use fertility stopping to accommodate gender preferences, it tells us little about the interaction between parental status and sex composition among previous offspring and therefore is not informative with regard to the TW hypothesis specifically. Here we fill this gap by applying event-history models to analyze the interaction of parental status and sex composition of previous offspring in determining the relative risks of parents at

¹ It should be noted in this context that status-differential stopping behavior may lead to a skewed distribution of sex composition types across status groups but does not affect status-group specific sex ratios.

different parities to have another child. This is a methodologically and theoretically more powerful way to study the TW effect compared to an approach that simply correlates SES and sex-specific parental investment on single investment indicators. Specifically, in following the TW prediction, we are interested to see whether parents with higher status are more likely to continue fertility to have at least one son and parents with lower status more likely to continue until they have at least one daughter.

In this paper we conduct a very liberal test of the TW hypothesis. This is necessary for two reasons. First, the TW effect among humans is predicted to be lower than in many other species, given the comparatively high degree of paternal investment in humans as compared to other species (Trivers and Willard 1973). To detect even small effects, common sample sizes in surveys are not sufficient. Here, we therefore use Swedish register data that provide large sample sizes to detect even small effects. Second, a theory that predicts which parental resources should be most relevant for the activation of somatic or psychological mechanisms responsible for the TW effect does not exist (see Schnettler 2010). Other researchers have, with few exceptions (e.g., Freese and Powell 1999) used different operationalizations of parental status (cf., Schnettler 2010), therefore making comparisons between studies difficult. Here, we will examine the interaction between social status and sex composition of previous offspring on a number of different status indicators, including income, post-transfer income, wealth, parental wealth, socioeconomic status, and education. Swedish register data offer good data on income, wealth, and other status variables in long time-series and for the complete population.

THEORY AND PREVIOUS RESEARCH

The Trivers-Willard hypothesis

Trivers and Willard (1973) predicted that in species in which the sexes differ in the variability of their reproductive success and where parents are able to pass on their condition to their offspring, evolution would favor the emergence of mechanisms leading to biased sex composition and parental investment in response to parental resource condition. Specifically, the authors expected that parents in good condition can maximize their reproductive fitness by adjusting investment and sex composition to favor the sex with a higher variance in reproductive success, i.e., in most species males. Parents in bad condition, on the other hand and on average are theoretically better off, reproductively speaking, when the respective bias is to the advantage of the less reproductively variable sex, i.e., in most cases females (Trivers and Willard 1973). Parents in bad condition are expected to increase their reproductive fitness by investing more in daughters. This is because their sons are in competition for mating partners with sons of parents in better condition and may therefore end up having few to no children at all. For daughters of parents in bad condition, mating competition is lower than for males; thus daughters are in this case a less “risky” investment (cf., Hopcroft 2005; Trivers and Willard 1973). A comparatively high share of paternal investment in humans, implying both a smaller difference in the cost of reproduction and a smaller difference in the variances of reproductive success between the sexes, leads to a smaller expected Trivers-Willard (TW) effect than in species with lower or no paternal investment (see also Trivers 2002).

Empirical research on the TW effect is focused on the conditions for (different reproductive variability between the sexes, correlation of parental and child status) and the existence of the TW effect (e.g., Almond and Edlund 2007; Fieder and Huber 2007; Klindworth and Voland 1995; W.C. Mackey and Immerman 2008). First, with regard to conditions, sociological research has amply demonstrated the correlation of children's status with that of their parents in a majority of historical and contemporary human societies (see e.g., Björklund, Jäntti, and Solon 2007; Breen and Jonsson 2005; Erikson

and Goldthorpe 1992). Second, a difference in reproductive variability between the sexes can plausibly be assumed on a theoretical basis, given both an average gestational period of nine months for each pregnancy and the female life-time limit in years of fecundity. Empirically, there is clear support for an association of wealth and reproductive success and partial support for a difference in reproductive variances between the sexes in pre-transition populations (Klindworth and Voland 1995; Low and Clarke 1992; Røskft, Wara, and Viken 1992; Scott and Duncan 1999; Voland 1995) (Woods 1939a). In contemporary developed societies, the pattern seems less clear: On the one hand, sociological research has shown that well-educated women in developed, Western societies have a higher probability to remain childless and have smaller families, due to structural constraints on combining work and family (cf., Kaufmann et al. 1998, 2002). On the other hand, there is evidence that at the extreme end of the wealth distribution, among the 400 wealthiest US Americans, fertility is above the population average (Essock-Vitale 1984). Using more recent data on the wealthiest US Americans, Cameron and Dalerum (2009) come to the same conclusion and further show direct evidence for higher sex-selective variability in reproductive success: US billionaires leave more grandchildren through their sons than through their daughters.

