# 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 form 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

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

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

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

**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

$$2 \cdot g = 0 \cdot 2^0 + 1 \cdot 2^{-1} + 2 \cdot 2^{-2} + \ldots + n \cdot 2^{-n} + \ldots \tag{3}$$

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:

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

$$2^{-1} + 2^{-2} + 2^{-3} + \ldots + 2^{-n} + \ldots \quad (4)$$

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

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

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

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

**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.