HeforShe: Bargaining Power, Parental Beliefs, and Parental Speech Investments*

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Abstract

We estimate a model of intra-household allocation of time-intensive parental investments. To address the identification challenge of separating preferences, expectations, and bargaining power, we leverage a unique data combination. First, we derive the quantity and quality of maternal and paternal speech from day-long audio recording using a state-of-the-art neural network classifier. Second, we elicit expectations from each parent about the returns to speech. Third, we exploit hyper-local variation in female bargaining power arising from inheritance practices. Our model and estimation reveal how female bargaining power influences paternal investments: fathers provide more and higher-quality speech investments when women have greater bargaining power, but only when mothers expect investments to improve child language development. These results align with a collective model in which powerful women elicit paternal investment when they believe it is productive. Our results highlight the role of economic power rather than broader social status in driving these investments.

Keywords: Parental investments, Child-directed speech, Female bargaining power, Parental beliefs.

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1 Introduction

Parental investments during early childhood constitute a major determinant of child human capital development (see Attanasio et al. 2022; García and Heckman 2023 for overviews of the literature). In particular, a rich language environment in the early years is essential for young children's vocabulary and language acquisition, as well as their long-term development (Suskind, 2015; Bergelson et al., 2023), spurring recent interventions to foster verbal investments by parents (List et al., 2021; Cunha et al., 2024; Dupas et al., 2025). The existing literature, however, primarily focuses on *maternal* investments, overlooking both the influence of *paternal* investments and the intra-household allocation of these investments. Worldwide, over 93% of all rigorously-evaluated early parenting interventions have focused on supporting mothers exclusively (Jeong et al., 2021), even though over 70% of households with children have a father present (United Nations, 2022). Rising global levels of female labor force participation and persistent inequalities in the burden of care make it necessary to understand family dynamics over parental investments in children and the drivers of paternal involvement.

This paper studies the intra-household allocation of time-intensive investments in children by *both* parents. Our analysis rests upon a unique trifecta: (i) frontier measures of mother's and father's investments for the same child, (ii) data on beliefs held by both parents about the returns and costs of these investments, and (iii) external variation in women's bargaining power.

A key innovation is our measure of parental investment: speech. We measure maternal and paternal speech from day-long, child-centered recordings of 196 children aged 6 months to 4 years (mean = 25 months), captured using a small device fitted to the child's clothing. Recordings were analyzed with an end-to-end neural network, the Voice Type Classifier (VTC, Lavechin et al., 2021), trained with various child-centered corpora of similarly aged children exposed to multilingual environments and languages similar to our study. This approach allows us to estimate three key dimensions of speech investment by each parent: the overall quantity of speech, the quantity of child-directed speech, and the interaction quality of child-directed speech, as proxied by the pitch of the parent's voice while talking to the child.[1] These measures are correlated

[1] Emotional expressiveness, particularly higher pitch, is key in maintaining a child's attention and fostering social and cognitive engagement (see, e.g., Saint-Georges et al., 2013; Ramírez et al., 2020).

with direct and indirect measures of parental investment, such as breastfeeding and BMI.

Motivated by the evidence that parental beliefs about the technology of child development shape investment decisions (e.g., Boneva and Rauh, 2018; Attanasio et al., 2024; Cunha et al., 2022; Bhalotra et al., 2025), we elicit both mothers' and fathers' beliefs about the production function of language development, as well as their perceived costs of talking to children. Both mothers and fathers expect that frequent child-directed speech yields positive returns but also entails positive costs. Importantly for our analysis, the within-couple correlation in beliefs is very low.

Finally, we exploit deep-rooted cultural heterogeneity in female bargaining power offered by our field setting, the Solomon Islands in the Pacific. Here, the prevalence of matrilineal inheritance, where daughters inherit land from their mothers, varies hyper-locally, even *within* ethno-linguistic groups (BenYishay et al., 2017). We establish that matrilineal inheritance is a reliable proxy for female bargaining power. Women in matrilineal villages enjoy advantages in the household, such as greater leisure and ownership of female-preferred assets, while matrilineal and patrilineal villages are otherwise comparable in terms of socio-economic, political, and cultural characteristics.[2]

Our data collection takes place among small-scale subsistence communities, isolated from major market centers and without any market-based solutions for child care. The rich cultural variation and subsistence context make our setting particularly well-suited for our analysis, minimizing biases from the joint determination of labor force participation, childcare, and bargaining power, as well as unobserved inputs into the production function of child development. Moreover, multilingualism and strong oral traditions shape how children learn in this context, making parental speech a particularly salient input in the production of early skills.

The data show that, on average, mothers talk to children twice as much as fathers. However, a key finding is that fathers invest more in speech in matrilineal villages, by 27% on average. We build a stylized model of intra-household allocation of parental speech investments to guide our investigation of the mechanism explaining this finding. Our modeling choices are informed by the local context and by empirical evidence that matrilineal inheritance is associated with differences in female bargaining power,

[2] See also, e.g La Ferrara (2007); Gneezy et al. (2009) and Lowes (2022) for evidence on the connection between matrilineal inheritance and female bargaining power.

but not in assortative mating, quality of the spousal match, expected returns and costs of parenting, or individual opportunity cost of time. We thus consider a collective household model in which the mother's Pareto weight in the collective utility function is higher under matrilineal inheritance. Both parents derive utility from child language development but bear a cost associated with speech investments. Parents have imperfect information about the language production function and form individual-specific beliefs about the return of their investment.

The model provides insights into how expected returns, perceived cost of investment, and female bargaining power influence paternal investments. It predicts that both the father's investment and, crucially, the responsiveness of his investment with respect to the mother's expected returns, increase with the mother's Pareto weight. This latter prediction suggests that mothers leverage their bargaining power to elicit paternal investment when they believe the investment is productive, and provides our main mechanism of interest.

Our estimation of the structural parameters of the model reveals our main empirical result, which is consistent with our theoretical prediction: fathers invest more in child speech when mothers have greater bargaining power *and* expect higher returns to investment. A one standard deviation increase in mothers' expected returns to parental speech increases fathers' speech investments by 0.39 standard deviations in matrilineal villages. This result holds for measures of quantity as well as quality of child-directed speech. Further, we show that the additional paternal investment is primarily directed towards girls. The estimation also reveals distinct pathways for paternal and maternal investments. Fathers are more responsive to their perceived costs of investment, while mothers respond primarily to their expected returns. Our results are robust to alternative modeling choices of the Pareto weights, utility functions, costs, and expected returns.

We implement a number of additional analyses to rule out alternative mechanisms. A potential concern is the presence of confounders that systematically vary with the interaction between female bargaining power and mothers' expected returns. We show that husbands of high-returns mothers in matrilineal villages are observationally similar to others, including in terms of expected returns and cost of speech, education, income sources, and social preferences. High-returns mothers in matrilineal villages are also similar to others, including in terms of fertility, and so are their children. Further, we show that our results are not driven by conversations between husband and wife or other proxies of the quality of the marriage. Overall, this suggests that our result is not driven by assortative matching, a quantity-quality tradeoff, inter-generational transmission, or other confounders of mothers' beliefs in matrilineal villages.

Second, we establish that our results are specific to speech investment. While fathers do spend more time with children when mothers have more bargaining power, they only invest more in *speech* when mothers also have high expected returns to child-directed speech. Moreover, the results on paternal speech are robust to conditioning on the the time spent with children. This shows that the quantity and quality of paternal investments are specific to the domains where mothers expect high returns.

Finally, we pinpoint the role of *economic* power in driving paternal investment, as opposed to other potential dimensions of female status, including kin and family networks linked to post-marital residence patterns (Bau, 2021). We provide additional evidence on the influence of *individual* economic power by leveraging within-village variation in the death of the mother's parents and in bride price.[3] These results further rule out unobserved variation across inheritance structures driving our results.

The sociocultural environment of our setting mirrors that of many other children worldwide. Half of pre-primary-age children around the world – about 175 million – are not enrolled in formal childcare or early childhood education (UNICEF, 2019), and between half and two-thirds of the world's population use two or more languages in their daily life, especially in Africa, South Asia, and Oceania, where many local languages have limited written materials and early learning relies heavily on spoken interaction (UNESCO, 2025). In addition, an estimated 1.5 billion people globally live under customary land tenure systems (Rights and Resources Initiative, 2015), and 14% of pre-industrial societies practiced matrilineal inheritance (Murdock, 1967). Together, these parallels highlight the broader external relevance of our setting and the value of studying parental investment in this environment.

Our work contributes to several literatures, starting with the economics of parenting. Parental investments play a crucial role in shaping children's development, especially in the early years (see, e.g., Cunha and Heckman, 2007), with specific benefits of speech investments for child human capital development (Suskind, 2015). An expanding body of work studies the determinants of parental investments in children

[3]See Anderson (2007); Ashraf et al. (2020); Lowes and Nunn (2018) for evidence on bride price and women's economic power.

(see Doepke et al. 2019; Doepke and Zilibotti 2019 for recent reviews). However, this literature provides only limited evidence on fathers' investments. Most theoretical models abstract from intra-household dynamics by assuming a representative parent and child (see discussion in Doepke et al., 2019), while empirical studies predominantly focus on mothers.[4] Our key contribution is to jointly examine investments by both parents, as well as what shapes the intra-household allocation of these investments.

We achieve this through a novel approach that combines frontier and objective measures of parental investment with data on parents' probabilistic beliefs about investment returns and perceived costs, and variation in bargaining power. A basic identification problem in understanding the drivers of parental investment is that observed investments are consistent with many alternative specifications of preferences, expected returns, perceived costs, and bargaining power (Manski, 2004). Our data allow us to disentangle their respective roles and answers calls in the literature by Manski (2004), Almås et al. (2024), and Caplin (2025) to measure typically unobserved constructs—such as expectations and bargaining power—to improve inference on decision-making. More broadly, our study contributes to the growing literature on subjective expectations and decision-making under uncertainty (Bachmann et al., 2023). While this literature has advanced rapidly, data capturing expectations about the same outcomes from *multiple* household members remain rare. As a result, heterogeneity in intra-household expectations, and its implications for household choices, has been largely unexplored. Exceptions include Giustinelli (2016) on parent–teenager expectations in school choice and Ke (2025) on within-couple disagreement in macroeconomic expectations.[5] Here, by exploiting within-household differences in expectations and variation in bargaining power, we identify whose beliefs shape each parent's investments.

This paper also makes several contributions to the literature on the importance of

[4] See Evans and Jakiela (2024) for a recent survey of the emerging literature on fathers' involvement in low- and middle-income countries, including studies that engage fathers and other household members alongside mothers (e.g., Betancourt et al. 2020). For data on parenting styles among both mothers and fathers in high-income countries, see Doepke and Zilibotti (2019). See also Giannola (2024) for an example of how parents allocate resources between siblings.

[5] Almås et al. (2024) also emphasize the data requirements for studying parental investments, providing an illustration with elicited beliefs, elicited preferences, and measures of bargaining power from mothers and fathers in Tanzania. However, their data, unlike ours, does not link parents' beliefs within the same couple.

kinship and social structures for the status of women, human capital formation, and economic development (e.g., Henrich, 2016; Bahrami-Rad et al., 2022). While most evidence highlights how social structures affect group-level outcomes, our theoretical and empirical approach microfounds these aggregate relationships. We provide the first estimation of a structural model that identifies a specific mechanism through which social structures interact with individual-level characteristics to predict individual behavior. Related literature connects female-biased cultural practices, such as matrilineal inheritance (La Ferrara, 2007; Gneezy et al., 2009; Lowes, 2022), matrilocal residence (Bau, 2021), and bride price (Anderson, 2007; Ashraf et al., 2020; Lowes and Nunn, 2018) to women's bargaining power, autonomy, and status, as well as to parental investments in children. Uniquely, we leverage both within-ethnicity and individual variation, attenuating potential concerns about unobserved heterogeneity across ethnic groups. Moreover, we exploit rich variation in inheritance, residence, and marriage payment practices to disentangle various dimensions of female status.

Finally, this paper contributes to the literature on computational modeling of language by developing improved and new measures of child-directed speech, parental time spent with children, and spousal conversations (see Appendix C). In particular, our pitch-based measure of parental vocalizations offers a new, scalable, automated, low-cost approach for measuring both the quantity and interaction quality of child-directed speech, bridging the gap between scale and qualitative insights.

2 Background: Context and Matrilineal Inheritance

Our study takes place in the Solomon Islands, an archipelago of the South Pacific inhabited by Austronesian-speaking peoples.[6] The richness of cultural diversity in the region has long attracted the attention of anthropologists like Marshall Sahlins, who noted how "the native peoples of Pacific Islands unwittingly present to anthropologists a generous scientific gift: an extended series of experiments in cultural adaptation" (Sahlins, 1963). Typical of Austronesian-speaking societies, the Solomon Islands exhibits remarkable linguistic and cultural diversity with 72 distinct living languages.[7]

[6] Austronesia extends from Madagascar to New Zealand, spanning the Indian Ocean and South Pacific. The Austronesian language family comprises more than 1,000 distinct languages spoken by over 360 million people (Blust, 2009).