But the existence of a link between socioeconomic status and fertility is not a necessary precondition for the TW effect in contemporary, developed societies—at least not according to the logic of evolutionary psychology: According to this perspective, human physiology and psychology have largely evolved during the Pleistocene, a phase during which humans are assumed to have lived as hunter gatherers (Barkow, Cosmides, and Tooby 1992)². For a respective mechanism to have evolved it may have been sufficient for the human species to have lived long enough in environments in which males in good condition out-reproduced women in good condition (Hopcroft 2005, 1114). The time since the Neolithic revolution, after which most societal changes are expected to have occurred, is considered too short for major changes in the human psychological architecture to have occurred (Barkow, Cosmides, and Tooby 1992)—an

² Some aspects of our human physiology and psychology are not uniquely human and have already evolved in our phylogenetic ancestors (Lloyd 1999:229), extending the potential time-frame in which mechanisms may have evolved that orchestrate the TW effect.

argument that remains contested among some evolutionary biologists (cf., H. Rose and S. P. R. Rose 2000; Schnettler 2010; Segerstråle 2000).

The TW Effect in Sex Composition at Birth

Whereas some animal studies identify a TW-consistent association of parental condition and sex composition at birth (Keller, Nesse, & Hofferth, 2001), metaanalyses and reviews of studies suggest diverging conclusions, drawing once on small-sample biases and publication bias and once on a better-timed measurement of parental condition (Brown and Silk 2002, Festa-Bianchet, 1996; Smith, 1983, p. 873, Cameron 2004). With regard to humans, the empirical evidence in support of the TW hypothesis, too, remains inconclusive. In human populations, a sex ratio of about 105 to 106 boys for every 100 girls is considered as “natural” (Lazarus 2002, 288). Whereas in a number of historical, pre-transition populations sex ratios differ markedly from this natural sex ratio for status-based subgroups (Bereczkei and Dunbar 1997; Mealey and W. Mackey 1990; Scott and Duncan 1999, 90), the picture is not so clear with regard to contemporary societies: Representative survey data for contemporary developed societies show mixed results (Freese and Powell 1999, 2001; Hopcroft 2005), but estimates obtained from population registers suggest very small TW-consistent effects (Almond and Edlund 2007; Chacon-Puignau and Jaffe 1996). Elite studies point to medium to large effects when elite status correlates with share of resources held (Cameron and Dalerum 2009; Essock-Vitale 1984; Woods 1939a), but again to inconclusive results when using mixed elite definitions (Wade C. Mackey and Coney 1987).

Trivers and Willard (1973) argued that it is very likely that *some* mechanisms leading to sex-ratio and parental-investment biasing may have evolved, leaving open the question of exactly which types of mechanisms could be responsible for such biases. Part of the reason for the mixed empirical pattern may be the absence of knowledge about when a set of proximate mechanisms would be most likely to operate. From a theoretical perspective, there are a number of possible stages at which a mechanism could be active: it may be that X- and Y-chromosome-carrying spermatozoa have different survival

chances prior to fertilization, that somehow they are differentially affected in their chances to fertilize the ovum, that male or female fetuses may have different degrees of vulnerability in the mothers' womb, and/or that sex-selective parental investment may be responsible for the survival chances of the offspring (see Lazarus 2002). From an evolutionary perspective, costs associated with the respective mechanism should be minimized in order to maximize reproductive fitness. Therefore, the earlier a sex-selective mechanism gets activated, the less somatic energy has to be written off as sunk fitness costs. Given that humans, throughout their evolutionary and phylogenetic history have likely been exposed to several changing environmental conditions (cf., Low and Clarke 1992, 464), it is likely that mechanisms have evolved that affect sex composition at different stages, but with a higher activation probability of less costly mechanisms.

Despite findings that point to a physiological mechanism acting at or around conception (Cameron 2004), little is known about the proximate determinants of sex composition at birth. One central role may be played by various stressors. Research on a range of social and economic calamities as well as research on individual socioeconomic status and psychological health shows that mothers who experience stress during the gestational period have a higher likelihood for female offspring (e.g., R. A. Catalano et al. 2006; R. A. Catalano 2003; M. Fukuda et al. 1998; Ruckstuhl et al. 2010; Subbaraman et al. 2010; Zorn et al. 2002), likely due to higher mortality of male fetuses (see Bruckner, R. A. Catalano, and Ahern 2010; R. A. Catalano et al. 2005; Grant 2007). Given contradicting results with increased sex ratios after the majority of wars (James 2009), the relationship between stressors and sex composition at birth seems to be affected by other mechanisms as well, with a likely role being played by female testosterone levels (Grant 2007; James 2009) and the higher vulnerability of male fetuses during pregnancy (Grant 2007; James 2009). A major conclusion of this latest research is that the direction of biased sex composition depends on the exact timing of the stressors between conception and birth (Grant 2007).

