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# Preference for Boys Does Not Necessarily Lead to a Gender Disbalance: A Realistic Example

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## Abstract

Intuitively, it seems that cultural preference for boys should lead to a gender disbalance – more boys than girls. This disbalance is indeed what is often observed, and this disbalance is what many models predict. However, in this paper, we show, on a realistic example, that preference for boys does not necessarily lead to a gender disbalance: in our simplified example, boys are clearly preferred, but still there are exactly as many girls as there are boys.

## 1 Formulation of the Problem

**Preference for boys – a cultural phenomenon.** In many cultures, it is important to have a son. So, if a family has a daughter, the parents continue to produce children until they have the desired son.

**In such situations, it is reasonable to expect gender disbalance.** Intuitively, it seems that this will lead to a gender disbalance, i.e., that we will have more boys than girls. Such a disbalance is indeed observed in many countries where cultures have such a preference, e.g., in Thailand.

This disbalance is predicted by several models of this phenomenon; see, e.g., [1].

**What we do in this paper.** In this paper, we consider a simplified model of preference for sons in which, somewhat surprisingly, this preference does not lead to a gender disbalance.

Our main simplifying assumption is based on the fact that in many countries with a strong preference for boys, most people are poor, they cannot afford to have too many children – even one child is not easy to support. For such countries, it is reasonable to make a simplifying assumption that, once the family gets a son, they stop producing children.

*Comment.* To make it understandable to people who are interested in demographic questions but may not be mathematically sophisticated, we have tried to make this example as mathematically clear as possible.

## 2 Description of Our Example

**Deriving the formula.** Let us make an additional simplifying assumption that each new child can be a boy or a girl with equal probability 0.5, and that genders of different children are statistically independent. In reality, the probabilities of having a boy and having a girl are slightly different from 0.5, but for our approximate computations, we can ignore this difference.

So, with probability  $1/2 = 2^{-1}$ , the first child is a son. In this case, according to our assumption, the family will stop producing children. So, in this case, the family will have 0 girls.

If the first child is a girl, then the family produces a second child. With probability  $1/2$ , this second child is a son. Since the genders of different children are statistically independent, the overall probability of this situation is equal to  $(1/2) \cdot (1/2) = 2^{-2}$ . In this situation, the family has 1 girl.

If the second child is also a girl, then the family produces a third child. With probability  $1/2$ , this third child is a son. Since the genders of different children are statistically independent, the overall probability of this situation is equal to  $(1/2) \cdot (1/2) \cdot (1/2) = 2^{-3}$ . In this situation, the family has 2 girls.

In general, the family can have  $n$  girls before they have a boy. The probability of such situation, when we have  $n$  girls followed by a boy, is equal to

$$(1/2) \cdot \dots \cdot (1/2) \text{ (} n \text{ times)} \cdot (1/2) = 2^{-(n+1)}. \quad (1)$$

In this model, each family has exactly one boy. The expected number  $g$  of girls in the family is equal to

$$g = 0 \cdot 2^{-1} + 1 \cdot 2^{-2} + 2 \cdot 2^{-3} + \dots + n \cdot 2^{-(n+1)} + \dots \quad (2)$$

**Computing the formula.** Let us find the value  $g$ . For this purpose, let us multiply both sides of the formula (2) by 2; then, each term  $n \cdot 2^{-(n+1)}$  becomes

$$2 \cdot n \cdot 2^{-(n+1)} = n \cdot (2 \cdot 2^{-(n+1)}) = 2^{-n},$$

so we get

$$2 \cdot g = 0 \cdot 2^0 + 1 \cdot 2^{-1} + 2 \cdot 2^{-2} + \dots + n \cdot 2^{-n} + \dots \quad (3)$$

Now, we can subtract, term by term, the formula (2) from the formula (3). Each term in both formulas has the form  $\text{const} \cdot 2^{-k}$ , for some natural number  $k$ . It is therefore natural to subtract terms corresponding to the same  $k$ .

- In the formula (2), we have  $k = n + 1$ , so  $n = k - 1$ , and the coefficient at this term is  $n = k - 1$ .

- In the formula (3), this term corresponds to  $k = n$ , so the coefficient at this term is  $n = k$ .

Thus, when we subtract the two expressions, each difference becomes

$$k \cdot 2^{-k} - (k - 1) \cdot 2^{-k} = 2^{-k},$$

so we get:

$$\begin{aligned} g = 2 \cdot g - g &= 0 \cdot 2^0 + (1 - 0) \cdot 2^{-1} + (2 - 1) \cdot 2^{-2} + (3 - 2) \cdot 2^{-3} + \dots = \\ &= 2^{-1} + 2^{-2} + 2^{-3} + \dots + 2^{-n} + \dots \end{aligned} \quad (4)$$

To compute the right-hand side of the expression (4), we can use the same trick: double both sides, as a result we get

$$2 \cdot g = 2^0 + 2^{-1} + 2^{-2} + \dots + 2^{-(n-1)} + \dots \quad (5)$$

When we subtract (4) from (5), all terms  $2^{-k}$  cancel each other, except for the term  $2^0$ :

$$g = 2 \cdot g - g = 2^0 + (2^{-1} - 2^{-1}) + (2^{-2} - 2^{-2}) + \dots = 2^0 = 1. \quad (6)$$

**Conclusion.** So, for each boy, we have, on average,  $g = 1$  girl – which shows that there is no gender disbalance, we have exactly as many boys as girls.

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## References

- [1] D. Basu and R. de Jong, “Son preference and gender inequality”, *Proceedings of the Annual Meeting of the Population Association of America AAA ’2018*, New Orleans, April 17–19, 2008, Section 16.