[7] See Ethnologue, accessed 2 July 2025. The extent and persistence of cultural diversity in the region is partly due to geographical fragmentation, limited reach of a centralized state, small popu-

Matrilineal inheritance. Unlike Eurasia and South Asia, where patrilineal inheritance is almost universal, many Austronesian societies practice female-centric kinship and inheritance, where land is passed from mothers to daughters — the predominant pattern of transmission among matrilineal cultures also practiced by many African and Native American societies.[8] According to the Ethnographic Atlas (Murdock, 1967), 14% of the world's pre-industrial societies practiced matrilineal inheritance, with shares ranging from 7% in the Circum-Mediterranean region to 20% in the Pacific and pre-contact societies of North America.[9] Genetic, linguistic, and archaeological evidence establish the ancestral prevalence of matriliny in Austronesia, dating as far back as the original dispersal and settlement of Austronesian peoples into Oceania around 5,000-4,500 BP (Jordan et al., 2009).

Austronesian societies also vary in the degree of unilineality, i.e., how strictly descent is passed solely through one parental line.[10] Accordingly, in our data, we measure matrilineal prevalence as a continuous variable, M_h, which takes a value of 0 in exclusively patrilineal villages (41.5% of our sampled villages), 0.25 in villages where patrilineal inheritance is dominant but not exclusive (26.8%), 0.50 in villages where matrilineal and patrilineal inheritance are equally prevalent (7.3%), 0.75 in villages where matrilineal inheritance is dominant but not exclusive (14.6%) and 1 in exclusively matrilineal villages (9.8%).[11] The mean value of M_h is 0.30, with a

lation sizes, and climatic variability (Giuliano and Nunn, 2021).

[8]In a minority of matrilineal cultures, property remains under male control, with land transferred from a maternal uncle to his sister's son. This form of inheritance is concomitant with avunculocal residence, where a male child is expected to join his maternal uncle's residence. Avunculocal residence is a minority practice in matrilineal systems (Kopytoff, 1977), prevalent in only 4.3% of societies recorded in the Ethnographic Atlas, and absent in our setting. In line with this, in our sample, uncles are hardly involved in their sisters' children's lives, even less so than unrelated individuals, with no difference by matriliny (Cassar et al., 2025).

[9]Matrilineal descent is presumed to have been more common before the adoption of livestock and plough agriculture, with colonial institutions and Western legal systems further accelerating the shift to patriliny (Holden and Mace, 2003). Other forms of inheritance recorded in the Standard Cross Cultural Sample (SCCS; Murdock and White, 1969) include patrilineal inheritance, prevalent in 40% of societies, or mixed systems of double (5%) or ambilineal descent (3%). The remaining societies have "bilateral descent without corporate kin group", recognizing relatives on both mothers' and fathers' sides without forming the basis for permanent, property-holding collective entities.

[10]A similar situation is found in West and Southern Africa, in contrast with other parts of sub-Saharan Africa, which have strictly unilineal structures.

[11]The matrilineal prevalence variable codes the village leader's answers to the question: "How is land inherited in this village?" - (i) father; (ii) mother; (iii) both, but mostly father; (iv) both, but mostly mother; (v) both, mother and father equally; (vi) other. We check the robustness of our results to coding M_h as a categorical variable (Figure 2).

standard deviation of 0.35.

Our context also offers variation in patterns of post-marital residence (either in the bride or groom's village) and in marriage practices, even within a given inheritance structure and ethno-linguistic group. Variation in post-marital residence is common within other matrilineal societies (Kopytoff, 1977).[12] We leverage the variation in post-marital residence and bride price in Section 6.3 to disentangle economic bargaining power from other dimensions of female status.

Broader economic and social context. The fragmented and remote geography of the Solomon Islands creates prohibitive trade costs, making market access extremely limited for most inhabitants outside the national or provincial capitals.[13] As a result, people rely overwhelmingly on subsistence horticulture and fishing. In our sample, less than 5% of respondents derive any income from paid work. On average, people work in their gardens a couple of times a week and sell goods in the market roughly once a month. Men fish a couple of times a week and women a few times a month. Only 7% of households in our sample have access to grid electricity, and 3% to improved sanitation.

Limited disposable income, high trade costs, and low market development imply the absence of market-based solutions for child care. Rural villagers do not have access to books, manufactured toys, daycare centers, or electronic resources, with no internet access.

This absence of books and written texts makes language the primary medium for education. Children must learn through oral tradition about their environment, horticultural and fishing techniques, as well as kinship, origin stories, genealogies, songs, and spells and prayers, which are of high cultural significance and central to family and village life.[14] Linguistic diversity also means that children have to learn multiple languages, reinforcing the importance of speech investments for language acquisition. Moreover, oral persuasion is an important source of social and political power, enabling the rise of so-called "Big Men" among relatively flat political structures and

[12] Out of the 26 matrilineal societies in the SCCS, 69% have matrilocal residence. In the matrilineal societies of the Pacific, the split is 50/50.

[13] In our sample, the main mode of transport is by ship or outboard canoe and, in general, access to roads is extremely limited. The average travel time between a village in the sample and the provincial capital is six and half hours, and the average travel time to the country's capital city is two and a half days, leaving most communities isolated from major markets.

[14] Anthropological research has documented the sophistication of oral traditions in the Solomon Islands, some of which reliably extend back nearly 1,000 years (Sheppard et al., 2004).

further reinforcing the importance of oratory skills (Henrich et al., 2015).

Our focus on speech investment is thus particularly relevant for our setting. The children in our sample have a median age of 2, a critical time for language acquisition. Existing research is consistent with differences in early language exposure having long-lasting effects ranging from language perception and production (Coffey and Snedeker, 2025) to academic achievement (Golinkoff et al., 2019) and emotional connection with parents (Smith and Trainor, 2008).

3 Data

3.1 Sample and Data Collection

We collected data from June to August 2019 in 44 villages across two provinces of the Solomon Islands, Western and Choiseul. Through public lotteries, we randomly selected 20 individuals in each village (roughly 5% of the average village population). To achieve representativeness at the village level and ensure that we had a sufficient number of couples with at least one child in the target age range (aged 6 months to 4 years old), we stratified the sampling to select 5 married couples (5 women, 5 men) and 10 additional individuals (5 women, 5 men). The full sample consists of 825 individuals, and the analytical sample of recordings includes 182 married couples, for whom we surveyed both wife and husband.[15] Appendix D details the survey measures. In a few cases where the couple had more than one child within the target age range, we included the additional children, for a total of 196 children.[16] Table A1 displays descriptive statistics for the analytical sample. Children in our sample are 25 months (median 24 months) on average, and 98.15% of children are 3 years old or younger. Mothers are 29 and fathers are 33 years old, and have 3 children, on average.

3.2 Speech Measures from Neural Network Classification

We collected day-long child-centered recordings using a wearable device, an increasingly used technique in early language development research (Lavechin et al., 2021).

[15]The sampling strategy aimed to recruit 44 x 5 = 220 couples in total. The final sample is smaller due to small population sizes in some villages.

[16]We check that our results are invariant to dropping the 14 additional children, or to clustering standard errors at the household level to account for correlated observations across siblings.

Children wore a t-shirt fitted with two small breast pockets, each containing a USB voice recorder. Parents were informed that the recorders would capture speech spoken to and by the child, and assured that the content of their conversations would not be listened to. Consent was near universal, with only one family declining participation.

We used two recorders per child to account for the fact that some devices may stop functioning. In total, we obtained 377 recordings for 196 children.[17] On average, recordings lasted 15.4 hours (SD 4.3 hours, range 0.11 minutes - 24 hours). Fewer than 5% of the recordings are less than 6 hours, which is similar by matriliny. We provide more information on the recording technology in Appendix Section C.

Speech recordings. We analyzed recordings with a Voice Type Classifier (VTC, Lavechin et al., 2020). VTC is an end-to-end neural network trained on child-centered corpora of children aged 0-4 years in multilingual environments, including Austronesian languages, that match the conditions of our study. For every 10 ms frame, VTC returns whether the key child (i.e., the child wearing the recording device), other children, an adult female, or an adult male is vocalizing. A vocalization is defined as a sequence of frames where the relevant speaker vocalizes.

A precursor of this method, called LENA, has been used for over a decade in the USA (for a meta-analysis see Wang et al., 2020) and in recent evaluations of interventions promoting parental verbal engagement in Senegal (Weber et al., 2017) and Ghana (Dupas et al., 2025). Our software solution relies on recent neural network architectures that improve the accuracy of female and male voice classification (Lavechin et al., 2020) and our hardware solution is better adapted to rural conditions with no internet or electricity. In Appendix Section C, we discuss how VTC compares with LENA and manual annotations performed on a subset of 384 1-minute clips randomly sampled from the recordings.

Measures of parental speech investments. We construct four measures of parental speech investments that capture the total quantity of speech, the quantity of child-directed speech, and the quality of child-directed speech.

First, following standard practice in the field (Cristia et al., 2020), we count the number of vocalizations attributed to the relevant speaker (e.g., adult male or adult female) across the entire recording. We divide this count by the total recording duration and scale it to a 12-hour day (i.e., a typical waking day) to produce a

[17] For 16 children, one USB failed completely. One child used three devices after one failed a few hours into the day and was replaced.

normalized per-day figure. These adult female and male **vocalizations per day** constitute our main measure of parental investment.[18] In robustness exercises, we consider alternative time ranges to best match actual patterns of awake vs. sleep time. While these vocalizations include both speech directed to the child and speech simply overheard by the child, prior work establishes that the overall quantity of adult vocalizations is positively correlated with children's production of speech-like vocalizations, which we verify in our data.[19]

We then construct both standard and novel proxies for the quantity and quality of child-directed speech. We start with the standard measure commonly used in LENA-based studies (see, e.g., Romeo et al., 2018; Dupas et al., 2025; Cunha et al., 2024), the **Conversational Turn Count** (CTC), which tallies child-adult or adult-child vocalization sequences. The aim of CTC is to capture conversations. However, because it may count sequences that are not actually conversations, such as a child vocalizing after an adult speaks, regardless of whether the child is responding, interrupting, or simply talking to themselves, CTC is a noisy measure (Cristia et al., 2020).

To improve the measurement of speech directed to the child, we build on research linking pitch to child-directed communication. Child-directed speech, often called motherese or parentese, is universally characterized by higher pitch (Cox et al., 2023). High-pitch speech captures young children's attention and promotes engagement. Infants respond more positively to high pitch speech, reinforcing parental use and fostering a feedback loop that enhances communication, supporting early language development, turn-taking in conversations, and vocabulary growth (e.g., Saint-Georges et al., 2013; Ramírez et al., 2020). Pitch is also a strong predictor of the emotional connection between caregiver and child (Smith and Trainor, 2008).

Drawing on these insights, we develop two new measures of child-directed speech that combine temporal proximity (in the spirit of CTC) and pitch characteristics. Specifically, we identify adult vocalizations that occur within one second of a child vocalization and compute the average pitch within each such vocalization.[20] Our

[18] A potential concern with this measure is that it might reflect proximity to the child rather than actual stimulation. We measure time spent with the child and show that our results are not mediated by how much time the father spends with the child.

[19] See Bergelson et al. (2023). In our data, children produce 60 (33) more vocalizations for every 100 female (male) vocalizations.

[20] On average, relative to the rest of the recording, adult female pitch is 1.1 standard deviations higher and adult male pitch is 0.72 standard deviations higher within one second of the key child's vocalization, confirming that parents in our sample raise their pitch in the presence of the child.

quality proxy, **median pitch** (or **pitch** for short), is defined as the median of these average pitch values for a given speaker type. Our quantity proxy, **vocalizations at high pitch**, counts the number of vocalizations whose pitch exceeds that median for a given speaker type.

The current state of technology does not allow us to distinguish speaker identity beyond adult female, adult male, key child, and other children's voices. From hereon, we consider female (male) vocalizations as mothers' (fathers') vocalizations. This assumption may introduce measurement error, but it is reasonable given that children in our sample spend the vast majority of their time with their parents. Other than parents, children receive the most care from their maternal grandmother and from neighbors and friends, who on average take care of the child between once a week and several times a month in our sample (see Cassar et al. 2025 for more detail). To ensure that our conclusions are not affected by such potential measurement error, we account for the frequency of care by female and male individuals other than the parents in robustness specifications.[21]

Table A1 presents descriptive statistics for the four measures of parental speech for adult female (mothers) and adult male (fathers) speakers. Overall, mothers vocalize more than twice as much as fathers, have more conversational turns with the child, and more vocalizations at high pitch. Consistent with sex-based differences in voice qualities, mothers' median pitch is higher than fathers', but mothers also *elevate* pitch more than fathers during a conversational turn with children, suggesting more intense engagement with children when talking to them.[22]

Additional speech-based measures. We build additional measures of parental care and spousal communication from the recordings, which both constitute innovations in the computational linguistics literature. We proxy *overall parental care* by parental presence around the child, which we calculate from the calendar time of speech logged in our speech recordings. In Appendix Figure A1, we show, for every hour of the day, (a) whether an adult male or female speaks, and (b) the average

[21] We additionally show in columns 12 to 14 of Table A6 that care by people other than the parents is unrelated to mothers' expected returns, matriliny, and their interaction. Potential measurement errors, therefore, would be orthogonal to our main variables of interest.

[22] When we regress pitch on whether the mother or father is speaking during a conversational turn with the child, the coefficient associated with the interaction between mother's voice and the conversational turn is positive and statistically significant at the 1% level, and suggests that mothers elevate their pitch by about 50% more than fathers when speaking to the child.

number of male and female vocalizations. Speech is concentrated between 8 am and 10 pm. Both male and female speech occur consistently throughout the day, reflecting the nature of economic activities that leave parents with small children for a large part of the day. We proxy parental presence around the child as the number of hours with at least 10 adult male (or female) vocalizations to proxy for the amount of time the father (or mother) spends near the child. We also measure *spousal conversations* as the daily count of adult male-female conversations that are not interspersed with child speech (see Appendix C).