The TW Effect in Parental Investment and Gender Preferences

Except for samples at the extreme end of a society's wealth distribution (see Cameron and Dalerum 2009; Woods 1939b), the effects on sex composition at birth are often rather small. And they are almost completely exogenous to human agency. Although Trivers and Willard (1973) pointed out that besides these forms of physiological discrimination sex-selective parental investment, that is, a behavioral form of discrimination³, may be possible. The evolutionary cost argument made above, on the other hand, predicts that any discriminatory mechanism should occur as early as possible to avoid sunk fitness costs and therefore makes behavioral discrimination less likely. But despite this argument there is plenty of empirical evidence that parental discrimination does occur during pregnancy or even after the child is born. In fact, extreme male biases with more than 130 boys for every 100 girls (cf., Hvistendahl 2011) bear witness to the possibility that sex-selective *behavior* affecting sex composition and thereby sex ratios in a population can be much stronger than most of the enumerated *physiological* effects. Therefore research that aims at inferring the strength of a biological effect (TW mechanism) from sex ratios at birth needs to study the role behavior plays in determining sex ratios. As part of an attempt to dissect the relevant mechanisms at play in determining sex composition at birth, this is important for two reasons: First, to detect if any behavioral response is itself in a direction consistent with the TW hypothesis. And second, to see the degree to which other behavioral effects either exaggerate, alleviate or even neutralize a physiological TW effect in data on sex composition at birth.

Parents may consciously or unconsciously bias their behavior in many ways, ranging from subtle forms of discrimination in parental investment to extreme forms of disinvestment in the form of maltreatment, sex-selective abortion, or infanticide (cf., Bélanger 2002; Sudha and Rajan 1999). Most research deals with either gender differences (Lye 1996) or class-differences in parental investment (e.g., Lareau 2003), but hardly has their interaction been taken into account. Keller et al. (2001) identify only

³ It is important to note, however, that it is extremely difficult to establish a biological origin in any of these behavioral forms of discrimination because behaviors are simultaneously shaped by cultural, social, and biological selection (cf., Runciman 2009).

eight studies that specifically test the TW hypothesis in data on parental investment. More recent studies have taken into account a wider variety of parental investment indicators, status measures and/or more appropriate research designs to facilitate within-family comparisons (Freese and Powell 1999, 2001; Schnettler 2010), yet they have not provided any conclusive evidence for the TW hypothesis.

Sex-selective abortion and infanticide both, in theory, directly affect sex composition in families. These practices, along with sex selection methods, play an influential role in producing strongly male-skewed sex ratios in large parts of Asia and North Africa (see, e.g., George 2002; Hesketh and Xing 2006; Sudha and Rajan 1999). Usually these types of disinvestment are known to occur under particular constellations of cultural and economic context conditions, that is, when male offspring implies extreme economic advantages and/or cultural preferences are extremely male biased (Nauck and Klaus 2007; cf., Nauck 2005). Structural encouragement or enforcement of fertility limits, e.g., the one-child policy in China, may even exacerbate this association (Hvistendahl 2011). Sex-selective abortion and infanticide play less of a role in developed “Western” countries. Sex-selective abortion is legally prohibited in many countries and cases of infant deaths as a consequence of parental neglect are only heard of occasionally. Lesser forms of parental discrimination may occur, but given resource abundance and highly developed health care systems, they can be considered irrelevant for influences on sex ratios (Teitelbaum 1972, 90). Nevertheless, evolved tendencies for parents to develop discriminating gender preferences may still prevail as a psychological mechanism.

Empirical studies on the TW effect in parental investment, that is, on differences in parental investment in response to parental status and sex composition among previous offspring report mixed findings. Comparing the Hungarian Gypsy population with the remaining population, Bereczkei and Dunbar (1997) report differences in abortion rates, breastfeeding duration and length of education that are consistent with the TW hypothesis. Moderately supportive evidence also comes from a contemporary sample of Polish respondents where the authors use birth spacing and breastfeeding as measures of investment (Koziel and Ulijaszek 2001). For the contemporary US, support for the TW

hypothesis comes from a representative sample of 900 women with birth spacing, birth weight, and breastfeeding as measures of parental investment and income and presence of a father as indicators of parental status (Steven J. C. Gaulin & Robbins 1991). Using considerably larger samples from two different representative US surveys and a variety of parental investment indicators, Freese and Powell (1999, 2001) find no support for the TW hypothesis. Also Keller and others, using data from the Child Supplement to the Panel Study of Income Dynamics, don't find support for the TW hypothesis (Keller et al. 2001).

Schnettler (2009) draws attention to the problem that even from a biological perspective we would not expect investment differences in a cross-family comparison with gender homogenous families (e.g., comparing son-only with daughter-only families). Therefore, he uses fixed-effects models to compare investment differences in adolescent sibling dyads in gender-*mixed* families only. He concludes that there are hardly any signs for investment differences consistent with the TW hypothesis (ebd.). A remaining problem, both in between-family as well as within-family designs, is that they are usually based on rather small samples, rendering the detection of small differences in parental investment almost impossible. What may further drive the mixed results in the studies surveyed here is that they use a variety of parental investment indicators, making a comparison between studies difficult. A central problem is also that parents may discriminate on particular investment dimensions but make up for these differences in other domains. It is therefore difficult to derive a conclusion about a general pattern of discrimination from single investment indicators. With regard to the operationalization of status indicators, the current state of TW theory does not give us any indication as to which dimension of social status should be expected to most strongly affect parental investment decisions (and sex composition at birth, for that matter). Trivers and Willard (1973) mention “physical” condition of the mother as the relevant measure of condition, leaving many possibly relevant parental status measures that link social status and physical condition, e.g, mediated through stress and nutritional status. Disagreement about the right status operationalization is also expressed in the respective research literature (see e.g., Hopcroft 2005).