Parental speech as parental investment. Given the novelty of our parental speech investment measures, we validate them using several direct and indirect proxies of parental investment collected for a subset of children.[23] These proxies include: (i) the duration of breastfeeding, a standard indicator of maternal investment (Jayachandran and Kuziemko, 2011); (ii) child BMI, which reflects both maternal prenatal investment and, in low-food environments, paternal provisioning; (iii) child cortisol levels from hair samples, a biomarker of socio-emotional well-being linked to parental care and attachment (Doom et al., 2018); and (iv) the maternal child loss ratio (children deceased over children ever born),[24] a long-run indicator related to early-life maternal investment (Almond and Currie, 2011).

Across these measures, we consistently find that greater parental speech investment is associated with better child outcomes (Table A2). Breastfeeding duration is positively correlated with all maternal speech measures. Child BMI is strongly and significantly associated with paternal speech (total vocalizations, vocalizations at high pitch, conversational turns) and with maternal total and high-pitch vocalizations. Maternal speech, especially high-pitch vocalizations, is positively correlated with child socio-emotional well-being. Finally, mothers' speech investments are negatively and significantly associated with the child loss ratio.

[23]Hair samples were collected only in Western Province because enumerators in Choiseul had to transport all materials and food supplies on a multi-week round trip with no intermediate storage, making it impractical to carry biosamples. Due to enumerator error, some breastfeeding and BMI data are also missing for some children.

[24]The average maternal child loss ratio in our sample is 3%, in line with national statistics in the 2019 Census of 3.3% and 3.9% under-five mortality rate in Western and Choiseul.

3.3 Expected returns and costs of child-directed speech

We measure both mothers' and fathers' beliefs about the returns to speaking to children by eliciting subjective probabilities that a child achieves a language development milestone under two hypothetical scenarios: frequent communication (high investment) and infrequent communication (low investment) from the caregiver. Following standard practice in low-income settings (Delavande, 2023), respondents were provided with 10 beans to express their beliefs in a probabilistic format, where each bean represents one chance out of 10. The language milestone was that a child strings together 2-3 words by the age of 2, as in Bhalotra et al. (2025). Data Appendix D details the exact wording, and Appendix B.1 discusses the data in more detail.

Appendix Figure A2 shows considerable heterogeneity in parental beliefs. Parents expect a higher probability of a child speaking 2-3 words by age 2 under the high investment scenario.[25] We transform the data into expected returns by taking the difference in expected outcomes between the high and low investment scenarios at the individual level. Men and women expect, on average, that frequently talking to the child, as opposed to rarely, will increase the likelihood of the child speaking sentences by age 2 by 43 percentage points. The distribution of expected returns is similar for mothers and fathers (p-value of 0.483 on a Kolmogorov-Smirnov test of equality of distributions shown in panel (a) of Figure 1).

Within couple, there is substantial heterogeneity in expected returns. This distinction is crucial: if parental beliefs were perfectly correlated, we would be unable to identify their respective influences on parental investment or the influence of spousal bargaining power. Correlation in parental returns could stem from assortative matching on beliefs, spousal communication or persuasion, or learning from a shared environment (including their child's specific ability). However, the raw correlation in our data is only 0.009. Panel (c) of Figure 1 displays the complete distribution of couples according to each partner's return. Very few couples are along the 45-degree line, where the distribution would fall if beliefs were perfectly correlated. The observed heterogeneity in beliefs, combined with limited correlation within couples, suggests that parents rely on different information sets and/or process the same information

[25] For both mothers and fathers, the mean answer is 7 in the high-investment scenario and 3 in the low-investment scenario. In the US context, 72% of children speak partial sentences by age 2 (Cunha et al., 2022), suggesting that our respondents' average expectations are well calibrated. We present additional data quality checks in Appendix B.1.

differently to form expectations.[26]

We also elicit mothers' and fathers' perceived cost of talking to their child on a scale from 0 to 10 (see Appendix D). Perceived costs are slightly higher for mothers compared to fathers (p-value of 0.005 on a Kolmogorov-Smirnov test of equality of distributions, see Panel (b) of Figure 1). Spousal correlation in costs of speech is slightly higher than for returns, but still low (0.221), and the distribution of spousal costs in Panel (d) in Figure 1 shows a wide dispersion of perceived costs within couples.

3.4 Descriptive facts

We establish four facts about matrilineal inheritance and parental investments.

Fact 1: Fathers talk more to children in matrilineal villages, but mothers do not.

Mothers invest more in parental speech than fathers. However, mothers' investments do not vary with matriliny (Table 1, column 1). By contrast, fathers invest substantially more in parental speech in matrilineal villages, by 27.15% on average (column 2). Panel (c) of Figure A1 further illustrates this pattern: at every hour of the day, the paternal investment distribution in matrilineal villages lies above that in patrilineal villages (even though fathers appear to be present at similar times of day).

Fact 2: Women in matrilineal villages enjoy advantages within the household consistent with higher female bargaining power, within identical socio-economic, political, and cultural contexts.

Panel A of Table 2 shows that women in matrilineal villages enjoy more leisure time, marry later (by an average of 1.7 years relative to a mean of 22 years), and share less with their spouse in a dictator game, an indication of a greater economic power within the household (Gnagey et al., 2018). Column 4 and 5 show how the distribution of household assets is tilted towards female preferences, with matrilineal households more likely to own a toilet and a stove (Panel A), but not an outboard motor or mobile phone (Panel B). Together, these results suggest a positive relationship between

[26] Prior research documents learning from social networks, often gendered in structure, about child outcomes (e.g., Sandberg 2006; Bellue 2024). As shown in Table A3, mothers with more kin in the village and who take care of other children more often expect higher returns to speech, suggesting that exposure to other children, whether through caregiving or kin networks, may influence beliefs by providing observational learning opportunities about the effectiveness of speech.

matriliny and female bargaining power, consistent with existing literature (Lowes, 2022) and ethnographic evidence (Stege, 2008).[27]

Yet, matrilineal women are identical to patrilineal women in terms of other socio-demographic characteristics, such as age or cognitive ability (columns 6 and 7), participation in productive activities (columns 8 and 9), participation in formal governance structures (column 10), and social preferences (columns 11 and 12). Panel B shows no difference in any of the outcomes for men, confirming the absence of broad socio-demographic, economic, political or cultural differences by matriliny.

Fact 3: Expected returns and cost do not vary by matriliny.
Table 1 (columns 2, 3, 6, 7) shows that neither mothers' nor fathers' expected returns and costs vary by matriliny. This indicates that inheritance systems do not generate systematic differences in how parents evaluate the returns or costs of parenting.

Fact 4: There is no difference in assortative matching, learning, quality of the spousal match, or spousal communication by matriliny.
Columns 9 and 10 of Table 1 show that the within-couple *gap* between mother's and father's expected returns, or costs, do not vary by matriliny. This gap captures both assortative matching on expected returns and costs of parental investments as well as learning from each other or a shared environment. Column 11 additionally shows the absence of difference in assortative matching in terms of cognitive ability by matriliny, ruling out spousal cognitive ability as a potential driver of paternal investment differences across matrilineal and patrilineal villages. Consistent with the absence of broad cultural differences across matrilineal and patrilineal villages and the absence of differences in assortative matching, we observe no difference in either spouse's tendency to compete with one another, a measure of spousal cooperation (Lowes, 2022), suggesting that household harmony does not vary with matriliny in our context (columns 4 and 8). Further, column 12 shows that levels of spousal communication are also identical across inheritance structures, ruling out that paternal investments in matrilineal villages are driven by more talkative fathers in general, or by spousal conversations not directed to the child.

[27] As stated by a woman of Palau island, in Micronesia, "the women here are so sure of themselves ... maybe it's that we know for sure that we have land ... Even if I don't get land from my husband, I still have it from my mother and nothing can change that" (cited in Stege, 2008).

4 A stylized model of parental speech investments

To understand why fathers invest more in parental speech in matrilineal villages while mothers do not, we present a stylized model of intra-household allocation of parental investment showing the role of bargaining power, parental expectations about child development, and parental cost of investment. Matriliny may affect parental investments through multiple channels, but the descriptive facts indicate that it does not influence assortative matching, perceived returns, perceived costs, or opportunity cost of time. Motivated by this evidence, we abstract from marital choice, and model matriliny as operating primarily through a shift in intra-household bargaining power, highlighting in particular the interaction between expected returns and bargaining power. We build on the seminal collective model of Chiappori (1988), which starts from the basic assumption that, in a multi-person household, household members have their own utility functions but cooperate in a bargaining process that results in a Pareto-efficient allocation.

We consider a household with a mother m, a father d and one child c. Each parent i derives utility from the child's human capital, proxied by language development Θ, and incurs a cost represented by a twice-differentiable convex cost function $C_i(x_i)$ associated with their time-intensive investment x_i. Parent i's utility is given by:

$$U_i(x_i, \Theta) = \omega_i \Theta - C_i(x_i), \quad i = m, d \tag{1}$$

where ω_i is parent i's utility associated with the child's language development.[28]

The cost function $C_i(x_i)$ incorporates both the direct effort cost of investment and the opportunity costs of foregone productive time. Fact 2 (similar economic activities by matriliny) suggests that systematic differences in opportunity costs of time are unlikely. We therefore treat $C_i(x_i)$ as a reduced-form cost that captures all effort and time costs without modelling time allocation explicitly. In Appendix B.2, we extend the model to incorporate time-allocation choices, allowing the opportunity cost of time to arise endogenously from economic activities and vary by matriliny. Importantly, the main comparative statics regarding expected returns, costs, and bargaining power continue to hold.

Looking at the household decision-making, we assume a collective model in which

[28] The assumption of linear utility in the child's language development is made for expositional clarity. All comparative statics continue to hold if $\omega_i(\cdot)$ is strictly increasing and concave.

the household utility function is a weighted sum of the mother's and father's expected utility function, U_m and U_d respectively:

$$U = \alpha U_m + (1 - \alpha)U_d. \tag{2}$$

The parameter α, often referred to as a Pareto weight, captures the relative importance given to the mother's utility in the couple's utility function. In our main analysis, α is assumed to vary with the inheritance structure in the village where the couple lives. In further analyses, we also consider bride price and having inherited land as Pareto weight shifters. The key characteristic of the collective model is that household decisions are efficient. This efficiency is achieved by maximizing the household utility function U subject to household constraints. As standard in these models, we assume common knowledge of individual preferences and expectations.

The household faces a language production function constraint. The objective production function of child c's language is as follows:

$$\Theta(x, \theta_0) = \mu_0 + \mu_1\theta_0 + \mu_2 x + \zeta_c, \tag{3}$$

where θ_0 is the child's human capital endowment at birth, x is the total investment received by the child, and ζ_c denote a mean-zero variable unknown to the parents at the time the investment decision is made. The parameter μ_0 is a constant term, the parameter μ_1 captures the productivity of initial endowment, the parameter μ_2 measures the elasticity of the investment in producing language development, while ζ_c are unexpected shocks that influence child development, such as the onset of an illness.[29]

The standard model assumes that parents know the actual production function. We relax this assumption and allow each parent to have their own subjective expectations over the parameters describing returns to investment. The production function that parent i *perceives* is given by:

$$\Theta_i(x, \theta_0) = \eta_{i,0} + \eta_{i,1}\theta_0 + \eta_{i,2}x + \xi_i, \quad i = m, d, \tag{4}$$

where $\eta_{i,j}$ are individual-specific beliefs about the production function parameters,

[29] Existing work typically assumes linearity, CES or Cobb-Douglas production function (e.g., Cunha et al. 2022; Tincani et al. 2022). We discuss robustness to relaxing the linearity assumption in Appendix B.2.

x is the total investment received by the child from both parents, and ξ_i is a zero-mean variable that captures beliefs uncertainty and is independent of investments. The assumption that the subjective production function depends on total investment x supposes that father's and mother's speech inputs are perfect substitutes. This simplifying restriction is not essential for our results: the same comparative statics hold under any speech aggregator $\Phi(x_m, x_d)$ that is increasing in both inputs.

Given these beliefs, parent i's expected utility is based on their own perceived production function, formulated as:

$$\mathcal{E}U_i(x_i, \Theta_i(x_d + x_m, \theta_0)) = \omega_i(\eta_{i,0} + \eta_{i,1}\theta_0 + \eta_{i,2}(x_d + x_m)) - C_i(x_i), \quad i = m, d. \tag{5}$$

The couple will choose the investment levels x_d and x_m to maximise the household expected utility subject to two effort constraints $x_i \leq X_i, i = m, d$. The expected household utility function is given by:

$$\begin{aligned}\mathcal{E}U = {} & \alpha\big[\omega_m\big(\eta_{m,0} + \eta_{m,1}\theta_0 + \eta_{m,2}(x_m + x_d)\big) - C_m(x_m)\big] \\ & + (1-\alpha)\big[\omega_d\big(\eta_{d,0} + \eta_{d,1}\theta_0 + \eta_{d,2}(x_m + x_d)\big) - C_d(x_d)\big].\end{aligned}$$

Assuming an interior solution, the first-order-conditions (FOCs) with respect to x_m and x_d are given by:

$$\frac{\partial \mathcal{E}U}{\partial x_m} = \alpha\left(\omega_m\eta_{m,2} - C'_m(x_m)\right) + (1-\alpha)\omega_d\eta_{d,2} = 0. \tag{6}$$

$$\frac{\partial \mathcal{E}U}{\partial x_d} = \alpha\omega_m\eta_{m,2} + (1-\alpha)\left(\omega_d\eta_{d,2} - C'_d(x_d)\right) = 0. \tag{7}$$

These FOCs first establish that the optimal investment strategy of a parent is increasing in both their and their spouse's expected returns $\eta_{m,2}$ and $\eta_{d,2}$ and decreasing in their own marginal cost. The FOCs also show that the father investment is increasing in the mother's Pareto weight α (and vice versa for mothers).

We are interested in how the father's investment x_d responds to changes in the mother's belief parameter $\eta_{m,2}$. We use implicit differentiation on the FOC for x_d with respect to $\eta_{m,2}$:

$$\frac{\partial}{\partial \eta_{m,2}}\left(\alpha\omega_m\eta_{m,2} + (1-\alpha)\left(\omega_d\eta_{d,2} - C'_d(x_d)\right)\right) = 0. \tag{8}$$

Solving for $\frac{\partial x_d}{\partial \eta_{m,2}}$, we have:

$$\frac{\partial x_d}{\partial \eta_{m,2}} = \frac{\alpha \omega_m}{(1-\alpha) C''_d(x_d)}. \tag{9}$$

Thus, the responsiveness of the father's investment to the mother's beliefs $\frac{\partial x_d}{\partial \eta_{m,2}}$ is increasing in her pareto weight α (and vice versa for mothers). This means that paternal investment will be more responsive to the mother's expected return when she has higher bargaining power.

The model is simple, designed to profile parents' decision-making process over their respective time-intensive investment in children and the role of bargaining power and beliefs. Our model omits other potentially important aspects, such as multidimensional skills, the role of financial inputs, the child's agency, and labor force participation. These simplifications are suited to our context. Our focus is on early childhood (6 to 48 months), where the child has yet no agency and speech development is the primordial skill, and in a subsistence economy context, where opportunities for financial investments in children and formal employment are limited.

In Section 5, we estimate the optimal maternal and paternal investment by exploiting unique data on parental investments x_d and x_m, parental beliefs $\eta_{d,2}$ and $\eta_{m,2}$ and shifter of the Pareto weight α.

5 Estimation and Results

5.1 Model Specification and Identification

Our objective is to estimate the optimal parental investments given by equations (6) and (7). To ensure tractability, we impose several parametric assumptions. First, we assume that the convex cost function is given by $C_i(x_i) = \chi_{i,1} x_i + \chi_{i,2} \frac{x_i^2}{2}, \chi_{i,1} \geq 0, \chi_{i,2} \geq 0$. Under this functional form assumption, the optimal level of investment x_m^* and x_d^* are linear in perceived returns and given by:

$$x_m^* = \frac{\omega_m}{\chi_{m,2}} \eta_{m,2} + (\frac{1-\alpha}{\alpha}) \frac{\omega_d}{\chi_{m,2}} \eta_{d,2} - \chi_m \tag{10}$$

$$x_d^* = \frac{\omega_d}{\chi_{d,2}} \eta_{d,2} + (\frac{\alpha}{1-\alpha}) \frac{\omega_m}{\chi_{d,2}} \eta_{m,2} - \chi_d \tag{11}$$

where $\chi_i = \frac{\chi_{i,1}}{\chi_{i,2}}, i = m, d$.

Second, we assume that the cost parameters χ_m and χ_d are a linear function of the individual perceived cost of talking to children (see section 3.3), as well as parent, child, and household characteristics, which we describe below, so that: $\chi_i = \kappa_{1,i} C_i + \gamma_i X_{i,c,h}, i = m, d$.

Third, we rely on matrilineal inheritance as a bargaining power shifter. In particular, we assume that $\frac{\alpha}{1-\alpha}$ is linearly related to the prevalence of matrilineal inheritance in the village such that: $\frac{\alpha}{1-\alpha} = \beta M_h$, $\beta > 0$ (implying $\frac{1-\alpha}{\alpha} = \frac{1}{\beta M_h}$),[30] so that the mother's Pareto weight α is increasing in matrilineal inheritance prevalence.

Fourth, we assume there is an additive measurement error in our parental speech measures. This error is assumed to be normally distributed with a mean of zero. Since the measurements of maternal and paternal investments are derived from the same recording, we allow for the possibility that the measurement errors may be correlated between maternal and paternal investments.

Our parametric assumptions yield optimal investments in equations (10) and (11) that are linear in expected returns and perceived costs. These expressions can be interpreted as linear approximations to the true optimal investment rules (Keane and Wolpin, 1997). We assess the robustness of our estimates to alternative assumptions in Appendix Section B. In particular, we relax the linearity assumption of the subjective production function of language and consider different specifications of the cost function. We also allow for spousal altruism and for different functional forms of the relationship between matrilineal inheritance and female bargaining power, namely relaxing the linearity assumption.

We estimate optimal parental investments using Seemingly Unrelated Regressions (Zellner, 1962):

$$\begin{aligned} Speech_{m,c,h} = a_m + \delta_{1,m}\eta_{m,2} + \delta_{2,m}\eta_{d,2} + \delta_{3,m}\frac{1}{M_h}\eta_{d,2} + \delta_{4,m}\frac{1}{M_h} \\ + \kappa_{1,m}C_m + \gamma_m X_{m,c,h} + \epsilon_{m,c,h} \end{aligned} \tag{12}$$

$$\begin{aligned} Speech_{d,c,h} = a_d + \delta_{1,d}\eta_{d,2} + \delta_{2,d}\eta_{m,2} + \delta_{3,d}M_h\eta_{m,2} + \delta_{4,d}M_h \\ + \kappa_{1,d}C_d + \gamma_d X_{d,c,h} + \epsilon_{d,c,h}, \end{aligned} \tag{13}$$

with $cov(\epsilon_{m,c,h}, \epsilon_{d,c,h}) = \sigma_{m,d}$.

[30] The $1/M_h$ term in the mother's investment equation creates a singularity issue for purely patrilineal villages. We replace $M_h = 0.1$ when $M_h = 0$ to take the ratio. We acknowledge this potential limitation of the linear approximation and consider alternative specifications in robustness, including a logistic specification, which show the main results are not sensitive to this functional form choice.

The dependent variable $Speech_{i,c,h}$ is a measure of speech by parent i to child c in household h. Because each child wore two USB devices, we construct child-level averages, weighted by the recording duration, for each measure. We estimate separate systems for the four speech outcomes. The term $\eta_{i,2}$ is i's beliefs about the returns to speaking to children.[31] The variable M_h measures the prevalence of matrilineal inheritance (hereafter, matriliny) in the village. The term C_i is the reported perceived cost of talking to children. The vector $X_{i,c,h}$ captures how the cost of talking to children varies with parent, spouse, child, and household level characteristics, including the child's age and gender, parent i's age, occupation, and cognitive ability, household wealth, the number of children in the household, and whether the recorded child is the father's biological child.[32] We include a set of province fixed effects throughout, omitting the province subscript for simplicity, and cluster standard errors at the village level. We weight each child-level observation by the sum of the recording durations to account for heterogeneity in the length of recordings, driven by random technical or incidental factors, that may affect the precision of our estimates.

Comparing the optimal investment rules in equations (10) and (11) with the estimating equations (12) and (13) clarifies which parameters of the structural model are identified and how. Because we observe separate belief measures for mothers and fathers, and because these beliefs display substantial within-couple heterogeneity, we can exploit this intra-household variation to identify how each parent responds to (i) their own beliefs and (ii) their spouse's beliefs. The coefficients on own beliefs, $\delta_{1,i} = \frac{\omega_i}{\chi_{i,2}}$, therefore capture the structural responsiveness of each parent's investment to their own perceived returns and are expected to be positive.

Identification of the bargaining power mechanism relies on both cross-village variation in matriliny M_h, which shifts the ratio $\frac{\alpha}{1-\alpha}$ but does not affect beliefs or costs

[31] If parental investments are perceived as perfect substitutes, the expected return is a measure of $\eta_{i,2}$. If parental investments are perceived as imperfect substitutes, the expected return is a weighted average of the subjective elasticities of father's and mother's investments in the child language production function.

[32] Since our fieldwork took place in the context of the roll-out of an RCT about child-directed speech, which targeted either mothers or fathers, we also control for treatment assignment in all specifications. All the variables we used were measured pre-intervention. Treatment assignment is balanced by matriliny (P-value of 0.801 for the coefficient on mother treatment condition, and 0.986 for father treatment condition, where M_h is the dependent variable) and was implemented after we measured subjective beliefs and costs. We were unable to collect follow-up data on the intervention due to COVID-19 and the country's shutdown.

(consistent with Fact 3), and on within-village variation in expected returns. The interaction coefficients, $\delta_{3,d} = \beta \frac{\omega_m}{\chi_{d,2}}$ and $\delta_{3,m} = \frac{1}{\beta} \frac{\omega_d}{\chi_{m,2}}$, thus measure how responsive each parent is to their spouse's beliefs at high versus low spousal bargaining power. These coefficients map directly into the model parameters and are predicted to be positive.

To identify interaction terms between spouse's beliefs and matriliny, the corresponding main effects must also be included. These main-effect coefficients ($\delta_{2,i}$ and $\delta_{4,i}$) absorb baseline variation in spouse's beliefs and matriliny but do not have a structural interpretation.

Variation in perceived costs C_i and observed characteristics $X_{i,c,h}$ identifies the parameters $\kappa_{1,i}$ and γ_i, which determine how the cost term χ_i in the first-order condition varies across individuals. These parameters capture how perceived and observable factors make investment effectively more or less costly for each parent.

The model therefore identifies the structural ratios governing how beliefs, costs, and bargaining power influence investments. Under our assumptions, the model predicts that parents increase investment when they expect higher returns ($\delta_{1,i} > 0$), higher perceived costs reduce investment ($\kappa_{1,i} < 0$), and the responsiveness to a spouse's beliefs is increasing in spousal bargaining power ($\delta_{3,m} > 0$ and $\delta_{3,d} > 0$).

5.2 Results

Before turning to the structural model, we describe how parents' vocalizations vary with their own expected returns and costs, and with their spouse's expected return and bargaining power.

Column 1 of Table 3 (Panel A for fathers and Panel B for mothers) reveals an asymmetric pattern across genders in the relationships of parental investments to *own* returns and costs. Fathers' investments do not respond to own expected returns, but rather are driven only (negatively) by own costs. In contrast, mothers' investments respond positively to own expected returns but not to own perceived costs.[33]

[33]Quantitatively, a one standard deviation increase in fathers' perceived costs is associated with a 0.11 standard deviation decrease, whereas a one standard deviation increase in mothers' returns is associated with a 0.13 standard deviation increase in vocalizations. The p-value for the difference in return coefficients across genders is 0.065; for cost coefficients, 0.102. These patterns are unlikely to be driven by greater measurement error in fathers' perceived returns: the distributions of mothers' and fathers' return beliefs are statistically similar, and fathers are no more likely than mothers to violate monotonicity in the practice probability question (Appendix B.1).

Column 2 of Table 3 additionally considers spouse's expected returns. The coefficients associated with spouse's returns are small and statistically insignificant, both for fathers and mothers, indicating that spousal beliefs about returns do not affect individual investments, on average. In addition, and consistent with Fact 1, the coefficient associated with female bargaining power (*Matriliny*) is consistently positive, large, and statistically significant in predicting fathers' total vocalizations, while mothers' total vocalizations are not responsive to male bargaining power (*1/Matriliny*).

We now turn to the structural model, which illustrates the mechanism through which matriliny increases paternal investment. Column 3 of Panels A and B of Table 3 presents the estimation results of Equations (12) and (13). The key mechanism emerges from fathers' responses to mothers' beliefs. The coefficient on the interaction between mothers' expected returns and matriliny (Panel A, column 3) is positive and statistically significant at the 5% level. This aligns with the model prediction: when women hold greater bargaining power, their expected returns exert a stronger influence on fathers' investments. The magnitude is large. A one standard deviation increase in mothers' returns is associated with a 0.39 standard deviation increase in fathers' speech in matrilineal villages.

For mothers, the coefficients associated with fathers' returns are insignificant, regardless of bargaining power. Together with the result that fathers' investments are unresponsive to their own returns, this suggests that fathers place relatively low value on language development,[34] and therefore do not leverage their bargaining power to elicit maternal speech investments, rationalizing why maternal investments do not vary by matriliny.

For additional flexibility, column 4 augments column 3's specification to allow for own preference and direct cost parameters to vary with bargaining power. The results are similar. If anything, the main coefficient of interest associated with the interaction between matriliny and mothers' returns in driving paternal speech investments is larger in magnitude and more precisely estimated. Table A4 displays all the coefficients associated with each of the included cost shifters. Mother vocalizations decrease with child age (at a decreasing rate) and older mothers vocalize more. Fathers' vocalizations are driven only by the interaction between mothers' bargaining power and mothers' beliefs.

[34]To be precise, this evidence is consistent with a low $\frac{\omega_d}{\chi_{d,2}}$.

As shown in Table A5, the results become larger in magnitude and more precisely estimated when we restrict recordings to intervals that best correspond to times when the child is awake (based on Figure A1). This pattern is consistent with parental vocalizations during these periods being more likely to capture speech investments.