The results of Scott and Duncan (1999) point towards some further intricacies in measuring the TW effect. Using data on a community in northern England between 1600-1800, they found that female infant mortality was significantly lower than male infant mortality in the elite class. But there was no statistical difference in infant mortality for tradesmen and the lowest class. At first, this result seems to be inconsistent with the TW hypothesis. But a closer analysis reveals that we need to distinguish between parental investment *intentions* and *consequences*. The authors argue that in their sample parental intentions are consistent with the TW hypothesis. But parents' wrong beliefs about the effects of breastfeeding and wet-nursing led to unintended, reverse consequences. Specifically, the story the authors provide is the following: Wet nursing was a common practice among elite families. But because it was seen as inferior to breastfeeding by the biological mother, wet nursing was mainly applied for daughters whereas sons were nursed by their biological mothers. Given the contraceptive effects of nursing and the desire to have a large number of children, elite mothers weaned their boys earlier than their daughters were weaned by their wet nurses. This left daughters better nourished than sons, a benefit of extended breastfeeding for infant development that was unknown to mothers at that time.

The TW Effect and Fertility Stopping

Both the lack of comparability when looking at single investment indicators and the need to distinguish parental intentions from investment consequences prompt us to focus on measures of parental sex preferences in an attempt to test the TW effect underlying parental investment. A good indicator for average parental gender preferences in a population or in specific social strata is to look at fertility stopping behavior. The neglect of the role of this behavioral mechanisms in the literature on the TW effect surprises, given that it has long been known by evolutionary biologists that fertility starting, stopping, and spacing are all part of a behavioral ecology of fertility behavior and can be seen as strategies to increase fitness in response to environmental conditions (Low and Clarke 1992, 464–465).

In the context of developing countries, where a common preference is to have at least one surviving son, fertility stopping, together with differential investment, is an important strategy for parents to achieve the desired offspring gender mix. In high-fertility populations like pre-modern China parity progression ratios could differ by 18% dependent on sex composition of previous children (Zhao 1997). Research on historical data for developed countries shows that stopping and spacing may have played a role before the fertility transition (e.g., Kolk 2011; Tsuya et al. 2010), often in response to current family composition. In recent years scholars have also increasingly looked at the role of parity-specific fertility behavior in contemporary, developed countries (Hank 2007). Fertility stopping is the only available way for parents to influence the sex composition of their children in western societies where sex selective abortion is absent. Comparing data on the transition from the second to the third child for a total of seventeen European countries, Hank and Kohler (2000) find that sex preferences are quite mixed with no gender preference in some countries, a preference for a mixed sex composition in others, and a slight daughter preference in yet others. For the US, studies show a clear preference for a mixed gender composition as indicated by the higher probability to experience a third birth by parents with two boys or girls as compared to parents with a boy and a girl, a small remaining boy preference as indicated by the higher probability to have a third child among parents of two daughters when compared to parents of two sons. But the data also show a general decline of the influence of the sex composition of previous children on parents' fertility decisions (Hank 2007, 763). A recent study employing Nordic register data provides evidence for a strong and stable preference for at least one child of each sex. For third births the parity progression probability of parents with either two daughters or two sons is between 20 and 25% higher than for parents with one daughter and one son (Andersson et al. 2006). In a review article, Hank (2007) concludes that sex preferences do still play a role in Western societies, if not as strongly as in many developing countries. Furthermore, sex preferences are often only revealed at higher parties. The preference that emerges as being most pervasive and clear is one for a mixed gender balance, but in some countries a slight daughter preference has emerged whereas in others a slight boy preference has

remained active. Sweden has been characterized by a daughter preference since the early nineties; this emerged simultaneously across educational groups (Andersson et al. 2007).

Although the mechanisms that explain how sex preferences come about are not completely solved (Hank 2007), other research has shown that the specific social, cultural, and economic context plays an important role in determining first the value that children of different gender have in a society and second the influence of the value of children on parental fertility and sex preferences, something that is most systematically elaborated in the value-of-children approach (Nauck 2001, 2005). Even in developed countries with high gender equality where economic incentives for having a son or a daughter can be seen as roughly equal, biased incentives may persist: a newly emerged daughter preference in some European countries, for example, is explained by the fact that women often remain the major caregivers for their parents in old age (cf., Brockmann 2001). This illustrates that not only biologically evolved mechanisms affect gender preferences but also social, cultural, and economic influences. Here, the question is whether in addition to the main effects stated here, we do find status-group specific differences in gender preferences that are consistent with the TW hypothesis.

But despite the central role of social status in sociology as a discipline, scholars in this field have not taken on to examine the TW hypothesis in fertility stopping behavior, or the interaction of sex composition of children and parental social status more generally (for an exception see Yamaguchi and Ferguson 1995). Theoretically, clear but opposing preferences for one gender in different status groups may be hidden behind a general preference for a balanced gender-mix. If, according to the TW hypothesis, some psychological mechanisms led high-status parents to prefer male offspring and low-status parents to prefer female offspring, one way for parents to fulfill this preference would be through continuing to have children until the preferred proportion of children of each sex is reached. In reality, it would be difficult for parents to reach the exact preference, but on average, we'd expect that parents of high status are the more likely to stop fertility the more male offspring is among their existing children, whereas they should be more likely to continue fertility if their existing offspring consisted mainly of daughters. The opposite should be true for low-status parents. And if such a psychological mechanism existed, it

could exist alongside other physiological mechanisms. Therefore, in an attempt to further clarify the interplay of potential mechanisms responsible for biasing sex composition in families in response to socioeconomic status, it seems essential to determine how a possible psychological effect would have a neutral, reinforcing, or leveling effect on sex composition biasing from physiological mechanisms (Yamaguchi and Ferguson 1995). It should be noted that fertility stopping theoretically links both sex composition in a family and sex-selective parental investment. We assume that the same parental gender preferences that drive parents' attempt to influence their family sex composition also affect parental investment. But even though fertility stopping may play a role in explaining family sex composition it is without consequence on population and status-group specific sex ratios⁴.

⁴ The following example illustrates why status-biased fertility stopping behavior does not produce biased sex ratios. Assume parents with higher status continue fertility until they have at least one son or a maximum of three children and parents with lower status to continue fertility until they have at least one daughter or a maximum of three children. Furthermore, for simplicity let's assume that at each birth the probability for a male or female birth was equal. In the case of the higher status group we would get the following distribution of family types: 50% with one son only, 25% with a first-born daughter and a second-born son, 12.5% with two daughters and a third-born son, and 12.5% with daughters only. In the case of the lower status group we would see the sex-reversed pattern: 50% with one daughter only, 25% with a first-born son and a daughter, 12.5% with two sons and a daughter, and 12.5% with three sons. That is, in both cases we have equal percentage of males and females, but a very particular distribution of sex-composition types in different status groups.

RESEARCH QUESTION

As the summary of previous research shows, behavioral influences have been checked for consistency with the TW hypothesis with regard to parental investment but not with regard to stopping and spacing behavior. Those scholars on the other hand who have examined stopping behavior and gender preferences have not taken into account the interaction of previous sex composition and social status. Here we wish to close this gap and test empirically if gender preferences are status-biased in a way consistent with the TW hypothesis. That is, are parents with higher social status more likely to continue fertility if their previous children include no or few sons? And do parents with lower social status more likely continue fertility if their previous children contain no or few daughters? It should be noted that other types of preferences influence parental decisions as well, including preferences about family size, a minimum number of children of a specific gender, and a preferred gender mix. As long as these other preferences are equally distributed across status groups, controlled for previous sex composition of children, our aggregate effects should not be systematically biased. A critique against the assumption of an equal distribution of the relative strength of family size versus gender preferences in different status groups is that only parents with more resources can financially afford to have more children in an attempt to fulfill sex composition preferences whereas parents with lower resource levels cannot. Even though research on data from the US has actually found such an effect for education and income (Seiver 1978; Yamaguchi and Ferguson 1995), it is less likely to be found in a country like Sweden that provides generous child support (cf., Esping-Andersen 1990; Kaufmann et al. 1998, 2002). If this is true, the status effect on differential stopping based on the gender mix among previous children may be reduced and we would only find an effect for higher status groups.

Based on the evolutionary cost argument made above, we expect it to be unlikely that a psychological mechanism has evolved that biases stopping and spacing behavior in a way as predicted by the TW hypothesis. And if such a mechanism existed, it should be activated only under rare circumstances and therefore lead to a very small average effect

on the level of status groups. At the same time culturally determined gender preferences lead to much stronger preferences. Therefore we expect to replicate the finding for a strong mixed-gender preference in all status groups. Given that parents of higher status may be better able to afford having more children, we assume that parents of higher education are on average more likely to continue fertility in order to fulfill this preference. Specifically this means that parents in all status groups should be more likely to have an additional child if they currently only have children of one sex. But given the statistical norm of having at least two children in Sweden, we expect to find this effect only at higher parities, that is, for parents with two or three children and their decision to have a third or fourth child. Parents with higher social status should be more likely to continue to have a third or fourth child if their mixed gender preference has not yet been fulfilled. Therefore, we should find increasing fertility with increasing status, an effect that should be stronger with regard to financial status indicators (income, wealth) as compared to education.

In addition, we expect stopping behavior to be related to status in more intricate ways, dependent on particular social status indicators with non-linear effects of status on sex preferences. One such status-specific effect is that parents with higher education may be more likely to continue fertility to have at least one daughter, given more progressive gender values among the group of the more educated. But this effect should be specific to education and—under control of education—be unrelated to other status indicators. Another such status-group specific effect may be that parents in the highest income and wealth stratum may have a higher preference for at least one son, given that women, even in a society with a high degree of gender equality like Sweden, still face ceiling effects that keep women from reaching the highest positions in the occupational hierarchy in equal numbers as men.