Since our framework reveals that the main dynamic of interest is between *paternal* investments and *mothers*' bargaining power and expected returns, we henceforth focus on paternal investments. Nevertheless, given that the estimates also confirm that measurement errors are correlated across maternal and paternal investments (the χ^2 of a Breusch-Pagan test of independence in column 4 is 44.71 with p-value< 0.001), we maintain our joint estimation strategy. We present the most flexible specification that corresponds to our model, as in column 4 of Table 3.

We examine other measures of quantity and interaction quality of paternal speech investments in Table 4.[35] For CTC, the coefficient associated with the interaction between mothers' returns and matriliny is positive but imprecisely estimated, consistent with an attenuation bias due to measurement errors in the CTC measure discussed in Section 3.2. However, it is positive and statistically significant for paternal vocalizations at high pitch (column 2) and paternal pitch (column 3), implying that both the quantity and the quality of paternal child-directed speech are more responsive to mother's returns when women have more bargaining power. A one standard deviation increase in mothers' returns is associated with a 0.27 standard deviation increase in the number of fathers' vocalizations at high pitch and a 0.44 standard deviation increase in fathers' pitch in matrilineal villages. These results suggest that the increased paternal speech investment induced by mothers with higher returns in matrilineal villages is both child-directed and more engaging.

Finally, we allow matriliny to flexibly shift bargaining power using categorical variables for inheritance systems. Figure 2 shows a monotonic increase in the responsiveness of paternal investments with respect to mothers' returns as matriliny prevalence rises, confirming that our conclusions are not an artifact of the functional form for M_h.

We also examine whether paternal investments vary by child gender by augmenting Equation (13) with a triple interaction of maternal returns, matriliny, and female child to allow for the preference parameter for language development to differ by child gender. The results in Table A8 show that paternal speech induced by high-returns

[35]Table A10 shows evidence of good model fit for both parents and all speech outcomes.

mothers in matrilineal villages is primarily directed toward girls.[36]

6 Threats to identification of the main mechanism

This section further supports our interpretation of the mechanism through which female bargaining power affects paternal investment. We rule out that our results are driven by key confounders, distinguish speech from general care, and show that the effects are specific to economic bargaining power.

6.1 Confounders of maternal beliefs in matrilineal villages

Because we identify $\delta_{3,d}$ (which captures how the father's responsiveness to the mother's expected return varies with her bargaining power) through the interaction of mothers' expected returns and matriliny, a concern is the presence of potential confounders that systematically vary with this interaction. For example, women with more bargaining power and higher returns may systematically marry spouses who speak more to the child (e.g., because they have low cost or high return) or are more conversational in general; or they may have children who elicit more paternal speech.

In Panel A of Table A6, we regress fathers' characteristics on mothers' returns, matriliny, and the interaction between the two. The results show that the husbands of high-returns matrilineal women are observationally similar to other men in terms of returns and costs of child-directed speech, age, formal education, income source, leisure, social preferences, from whom they receive help with childcare, or their in-migration status. Similarly, Table A6 shows that the *children* of high-returns matrilineal women are also observationally similar to other children (columns 1 and 2). As shown in Panel B, high-returns matrilineal women *themselves* are not observationally different from other women, along a wide range of characteristics, including fertility (thereby ruling out a quantity-quality tradeoff as an alternative mechanism), as well as age, education, economic activity, leisure, social preferences, or how much help with childcare they receive from various caretakers. Overall, other characteristics of these women, their children, or husbands are unlikely to confound our result. Using

[36] The coefficient associated with the triple interaction is positive and precisely estimated for total vocalizations with our continuous measure of matriliny. For other speech outcomes, the estimates are less precise using the continuous measure, but are statistically significant when using a binary indicator for purely matrilineal villages in columns 4-6.

our novel measure of spousal conversation from the recordings, Table A7 shows no difference in spousal conversation driven by high returns mothers in matrilineal villages, and further shows that our results on paternal speech are robust to conditioning on spousal conversations.

To gauge the possible influence of other, unobservable dimensions of the couple or their child, we perform a randomization inference test, in which we randomly reassign the mother's returns over 1,000 repetitions. In this procedure, we keep all other dimensions of the match between a husband and wife, as well as the child's characteristics, constant and only systematically vary the mother's returns. Figure A4 shows that our estimated coefficients of interest on the interaction between mother's returns and matriliny are well outside the range of coefficients estimated from the random reassignments.

6.2 Father's presence versus speech investment

Women with bargaining power may be able to elicit more paternal care overall. If so, do our results simply derive from paternal care or do they truly reflect a domain-specific response to maternal beliefs?

Using our recording-based measure, Column 1 of Table 5 shows that fathers spend more time with their children in matrilineal villages. However, this outcome does not vary with mothers' expected returns in matrilineal villages (column 2). In other words, all women with higher bargaining power elicit more paternal care, but only mothers with higher expected returns elicit *specific* investments in speech. We further show that our results on speech investments are robust to conditioning on the amount of time fathers spend with their children (columns 3-5 of Table 5). Together, these results confirm that our speech measures capture targeted investments, not simply time spent around children, and that paternal investments respond specifically to the domain of maternal beliefs.

6.3 Mothers' economic power as the driver of investment

Matrilineal inheritance may capture female status, beyond economic bargaining power. To isolate the role of economic power from other dimensions of female status, we leverage variation along both individual inheritance and residence patterns.

Under matrilocal residence patterns, newly married couples reside in the bride's village after marriage (see, e.g. Bau 2021). Women have closer access to their kin in matrilocal places and higher social status, but not necessarily more land or assets that would confer economic bargaining power. Fifteen percent of the villages in our sample are matrilocal (with the remaining patrilocal), about half of which are also primarily matrilineal (M_h more than 0.5). This variation enables us to separate the influence of status and kinship networks from economic bargaining power. Even columns in Panel A of Table 6 report the estimation results of Equation (13) for our outcomes of interest replacing M_h by a dummy variable taking value one if the village is matrilocal. In contrast with matrilineal inheritance, we do not observe higher paternal speech investments in matrilocal villages, even when mothers expect high returns. Odd columns show that all our results on matrilineal inheritance and both quantity and quality of paternal speech are robust to conditioning on matrilocality, even when matrilocality is also interacted with beliefs.

We offer direct evidence on individual women's economic power in Panel B of Table 6. In columns 1 to 3, we first leverage variation stemming from quasi-random variation in whether a woman has lost a parent, which generates variation in whether she has already inherited land. We re-estimate Equation (13) replacing M_h by an individual level variable that takes value one if the woman has inherited land. Relying on such individual level variation enables us to augment our specification with village level fixed effects so that we compare, within a village and traditional inheritance structure, women who have high *realized* economic bargaining power vs. women who have not (yet) inherited. The results show that higher quantity of paternal investment is driven by high returns women who have already inherited land. They also rule out that unobservable village level variation drives our main results.

In columns 4 to 6, we rely on another source of within-village, individual female economic bargaining power, stemming from marriage practices. The practice of bride price has been associated with higher educational investments in girls (Ashraf et al., 2020) and higher bargaining power and more autonomy conferred to women (Anderson, 2007; Lowes and Nunn, 2018). In our sample, 34.23% of women have received a bride price at marriage, with traditional money (consisting of shell money, porpoise teeth, or feathers) as the main form of payment.[37] The practice of bride price is uncorrelated with the prevalence of matrilineal inheritance at the village level (raw

[37]For the remaining 63.76% of marriages, no exchange of money or goods took place, and in 2.01% of the cases, there was a reciprocal gift exchange.

correlation: 0.005) but more prevalent, although not universal, in patrilocal villages (raw correlation: 0.28), consistent with the ethnographic record (Anderson, 2007). Results show that the husbands of high returns women who have received a bride price talk more to their child and do so at a higher average pitch, with the measures of total vocalizations and pitch statistically significant at the 5% level and results for vocalizations at high pitch close to standard levels of statistical significance.

7 Robustness to modeling and specification choices

In this section, we assess the robustness of our results to alternative theoretical assumptions about expected returns, Pareto weights, utility functions, and costs.

We first provide non-parametric evidence by plotting the distribution of fathers' vocalizations according to matrilineal inheritance and mothers' expected returns. Figure A3 shows that the median, 25th, and 75th percentiles of fathers' vocalizations are higher for men married to high returns mothers in matrilineal villages. Median vocalizations by fathers married to high returns mothers in matrilineal villages are one standard deviation higher than median vocalizations in any other group. These non-parametric differences indicate that the patterns we document are not driven by functional-form assumptions or by outliers.

In Appendix B.1, we discuss the quality of our probabilistic beliefs data, and the robustness of our results to alternative modeling choices for beliefs that address potential measurement error. Table B1 shows that our conclusions remain unchanged after excluding the small number of respondents who violate the monotonicity of probabilities in practice questions, incorporating observations with negative returns to investment in speech, excluding observations with missing returns or costs, and addressing potential measurement errors in beliefs by averaging across our primary measure of returns to speech and alternative metrics, as in Cunha et al. (2022) and Bhalotra et al. (2025). We also provide evidence on the extent of within-village variation in beliefs and costs across various types of inheritance practices, showing no spatial clustering in the distributions of beliefs and costs (Figure A5 and Table A9). Another potential concern is that people ex-post rationalize their beliefs, for example, reporting low returns to justify the low investments they made due to their high costs. The correlation between beliefs and cost is positive and very low (0.0126 for mothers and 0.0391 for fathers), limiting this concern.

We then consider robustness to alternative assumptions about Pareto weights. We have already discussed the results when we flexibly shift the bargaining power by using categorical variables for each inheritance system (Figure 2). In Section B.2 of the Appendix, we consider alternative functional forms for the relationship between Pareto weights and matriliny, including relaxing the linearity assumption between $\frac{\alpha}{1-\alpha}$ and M_h. Under some of these alternative specifications, the preference parameters are overidentified and we estimate them jointly out of the two optimal investment equations. Results in Tables B3 and B4 show that our results are robust across all measures of paternal investments.

We also consider alternative assumptions about the agents' utility function. We first consider spousal altruism, allowing individuals to internalize their spouse's cost of parental speech, with altruism parameter that can also vary with matriliny. We then relax the linearity assumption in the subjective language production function (Equation 4). All our results carry through (see Table B5, Section B.2 and Table B6).

We finally consider different assumptions about the cost function. In Table B7, we first show that our results are insensitive to the choice of conditioning variables entering the cost function. Our results are almost identical without any child or parent-level variables entering the cost functions (columns 1, 2, with column 3 as baseline for comparison), with more flexible specifications of the cost function, allowed to vary by matriliny (column 4), when the cost also accounts for the amount of care that the child receives separately from caretakers other than their parents or for whether the child has a big sister (columns 5, 6),[38] when parents' costs depends on the day of the recording (by conditioning on date fixed effects, column 7), or when accounting for unobserved heterogeneity across linguistic groups with language fixed effects (column 8). In column 9, we include vocalizations by children other than the key child in the cost function, since inputs by other children may crowd out or substitute for parental investments. Again, our results are unchanged. Columns 10-13 further demonstrate that our findings are stable when we account for other potential determinants of parents' opportunity cost of time, such as the presence of a market, a primary school, or the village's governance structure.

[38] Considering care by other caretakers also accounts for the possibility that the recorded vocalizations may not be from the child's parents. The results are robust and close in magnitude to our main estimates, suggesting that such potential measurement error does not influence our results.

Lastly, we show that our results are robust to different assumptions about the structure of the error terms and sample (see Appendix B.2).

8 Conclusion and Policy Simulations

This paper studies the intra-household allocation of speech investments in children. We document large gaps in speech investments in children between mothers and fathers. Yet, we show that female bargaining power can tilt the division of parental investment. Fathers invest substantially more in matrilineal communities, and we identify the mechanism underlying this pattern: when women hold greater bargaining power and believe that speech matters for child language development, they elicit more, and more engaging, speech from fathers. We show that these results are unlikely to be driven by assortative matching between parents, learning, or communication, by other characteristics of parents and children, or by unobservable village, partners, or child level differences. Paternal investment does not simply reflect higher paternal care but specific investment that matches the mother's beliefs. We provide further evidence leveraging individual-level variation within villages and inheritance structures that singles out the role of female economic bargaining power from other dimensions of female status. Altogether, our results suggest that women with greater economic power are able to elicit from their spouses the investment that they believe are productive.

We use the estimated structural parameters to simulate how mothers and fathers respond to three policy levers: providing information to mothers, lowering fathers' costs of talking, and increasing women's bargaining power (Table 7). Column 1 reports the baseline predicted by our model. Column 2 reports the effects of information interventions that increase mothers' perceived returns to verbal engagement, similar to Dupas et al. (2025) and Cunha et al. (2024). These interventions shift mothers' perceived return $\eta_{m,2}$ in the subjective production function. Informed by belief changes documented in earlier programs (discussed in Bhalotra et al. 2025), we model a 0.40 SD increase in this parameter. Column 3 simulates reducing fathers' costs of talking by a similar extent, an intervention that could be implemented through fathers' groups or activities that make father–child verbal engagement more enjoyable. Column 4 examines a female empowerment intervention, modeled as shifting inheritance rules from fully patrilineal to equal inheritance ($M_h = 0$ to $M_h = 0.5$) in patrilineal villages, consistent with securing women's control over resources (e.g., Field et al., 2021).

Increasing mothers' perceived returns raises predicted paternal speech by about 6% in matrilineal villages, has no effect in patrilineal villages, and yields modest gains in maternal speech. Reducing fathers' costs produces only a 1–2% increase in paternal vocalizations in both types of villages. By contrast, female empowerment leads to a 17% increase in total fathers' vocalizations in patrilineal villages. Overall, the empowerment intervention generates far larger increases in paternal investments than either raising maternal beliefs or lowering fathers' costs, but the interventions operate differently across contexts: information interventions are effective in matrilineal villages, empowerment has its strongest effects in patrilineal villages, while reducing fathers' costs has universal but modest effects.

The policy implications of our findings extend beyond these exercises. Our study demonstrates the effectiveness of a scalable and cost-efficient method for measuring various dimensions of paternal and maternal language inputs and male-female bargaining. This method, coupled with our approach of measuring beliefs and costs, provides a comprehensive framework for understanding parental investment decisions. We hope this work inspires future research to adopt similar data collection strategies, furthering our understanding of the economics of parenting and promoting rich, engaging, and fruitful parental investments in children.

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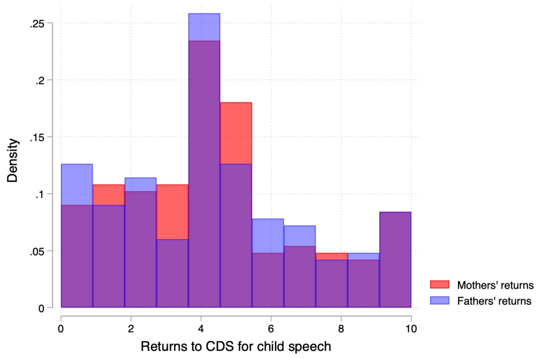
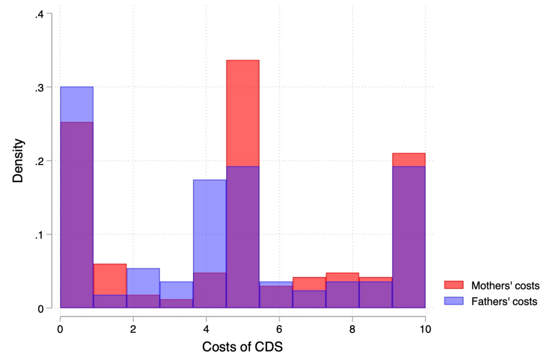
9 Figures and Tables

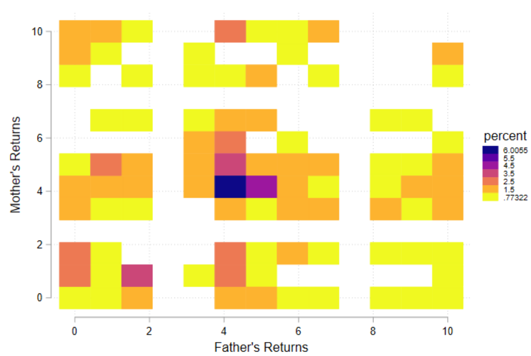
Figure 1: Mothers' and fathers' beliefs about returns and costs of Child-Directed Speech (CDS)



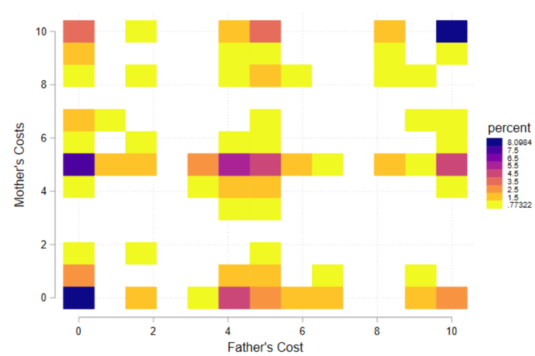
(a) Returns to CDS



(b) Costs of CDS



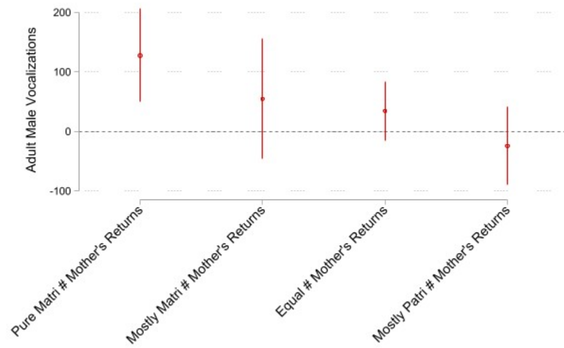
(c) Correlation of returns



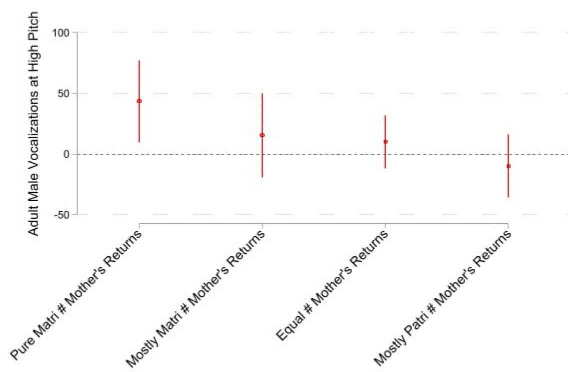
(d) Correlation of costs

Panel (a) display mothers' and fathers' expected return to talking to their child. A Kolmogorov-Smirnov tests of equality of the distributions has a p-value of 0.483. Panel (b) displays mothers' and fathers' costs of talking to their child. A Kolmogorov-Smirnov test of equality of the distributions has a p-value of 0.005. Panels (c) and (d) show a heat map of the correlation between mothers' and fathers' returns and costs, respectively.

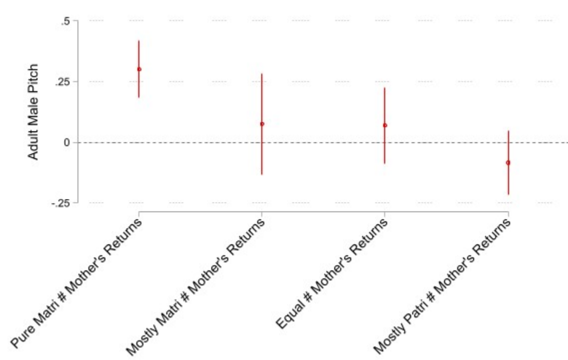
Figure 2: Main results by land inheritance category



(a) Vocalizations



(b) Vocalizations at High Pitch



(c) Pitch

The figures plot the joint estimation results of equations (12) and (13) when M_h is a categorical variable and displays father results. The dots correspond to the coefficients associated with the interaction between the mother's returns and each land inheritance type (as indicated). The vertical lines represent 90% confidence intervals. Pure patriliny is the omitted category. The dependent variable in Panel (a) is the total number of adult male vocalizations per day. The dependent variable in Panel (b) is the number of vocalizations at high pitch per day, where the high pitch threshold is above the speaker's median pitch within 1 second of child vocalization. The dependent variable in Panel (c) is the median pitch of the adult male speaker's voice within 1 second of a child vocalization.

Table 1: Matriliny, parental investments, beliefs and costs, and assortative matching

	Mothers				Fathers				Couples			
	Vocs	Returns	Costs	Compete	Vocs	Returns	Costs	Compete	|Diff Returns|	|Diff Costs|	|Diff Cognition|	Conversations
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Matriliny	-2.307	-0.453	-0.235	0.040	356.313*	-0.476	0.428	0.075	-0.474	-0.510	-0.224	18.866
	(231.112)	(0.643)	(0.787)	(0.114)	(208.997)	(0.587)	(0.711)	(0.119)	(0.511)	(0.410)	(1.505)	(53.051)
Observations	196	182	182	182	196	182	182	182	182	182	182	196
Mean DV	2782.89	4.32	4.96	0.59	1312.15	4.36	4.50	0.59	3.17	3.37	7.12	485.95
SD DV	931.40	2.76	3.59	0.48	560.82	2.89	3.57	0.48	2.46	2.95	4.81	250.69

* $p < 0.10$, ** $p<0.05$, *** $p < 0.01$. OLS estimates. In columns (1) and (5), the unit of observation is a child recording, and the dependent variable is the total number of adult female and male vocalizations per day, respectively. In columns (2)-(4) and (6)-(8), the unit of observation is the mother and the father, respectively, and the dependent variables are: expected returns (2 and 6), perceived costs (3 and 7), and whether the parent competes with their spouse in the competition task (4 and 8). In columns (9)-(11), the unit of observation is a couple, and the dependent variables are the absolute value difference in mothers' and fathers': expected returns (9), perceived costs (10), and cognitive abilities (11). In column (12), the unit of observation is a child recording and the dependent variable is the number of conversations between the adult female and male speakers per day. All estimates control for the child's age, age squared, and gender, the number of children in the household, whether the recorded child is the father's biological child, the household asset index, and a province fixed effect. Columns (1)-(4) additionally control for mother's cognitive ability, while columns (5)-(8) control for father's cognitive ability. Columns (9), (1), and (12) control for both mothers' and fathers' cognitive ability. Missing observations imputed for beliefs, cognitive ability, and competition, and all estimates include indicator variables for missing observations. Standard errors clustered at the village level in parentheses. Columns (1) and (12) weight estimates by the total duration of recordings.

Table 2: Matriliny and female bargaining power among otherwise similar socio-economic and cultural-political contexts

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A: Women	Leisure Time	Age at Marriage	Share Sent to Spouse	Toilet	Stove	Age	Cognitive Ability	Occupation Land	Occupation Fish	Village Leadership	Generalized Trust	Reciprocity
Matriliny	0.819***	1.733**	-0.127*	0.219**	0.196**	-2.041	0.954	-0.081	0.037	0.033	-0.213	0.020
	(0.291)	(0.733)	(0.074)	(0.100)	(0.086)	(1.341)	(1.106)	(0.111)	(0.069)	(0.109)	(0.239)	(0.509)
Mean DV	3.12	22.08	0.47	0.34	0.32	31.43	11.46	0.54	0.12	0.48	2.49	7.25
SD DV	1.60	4.37	0.26	0.47	0.47	7.26	6.28	0.50	0.33	0.50	1.08	2.57
Panel B: Men	Leisure Time	Age at Marriage	Share Sent to Spouse	Mobile Phone	Outboard Motor	Age	Cognitive Ability	Occupation Land	Occupation Fish	Village Leadership	Generalized Trust	Reciprocity
Matriliny	0.526	0.308	-0.047	0.050	-0.038	-0.359	-0.021	0.062	0.027	0.096	0.250	0.019
	(0.389)	(1.366)	(0.070)	(0.081)	(0.065)	(1.383)	(0.874)	(0.163)	(0.154)	(0.121)	(0.256)	(0.571)
Mean DV	3.32	25.81	0.56	0.73	0.27	34.65	13.67	0.35	0.31	0.75	2.61	7.54
SD DV	1.49	4.80	0.24	0.45	0.44	6.98	6.19	0.48	0.46	0.43	1.26	2.75

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. OLS estimates. Each cell is the coefficient from the regression of the dependent variable indicated at the top of the column on the matriliny variable, controlling for a province fixed effect and clustering standard errors at the village level (in parentheses). The sample includes all individuals selected in the public lottery who have children. In Panel A, the unit of observation is female respondents, and in Panel B, it is male respondents. *Leisure Time* indicates the amount of time the respondent spends doing leisure activities, where 0 = never; 1 = less than once a month; 2 = more than once a month; 3 = once a week; 4 = a couple times a week; 5 = everyday, a little bit; and 6 = every day, for a large part of the day. *Age at Marriage* is the age at which the respondent got married in years. *Share Sent to Spouse* is the share of the dictator game endowment sent to the respondent's spouse. *Toilet*, *Stove*, *Mobile Phone*, and *Outboard Motor* are binary variables equal to one if there is a toilet, stove, mobile phone, or outboard motor in the household. *Age* is the respondent's age in years. *Cognitive ability* is the number of correct puzzles solved (out of 24). *Occupation: Land* is a binary variable equal to one if the respondent's primary income source is from farming or logging. *Occupation: Fish* is a binary variable equal to one if the respondent's primary income source is from fishing. *Village Leadership* is a binary variable equal to one if the respondent is a member of any leadership organizations in their village. *Generalized Trust* is measured with the following question: "Generally speaking, would you say that most people can be trusted, or that you can't be too careful in dealing with people", where 1 is complete distrust and 5 is complete trust. *Reciprocity* is measured with the following question: "How well does the following statement describe you as a person? I try especially hard to help someone who has helped me in the past, where 0 does not describe me at all and 10 describes me perfectly."