DATA AND ANALYSIS

Data

If sociocultural and socioeconomic influences can act on sex preferences simultaneously to psychological/biological influences, and if social influences that bias sex preferences have been much reduced if not disappeared in contemporary societies (see Lundberg 2005), the corollary is that biological influences should be stronger than social influences in developed societies (to the degree that the biological effect on sex preferences has remained constant). As an individualistic welfare state with high gender equality, Sweden, like the other Nordic countries, is a particularly good test case in this regard. That is, as compared to other developed welfare states, Sweden along with the other Nordic countries has policies that target the individual (cf., Esping-Andersen 1990) and can therefore be assumed to influence the economic and cultural opportunity costs of children less than in other historical and contemporary societies. In such a setting, biological effects may therefore even be relatively stronger. That is, even though we still expect cultural influences to be strong and potentially stronger than biological effects on gender preferences, a study in contemporary Sweden is a more liberal test of the TW hypothesis than in many other contexts. A counter-argument would be that the high degree of gender equality in Sweden leads parents to suppress their gender preferences, in case they have any. But whereas we do agree that this might lead to social desirability biases in survey responses on gender preferences, such an equality-norm should play less of a role in data on fertility stopping. Here, individual decisions, even if actually driven by gender preferences, may easily be concealed vis-à-vis others by referring to family size preferences and/or sex composition as a chance process. Furthermore, for our purposes Sweden is a good test case as here the negative association between SES / education and completed family size, observed for a number of other European countries (Kaufmann et al. 1998, 2002), has only been weak, both today (Andersson et al. 2009; Hoem, G. Neyer, and Andersson 2006) and in the past (Edin and Hutchinson 1935; Wrong 1980). That is, our analysis of the interaction between social status and the sex of

previous children in determining parity progression probabilities won't be complicated by a general interaction effect of status on parity progression independent of the sex of previous children.

But even though we expect biological influences to come out most clearly in individualistic societies, it follows from our last section on our research question that we nevertheless expect the TW effect to be small to nonexistent. In order to detect even small effects, we require a very large data set. It is therefore, that we use Swedish register data that both offer the required large case numbers and cover a long duration of individuals' fertility and status histories. Specifically, the data for this study are an assortment of Swedish administrative registers. Registered vital events are used to create longitudinal birth histories to which we apply event history models. Census data and administrative registers on education and taxes are then linked to our demographic data. Due to limited data availability, different registers and periods are studied for different status variables. The study population consists of all Swedish women born in Sweden after 1925 conditioned on the fact that they are present in the registers at some point after 1960. They are followed from age 16 and right censored at death, first out migration, twin birth, age 50 or the end of 2007. Our study population used in our models on the transition from 2nd to 3rd births is: N=849 295 for income, post transfer income, wealth and parental wealth, N=984 285 for education and N= 1 169 170 for socioeconomic status at 2nd birth. An overview of childbearing patterns for the population in our study can be found in Andersson and Kolk (2011).

Data on income, post-transfer income, wealth, and parental wealth are collected from Swedish tax registers and updated on a yearly basis (see Table 1 for some descriptive statistics). Data are available from 1968 until 1989 which is also the start and end date of our models on those variables. Incomes are adjusted according to the wage development for industrial workers in Sweden using a time series with 2004 as reference year (Larsson 2007). Standardizing by income growth rather than inflation is important as we primarily are interested in income relative to other individuals and we don't want a data set in which the population gets progressively richer by decades. Income data is collected from tax-records and is annual registered income from labor. Disposable

income after government transfers is also included and is based on income from labor but also income from other social support systems, e. g., sickness allowances, unemployment insurance and child allowances. Data on wealth and parental wealth is based on tax registers on taxable fortune. Due to a large number of tax exemptions it is unreliable for fortunes above approximately 1 million US Dollars in contemporary currency. The tax agency data is susceptible to tax avoidance and evasion, but at lower levels than in other western countries. Parents are connected using the Swedish multigenerational register. Parental wealth refers to the sum of the shared fortune of the biological mother and father of the index-persons. Data on education is based on contemporary registers with yearly data starting from 1990 until 2007. The data is time-varying and measure highest achieved level of education. The period after 1990 is characterized by the emergence of a small girl preference at the national level (Anderson et al 2007).

Data on socioeconomic status (SES) are based on information collected in censuses in 1960, 1970, 1980 and 1990. Original data collection and classification is by Statistics Sweden and based on the class measure ‘Socioekonomisk indelning’, SEI (SCB 1982). We transformed the classification into the Erikson, Goldthorpe and Portocarero class scheme (EGP). Given that the data is based on decennial status the population is grouped into cohorts according to the decade they were born, starting with 1930. In the census they are then assigned a SES value from the latest census according to group of birth cohort that is time varying and updated on a 10-year basis. For example, the 1930-1940 cohorts are assigned a SES in 1960 when they are 20-29 years, a new SES in 1970 when they are 30-39 years, etc. For our SES models the population is followed between 1960-2000. SES-data is based on occupation. If the woman is not working the occupation of the head of the household is used.