Table 3: Returns, Costs, and Vocalizations

DV: Adult vocalizations per day	(1)	(2)	(3)	(4)
Panel A: Father's Vocalizations				
Matriliny	376.779**	377.949**	4.432	196.246
	(175.461)	(178.756)	(215.959)	(426.157)
Father's Returns	-5.914	-5.286	-4.972	2.741
	(11.947)	(12.875)	(13.279)	(17.040)
Father's Costs	-18.086*	-17.969**	-15.865*	-10.828
	(9.484)	(9.103)	(9.146)	(10.913)
Mother's Returns		1.067	-21.973	-24.504
		(17.896)	(20.338)	(21.464)
Matriliny × Mother's Returns			97.930***	102.350***
			(32.555)	(33.991)
Matriliny × Father's Returns				-24.802
				(50.069)
Matriliny × Father's Costs				-21.279
				(19.888)
R^2	0.30	0.30	0.30	0.29
Mean DV	1,312.15	1,312.15	1,312.15	1,312.15
SD DV	560.82	560.82	560.82	560.82
Panel B: Mother's Vocalizations				
1/Matriliny	22.667	22.468	35.012	61.457
	(20.819)	(21.382)	(35.140)	(60.515)
Mother's Returns	43.387*	44.180*	44.092*	66.734
	(22.123)	(25.834)	(25.781)	(42.486)
Mother's Costs	17.125	17.228	14.465	41.852
	(19.677)	(19.631)	(19.366)	(35.401)
Father's Returns		1.928	19.349	11.749
		(21.356)	(29.326)	(32.265)
1/Matriliny × Father's Returns			-2.732	-1.585
			(4.076)	(4.868)
1/Matriliny × Mother's Returns				-3.325
				(6.168)
1/Matriliny × Mother's Costs				-4.090
				(4.499)
R^2	0.18	0.18	0.21	0.21
Mean DV	2,782.89	2,782.89	2,782.89	2,782.89
SD DV	931.40	931.40	931.40	931.40
# Clusters	41	41	41	41
Observations	196	196	196	196

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Table presents results from the joint estimation of father (Panel A) and mother (Panel B) equations. Unit of observation is a child. The dependent variable is the total number of adult male (Panel A) and adult female (Panel B) vocalizations per day. Each outcome is the weighted average of recordings (by duration of recording). All estimates control for the child's age, age squared, and gender, the number of children in the household, whether the recorded child is the father's biological child, the household asset index, and a province fixed effect. Panel A additionally controls for father's cognitive ability, age, age squared, and occupation. Panel B additionally controls for mother's cognitive ability, age, age squared, and occupation. Missing observations imputed for beliefs, cognitive ability, and parents' age, and all estimates include indicator variables for missing observations. Standard errors clustered at the village level in parentheses. All estimates are weighted by the total duration of recordings.

Table 4: Child-Directed Speech by Fathers

DV: Speaker: Father	CTC (1)	Vocs at High Pitch (2)	Pitch (3)
Matriliny × Mother's Returns	13.676	32.971**	0.263***
	(15.245)	(14.407)	(0.085)
Matriliny × Father's Returns	-24.071	-19.485	-0.061
	(17.155)	(22.790)	(0.082)
Matriliny × Father's Costs	-12.525	-7.407	0.028
	(9.132)	(9.948)	(0.046)
Mother's Returns	-9.250	-8.535	-0.064
	(7.803)	(8.627)	(0.042)
Father's Returns	3.129	-0.895	0.070*
	(7.463)	(7.843)	(0.041)
Father's Costs	-3.935	-4.647	0.033
	(5.922)	(4.858)	(0.022)
Matriliny	208.815	157.108	-0.718
	(161.800)	(186.685)	(0.668)
Observations	196	196	196
R^2	0.34	0.26	0.31
# Clusters	41	41	41
Mean DV	441.93	567.08	22.56
SD DV	260.99	250.71	1.25

* p< 0.10, ** p<0.05, *** p < 0.01. Table presents results from the joint estimation of mother and father equations, and displays father's results only. Unit of observation is a child. The dependent variable in column (1) is the number of conversational turns per day between the child and adult male speaker. The dependent variable in column (2) is the number of vocalizations at high pitch per day, where the high pitch threshold is above the speaker's median pitch within 1 second of a child vocalization. The dependent variable in column (3) is the median pitch of the adult male speaker's voice within 1 second of a child vocalization. Each outcome is the weighted average of recordings (by duration of recording). All estimates control for a province fixed effect, as well as the following additional controls: the child's age, age squared, and gender, the number of children in the household, whether the recorded child is the father's biological child, the father's cognitive ability, age, age squared, and occupation, the household asset index, and a province fixed effect. Missing observations imputed for beliefs, cognitive ability, and father's age, and all estimates include indicator variables for missing observations. Standard errors clustered at the village level in parentheses. All estimates are weighted by the total duration of recordings.

Table 5: Father's Time Spent With Child

DV:	Hours With Child (Father)		Father's Speech		
			Vocs	Vocs at High Pitch	Pitch
	(1)	(2)	(3)	(4)	(5)
Matriliny	0.737*	0.533	302.469	204.648	-0.695
	(0.422)	(1.129)	(338.125)	(149.760)	(0.672)
Matriliny × Mother's Returns		0.115	71.043***	20.131*	0.257***
		(0.145)	(26.007)	(11.393)	(0.085)
Mother's Returns		0.096	-32.001***	-11.448**	-0.064
		(0.106)	(11.963)	(5.125)	(0.041)
Hours with child (Father)			117.961***	47.405***	0.011
			(15.342)	(6.478)	(0.034)
Observations	196	196	196	196	196
R^2	0.16	0.19	0.41	0.42	0.31
# Clusters	41	41	41	41	41
Mean DV	12.45	12.45	1,312.15	567.08	22.56
SD DV	2.73	2.73	560.82	250.71	1.25

* p< 0.10, ** p<0.05, *** p < 0.01. Table presents results from the joint estimation of mother and father equations, and displays father's results only. In columns (1)-(2), the dependent variable is the total number of recording hours with at least 10 adult male vocalizations per hour. The dependent variable in column (3) is adult male vocalizations per day. The dependent variable in column (4) is the number of adult male vocalizations at high pitch per day, where the high pitch threshold is above the speaker's median pitch within 1 second of a child vocalization. The dependent variable in column (5) is the median pitch of the adult male speaker's voice within 1 second of a child vocalization. Each outcome is the weighted average of recordings (by duration of recording). All estimates control for the child's age, age squared, and gender, the number of children in the household, whether the recorded child is the father's biological child, the household asset index, father's cognitive ability, age, age squared, and occupation, and a province fixed effect. Columns (3)-(5) also control for father's returns and costs, interacted with *Matriliny*. Missing observations imputed for beliefs, cognitive ability, and father's age, and all estimates include indicator variables for missing observations. Standard errors clustered at the village level in parentheses. All estimates are weighted by the total duration of recordings.

Table 6: Female Status and Father Speech Investments

DV: Father's Speech	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Matrilocality	Vocs	Vocs	Vocs at High Pitch	Vocs at High Pitch	Pitch	Pitch
Matrilocality × Mother's Returns	-51.172	-49.038	-10.702	-7.463	-0.033	-0.066
	(35.985)	(36.904)	(17.440)	(17.953)	(0.108)	(0.109)
Matriliny × Mother's Returns		102.067***		30.538**		0.248***
		(34.325)		(14.061)		(0.075)
Observations	196	196	196	196	196	196
R^2	0.16	0.23	0.22	0.27	0.30	0.33
# Clusters	41	41	41	41	41	41
Mean DV	1,312.15	1,312.15	567.08	567.08	22.56	22.56
SD DV	560.82	560.82	250.71	250.71	1.25	1.25
Panel B: Female Status	Inherited Land			Bride Price		
	Vocs	Vocs at High Pitch	Pitch	Vocs	Vocs at High Pitch	Pitch
Female status × Mother's Returns	59.654*	23.240*	-0.088	86.598**	26.219	0.149**
	(33.183)	(13.371)	(0.074)	(37.936)	(16.847)	(0.065)
Observations	196	196	196	162	162	162
R^2	0.46	0.51	0.52	0.46	0.51	0.61
# Clusters	41	41	41	41	41	41
Mean DV	1,312.15	567.08	22.56	1,315.99	575.08	22.61
SD DV	560.82	250.71	1.25	544.59	249.63	1.27

* p< 0.10, ** p<0.05, *** p < 0.01. Table presents results from the joint estimation of mother and father equations, and displays father's results only. The unit of observation is a child. All specifications regress a measure of adult speech on a measure of female status interacted with mother's returns, father's costs, and father's returns (and displays only the interaction with mother's returns), controlling for the child's age, age squared, and gender, the number of children in the household, whether the recorded child is the father's biological child, the household asset index, the father's cognitive ability, age, age squared, and occupation, as well as a province fixed effect (Panel A) and village fixed effects (Panel B). In Panel A, the measure of female status is whether the village is a matrilocal village. In Panel B, the measure of female status in columns (1)-(3) is whether the mother has inherited land in the village where she resides, and in columns (4)-(6), the measure of female status is whether the mother's family received a bride price at marriage and is restricted to children of married couples. *Vocs* is the number of adult male vocalizations per day. *Vocs at High Pitch* is the number of adult male vocalizations at high pitch per day, where the high pitch threshold is above the speaker's median pitch within 1 second of a child vocalization. *Pitch* is the median pitch of the adult male speaker's voice within 1 second of a child vocalization. Each outcome is the weighted average of recordings (by duration of recording). Standard errors clustered at the village level in parentheses. All estimates are weighted by the total duration of recordings.

Table 7: Policy experiments

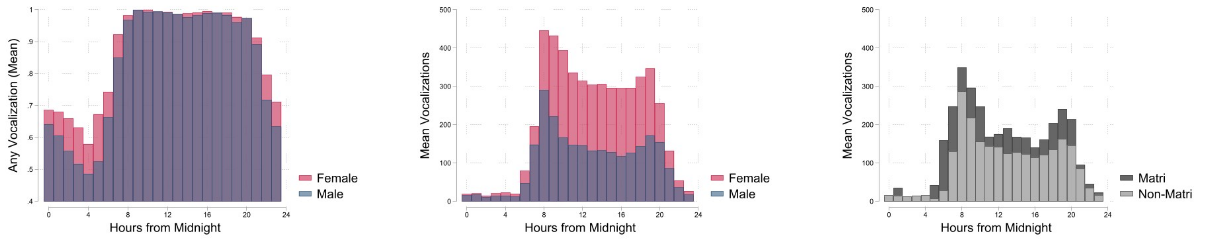
		(1)	(2)	(3)	(4)
		Baseline	Increase mother returns by 0.4 s.d	Reduce father costs by 0.4 sd	Empower women $M_h = 0$ to 0.5
Male vocalizations					
	Patri	1294.48	1271.35	1315.24	1523.43
	Matri	1555.51	1643.21	1596.96	1555.51
Female vocalizations					
	Patri	2946.35	2996.38	2946.35	2801.98
	Matri	2799.70	2871.79	2799.70	2799.70
Male vocs at high pitch					
	Patri	569.01	562.42	577.47	665.22
	Matri	661.02	689.30	674.49	661.02
Female vocs at high pitch					
	Patri	1221.68	1247.03	1221.68	1152.16
	Matri	1139.48	1167.23	1139.48	1139.48

Predicted speech investments estimated after joint estimation of mother and father equations. *Vocalizations* is the number of adult vocalizations per day. *Vocs at High Pitch* is the number of adult vocalizations at high pitch per day, where the high pitch threshold is above the speaker's median pitch within 1 second of a child vocalization. Vocalizations (top panel) are predicted from the coefficients presented in Table 2, Panel B, column 3. Vocalizations at high pitch (bottom panel) are predicted from the coefficients presented in Table 3, column 2.

HeforShe: Bargaining Power, Parental Beliefs, and Parental Investments
Appendix

A Additional Results

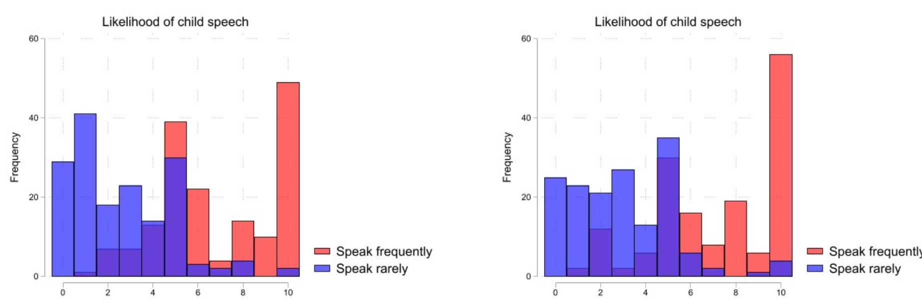
Figure A1: Time of Day of Speech



(a) Any Speech by Hour (b) Mean Speech by Hour (c) Male Speech by Matriliny

Panel (a) displays the mean of whether any vocalization occurred, by each hour of the day (in hours from midnight, where 0 is midnight), separately for adult female and adult male speakers. Panel (b) displays the mean number of vocalizations, by each hour of the day (in hours from midnight), separately for adult female and adult male speakers. Panel (c) displays the mean number of adult male vocalizations by hour, separately for matriliny and non-matriliny. Sample restricted to recordings with a duration of 12 or more hours (85% of observations).

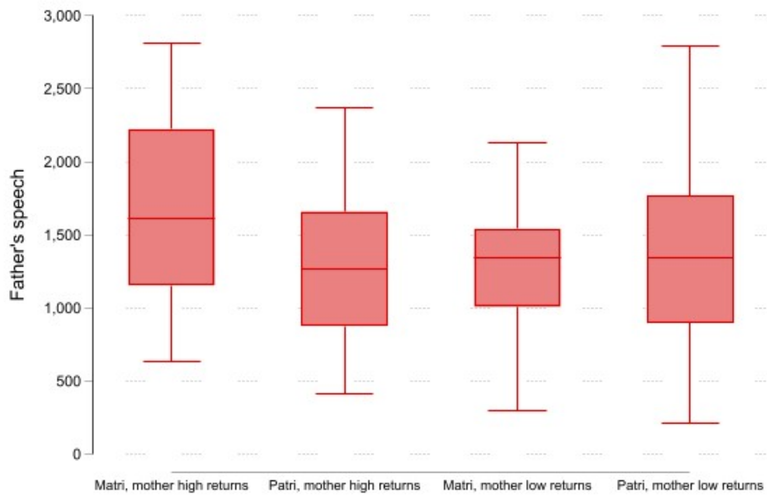
Figure A2: Distribution of Beliefs About Returns to Speech



(a) Mother's Beliefs (b) Father's Beliefs

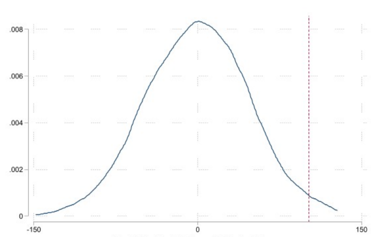
The Figure displays mothers' and fathers' beliefs about the likelihood that a child puts together 2-3 words by age 2 when the carer speaks frequently and rarely to the child.