Methods

We use event history analysis to model the transition to the next child and control for sex composition of previous children and parental status preceding the time of that birth. Given that we are interested in the effect of previous sex composition on fertility, we don't model the transition to first birth, but only the transition to second, third, and fourth birth.

Separate piece-wise exponential proportional hazard models are run for socioeconomic status, education, wealth, parental wealth, income, and post-transfer income. Because of different underlying data both study periods and measures vary between methods. Given that we have a theoretical reason to believe that the TW effect would be stronger among elites, most of the categories are stratified with smaller substrata at the upper ends of the relative distributions for our status measures. Besides our explanatory variables on the interaction between our social status measures and sex-composition of previous children, all our event history models include controls on period, age (time varying), and duration since last birth (baseline hazard). Our modeling strategy is to first run event history models in which we estimate the full interaction between our various operationalizations on socioeconomic status and the sex composition on previous children. By doing this we can estimate how the hazard on having a birth changes with socioeconomic status at each parity for all possible previous sex compositions.

To further analyze our data we compare families with sons only and daughters only at each parity (e.g. at parity 2 $\rightarrow$ 3 we compare the risk of mothers of two sons with that of mothers with two daughters). The TW hypothesis predicts that high status parents should have a stronger desire for male children. That is, for example, high status parents should have a lower risk of a new birth if they have two sons compared to a case in which they have two daughters (and vice versa for low-status parents). To examine this we plot the ratio in relative risk for son-only families divided by the relative risk for daughter-only families for parities two, three, and four (see Figure 4).

RESULTS

In Figures 1-3 we display the relative risks of parents to have another child at parities one, two, and three, respectively. The risk ratios result from the event-history models and take into account the interaction between the sex of previous children and social status on a number of status indicators. Here, we can interpret three things: First, shifts of the lines upwards and downwards indicate the main effect of sex composition of previous children on the transition to the next child. Second, the slope of each line indicates the main effect of the status variables on the transition to the next child. And third, differences in slopes between different sex composition lines indicate an interaction effect between status and sex composition.

Overall, the data confirm previous findings of a preference for at least one son and one daughter, a preference that seems to be shared by parents in all status groups. But whereas the data reveal some interesting interactions between parental status and the gender balance of previous children in parents' decision to continue to the next parity, we do not find evidence for a TW effect in fertility stopping. And neither do we find evidence for a reverse TW effect. This holds true for all status indicators applied in our study, including SES, education, wealth, parental wealth, income, and post-transfer income. This has important implications for future studies on the TW effect that we will discuss in more detail in the concluding section of this paper.

Specifically, at parity one the risk to have another child is the same for parents of a son and those of a daughter. This can be seen in Figure 1 and holds true for all status indicators. At parities two and three the data on the risk of progressing to the next parity show a clear preference for a gender mix with at least one son and one daughter: At parity two, parents of two sons or two daughters have a risk for continuing to parity three that is about equal. And their risks are higher than for parents with a mixed gender composition of one son and one daughter. This can be seen in Figure 2. In each panel we see the relative risks of parents by sex composition of previous children for different status measures. In each of these panels the dashed line represents the relative risk of parents who have one daughter and one son. The two continuous lines represent relative

risks of parents with either two sons or two daughters. As we can clearly see, the dashed line is below the two continuous lines, therefore indicating a lower relative risk to continue fertility for parents with a mixed sex composition as compared to parents with a gender homogenous sex composition among their previous children. Similar at parity three: here, parents with three sons or three daughters have a risk of progressing to parity four that is, by and large, equal and bigger than the one for parents with either two daughters and one son or two sons and one daughter. This can be seen in the panels of Figure 3 where the dashed lines, again representing relative risks of parents with a mixed sex composition among their previous children, are below the continuous lines, representing relative risks for parents with a homogenous sex distribution among their previous children. There are some minor exceptions to this pattern in higher status groups for some status indicators (income, income replacement, wealth, and education), but with no clear overall pattern.

In order to evaluate the TW hypothesis, we compare relative risks of parents with either sons or daughters only among their previous children in Figure 4. Each panel represents data for a different status measure. The comparison is facilitated by calculating risk ratios, that is, at each parity we divided the relative risks of progressing to the next parity for parents with either just sons or just daughters. For example, the risk ratio at parity one compares the risk of progressing to the next parity of parents with one son to that of parents with one daughter. At parity two, it compares the risk of progressing to parity four by parents with three sons as it compares to parents with three daughters. According to the TW hypothesis, parents with higher status should have a stronger son preference. Therefore, with increasing status we expect parents to have a higher relative risk to continue fertility if the previous children consist of daughters only and to have a lower relative risk to continue fertility if the previous children consist of sons only. And, vice versa, we expect that with decreasing status, parents should have a lower relative risk to continue fertility if their previous children are daughters only and a higher relative risk if their previous children are sons only. In the calculation of risk ratios, the relative risk of parents with sons only is entered in the numerator and the relative risk of parents

with daughters only in the denominator. Overall therefore the TW prediction should translate into a gradient such that risk ratios decrease with status.

A look at Figure 4 reveals that this is clearly not what we find. Here, each column pertains to a different status measure and status is presented in an increasing order on the x-axes. We find strong evidence against the prediction of an increase in son-preferences with increasing status. As we can see, for none of the status indicators are the risk ratios clearly declining with increasing status. For most status and parity combinations the risk ratios hover around a value of one. And, as indicated by the 95% confidence intervals, hardly any deviation from this overall pattern is statistically significant. For education we even find a small reverse TW effect of the sort that parents with higher education seem to have a slight daughter preference. Yet, even this trend is not statistically significant. Case numbers in the highest status groups and for parity three become rather small which leads to rather wide confidence intervals for these groups. Therefore even the comparatively high deviations of the risk ratios in the highest status groups at parity three on some of the status variables are not statistically significant.

DISCUSSION

In the current paper, we reviewed the literature on the TW hypothesis that predicts that parents with higher status should have more male offspring and parents with lower status more female offspring, and that parents should bias their parental investment accordingly. The review of previous research shows that good advances have been made towards establishing a potential physiological mechanism, or set of mechanisms, affecting sex composition around conception and during pregnancy. However, less progress has been made with regard to a potential TW effect in parental preferences, possibly affecting both parental investment and fertility stopping. Behavioral influences on sex composition, studied prominently in sociology and demography, have not been studied examining differences in gender preferences by social status. Here, we closed this gap by examining what role fertility stopping as one important behavioral and preference-based mechanism plays in shaping sex composition at birth. Furthermore, our analysis provides several advantages as compared to previous research on the TW effect in parental investment: First, by focusing on parents' gender preferences rather than on specific parental investment indicators, we are better able to get at the overall picture of discrimination and avoid the problem that parents may make up investment differences in one domain by higher investment in another domain. Second, as compared to surveys asking for gender preferences directly, the stopping approach avoids social desirability issues. Third, by using register data we would have been able to detect even small effects. Fourth, by using Swedish register data we were able to study fertility stopping using a prospective design to make sure that we always measure parental status before the birth event.

We neither find support for fertility stopping that is clearly in the predicted direction of the TW hypothesis nor in the opposite direction. Therefore, our research contributes in an important way to dissecting the mechanisms that play a role in orchestrating the TW effect. In this case, a null result is meaningful, given that we can exclude one mechanism of a possible set of biological and behavioral mechanisms that could together be relevant in producing TW consistent behavior and sex composition. Our result is particularly important with regard to research on the TW effect in parental

investment. If we do not find a clear TW-consistent gradient in parental gender preferences, it is unlikely that parents show a TW-consistent investment pattern. Therefore future research on the TW effect should concentrate on exploring physiological effects producing status-biased sex composition and sex ratios. This finding is consistent with the evolutionary cost hypothesis that predicts that a TW mechanism should occur as earlier as possible between conception and post-partum in order to avoid sunk fitness costs.

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FIGURES AND TABLES

Table 1: Descriptive Statistics for Status Variables

<i>Status Variable</i>	<i>Grouping</i>	<i>N at 1st birth</i>	<i>Exposure** (in %)</i>
Socioeconomic status (Years: 1960-2000)	Workers (EGP=VI,VII)	1 431 851	41.5
	Self-employed & farmers (EGP=IVab,IVcd)		6.0
	Routine non-manual (EGP = IIIa,IIIb)		23.8
	Lower service class (EGP=II)		20.1
	Upper service class (EGP=I)		8.5
Educational level (Years: 1990-2007)	Primary	880 702	15.0
	Secondary		39.0
	Tertiary		46.1
Income* (1968-1989)	No income	1 019 076	15.1
	<150 000 SEK		14.9
	150 000 - 450 000 SEK		46.4
	450 000 - 750 000 SEK		21.5
	750 000+ SEK		2.1
Income + Transfers* (Years: 1968-1989)	No income	1 019 076	11.6
	<150 000 SEK		15.4
	150 000 - 450 000 SEK		48.6
	450 000 - 750 000 SEK		22.0
	750 000+ SEK		2.4
Fortune* (Years: 1968-1989)	No income	1 019 076	64.1
	<150 000 SEK		10.8
	150 000 - 450 000 SEK		10.1
	450 000 - 3 000 000 SEK		14.6
	3 000 000+ SEK		0.4
Parental Fortune* (Years: 1968-1989)	No income	1 019 076	63.7
	<225 000 SEK		7.3
	225 000 - 600 000 SEK		6.7
	600 000 - 3 750 000 SEK		20.4
	3 750 000+ SEK		2.0
* Annual income/fortune indexed to a time serie on wage developments for female industrial workers, indexed to 2004 wages			
**For models on transition from 2nd to 3rd child			

Fig. 1: Relative risks of transitioning to next child at parity 1, by sex of previous child and social status, controlling for period and age

Fig. 2: Relative risks of transitioning to next child at parity 2, by sex of previous children and social status, controlling for period and age

Fig. 3: Relative risks of transitioning to next child at parity 3, by sex of previous children and social status, controlling for period and age

Fig. 4: Relative risk ratios of transitioning to next child, comparing only boy with only girl families, by social status

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