Figure A3: Father's Speech by Mother's Expected Returns and Matriliny

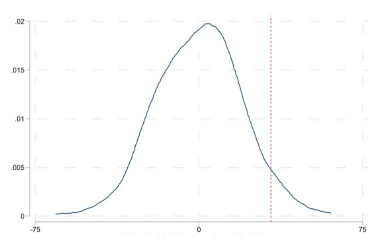


The Figure displays a box plot of fathers' vocalizations by matriliny and mothers' expected returns. We divide the sample into four groups according to matrilineal status of the village ("Matri": M_h equal to or above 0.75, otherwise "Patri") and mothers' expected returns ("high" is above median, otherwise "low"). The center line in each box represents the 50th percentile (median). The bottom of each box represents the 25th percentile and the top represents the 75th percentile. The interquartile range is the difference between the 75th and 25th quartiles. The bottom whisker below the box is equal to the 25th percentile minus 1.5 times the interquartile range. The upper whisker above the box is equal to the 75th percentile plus 1.5 times the interquartile range.

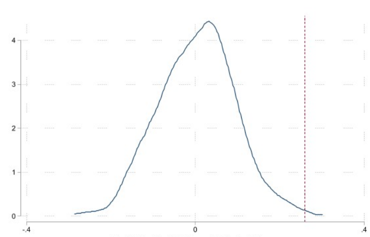
Figure A4: Randomization inference - Father's Speech



(a) Vocalizations



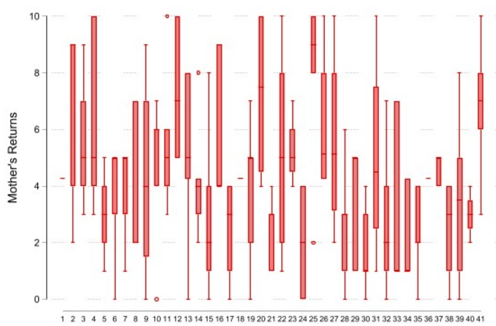
(b) Vocalizations at high pitch



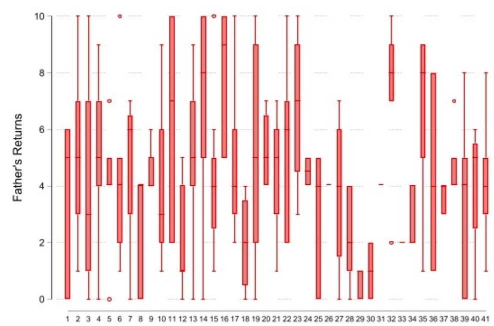
(c) Pitch

The Figure plots the results of randomization inference exercises that replicate Panel B, column (4) of Table 3 (in (a)), column (2) of Table 4 (in (b)), and column (3) of Table 4 (in (c)) by randomly re-assigning the mother's expected returns over 1,000 repetitions. The solid line plots the kernel density of the coefficient estimates for *Matriliny x Mother's Returns*. The red, vertical dash line represents the coefficients estimated from the true sample (see Panel B, column (4) of Table 3, column (2) of Table 4, and column (3) of Table 4).

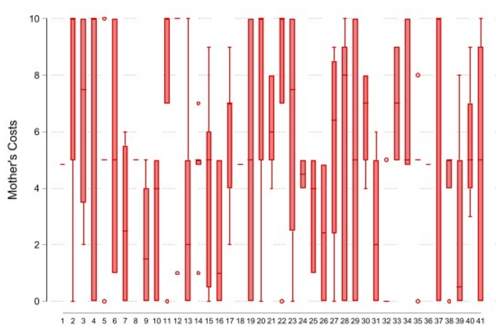
Figure A5: Village Variation in Expected Returns and Perceived Costs



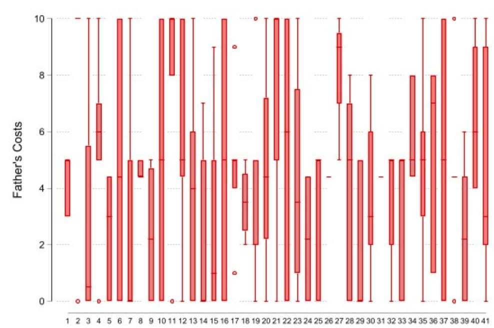
(a) Mother's Returns



(b) Father's Returns



(c) Mother's Costs



(d) Father's Costs

The Figure displays the village-level box plots for mother and father returns and costs. Villages are sorted on the x-axis in order of matriliny, where villages 1-17 are purely patrilineal, 18-28 are mostly patrilineal, 29-31 are equally patrilineal and matrilineal, 32-37 are mostly matrilineal, and 38-41 are purely matrilineal.

Table A1: Summary Statistics

	N	Mean	SD	Min	Max
Household Variables					
Purely patrilineal	182	0.45	0.50	0	1
Mostly patrilineal	182	0.26	0.44	0	1
Equally patri and matri	182	0.07	0.25	0	1
Mostly matrilineal	182	0.12	0.33	0	1
Purely matrilineal	182	0.11	0.31	0	1
Mother's age	182	29.38	5.67	20	47
Father's age	182	33.42	6.00	21	54
Total children in HH	182	3.03	1.66	1	11
Father not biofather	182	0.16	0.37	0	1
Mother's cognitive ability	182	11.32	6.27	0	23
Father's cognitive ability	182	13.59	5.74	0	23
Mother completed secondary school	182	0.31	0.46	0	1
Father completed secondary school	182	0.35	0.45	0	1
Asset Index	182	3.87	1.89	0	8
Earns income from employment	182	0.05	0.22	0	1
Access to grid electricity	182	0.07	0.25	0	1
Access to improved sanitation	182	0.03	0.18	0	1
Water tank	182	0.57	0.48	0	1
Child Variables					
Recorded child's age (months)	196	25.30	9.03	6	48
Recorded child female	196	0.47	0.50	0	1
Speech Measures					
Adult female vocalizations (per day)	196	2782.89	931.40	765.6	6203.5
Adult male vocalizations (per day)	196	1312.15	560.82	206.4	2808.6
Adult female conversational turns (CTC) (per day)	196	1415.36	668.30	185.0	4005.2
Adult male conversational turns (CTC) (per day)	196	441.93	260.99	48.93	1545.8
Adult female vocs at high pitch (per day)	196	1144.79	403.44	275.7	2642.9
Adult male vocs at high pitch (per day)	196	567.08	250.71	75.73	1280.3
Adult female pitch (median)	196	28.07	0.90	24.19	30.10
Adult male pitch (median)	196	22.56	1.25	17.67	26.62
Beliefs About Speech					
Mother's returns	182	4.33	2.80	0	10
Father's returns	182	4.32	2.91	0	10
Mother's costs	182	4.88	3.58	0	10
Father's costs	182	4.41	3.57	0	10

Asset Index is defined as the sum of dummy variables taking value one if the household owns each of the following assets: mobile phone, radio, iron roof, solar light, water tank, toilet, stove, and outboard motor.

Table A2: Parental Speech and Other Parental Investments

DV:	Breastfeeding	BMI	ln(Cortisol)	Child Loss
	(1)	(2)	(3)	(4)
Panel A: Mother's Speech				
Vocalizations	0.520*	0.180*	-0.307	-0.013*
	(0.277)	(0.091)	(0.200)	(0.008)
CTC	0.648**	0.109	-0.136	-0.020**
	(0.313)	(0.107)	(0.159)	(0.009)
Vocs at high pitch	0.555**	0.206**	-0.356*	-0.015*
	(0.241)	(0.098)	(0.181)	(0.008)
Pitch	0.065	-0.158	0.028	-0.014
	(0.547)	(0.104)	(0.176)	(0.011)
Panel B: Father's Speech				
Vocalizations	-0.107	0.267***	0.049	-0.001
	(0.283)	(0.069)	(0.089)	(0.010)
CTC	-0.185	0.262**	0.068	-0.008
	(0.308)	(0.101)	(0.111)	(0.007)
Vocs at high pitch	-0.160	0.315***	0.045	-0.005
	(0.310)	(0.075)	(0.101)	(0.009)
Pitch	0.120	-0.109	-0.107	-0.009
	(0.308)	(0.112)	(0.143)	(0.007)
Observations	105	103	99	182
Mean DV	16.09	-0.00	1.31	0.03
SD DV	4.73	1.00	1.23	0.09

* $p< 0.10$, ** $p<0.05$, *** $p < 0.01$. OLS estimates. Each cell represents the coefficient from a separate regression of the dependent variable (top row) on a measure of adult speech (first column). Adult speech variables are the weighted average of recordings (by duration of recording) and standardized to mean zero, standard deviation one. All estimates control for the child's age, age squared, and gender, the number of children in the household, whether the recorded child is the father's biological child, the asset index, and a province fixed effect. Panel A controls for mother's cognitive ability, age, and age squared. Panel B controls for father's cognitive ability, age, and age squared. *Breastfeeding* is the total number of months that the mother breastfed the recorded child. *BMI* is the recorded child's BMI standardized to mean zero, standard deviation one. *ln(Cortisol)* is the log of the recorded child's cortisol level measured in their hair. *Child Loss* is the ratio of the total number of children who have died to the total number of children ever born to the mother. Missing observations imputed for parents' age and cognitive ability and all estimates include indicator variables for missing observations. Standard errors clustered at the village level in parentheses.

Table A3: Descriptive Correlates of Expected Returns and Perceived Costs

Parent:	Mothers		Fathers	
DV:	Returns (1)	Costs (2)	Returns (3)	Costs (4)
Matriliny	-0.621	0.100	-0.630	0.496
	(0.653)	(0.760)	(0.654)	(0.744)
Female child	-1.033**	-0.427	-0.535	-0.221
	(0.383)	(0.492)	(0.431)	(0.583)
Child's age	0.319**	0.045	0.041	0.007
	(0.126)	(0.145)	(0.124)	(0.180)
Child's age^2	-0.006**	-0.000	-0.001	-0.000
	(0.002)	(0.003)	(0.002)	(0.004)
# Children in HH	0.082	0.288*	-0.041	-0.081
	(0.153)	(0.147)	(0.118)	(0.173)
Spouse not biofather	-0.697*	-1.371**	0.191	0.228
	(0.376)	(0.625)	(0.432)	(0.652)
Cognitive ability	-0.005	0.000	0.072**	0.004
	(0.026)	(0.049)	(0.034)	(0.055)
Household Asset index	0.001	0.200	0.090	-0.031
	(0.100)	(0.144)	(0.124)	(0.129)
Main income source: Land	-0.343	1.132*	0.433	0.285
	(0.476)	(0.652)	(0.600)	(0.959)
Main income source: Fish	0.222	0.711	0.185	0.333
	(0.595)	(0.882)	(0.549)	(0.937)
Provide childcare to others	0.790**	-0.193	0.256	-0.922
	(0.311)	(0.564)	(0.452)	(0.627)
IHS(Kin in village)	0.498**	-0.031	0.126	-0.104
	(0.235)	(0.296)	(0.264)	(0.338)
Observations	182	182	182	182
R^2	0.277	0.089	0.274	0.035
# Clusters	41	41	41	41
Mean DV	4.33	4.88	4.32	4.41
SD DV	2.80	3.58	2.91	3.57

* p< 0.10, ** p<0.05, *** p < 0.01. OLS estimates. Unit of observation is the parent of a recorded child. All estimates control for a province fixed effect. *IHS(Kin in village)* is the inverse hyperbolic sine of the mother's and father's direct kin who live in the same village as the child. Missing observations imputed for beliefs, cognitive ability, and father's childcare to others. All estimates include indicator variables for missing observations.

Table A4: Returns, Costs, and Vocalizations - Cost Characteristics

DV: Adult vocalizations per day	Mothers		Fathers	
	(1)	(2)	(3)	(4)
Bargaining power	35.012	61.457	4.432	196.246
	(35.140)	(60.515)	(215.959)	(426.157)
Mother's Returns	44.092*	66.734	-21.973	-24.504
	(25.781)	(42.486)	(20.338)	(21.464)
Father's Returns	19.349	11.749	-4.972	2.741
	(29.326)	(32.265)	(13.279)	(17.040)
Own Costs	14.465	41.852	-15.865*	-10.828
	(19.366)	(35.401)	(9.146)	(10.913)
Bargaining power × Father's Returns	-2.732	-1.585		-24.802
	(4.076)	(4.868)		(50.069)
Bargaining power × Mother's Returns		-3.325	97.930***	102.350***
		(6.168)	(32.555)	(33.991)
Bargaining power × Own Costs		-4.090		-21.279
		(4.499)		(19.888)
Child's age	-115.253***	-115.619***	11.977	14.523
	(35.113)	(34.844)	(22.135)	(20.547)
Child's age^2	1.905***	1.901***	-0.270	-0.310
	(0.648)	(0.646)	(0.404)	(0.378)
Age	154.950*	168.076*	-25.765	-38.193
	(88.011)	(85.900)	(44.218)	(45.309)
Age^2	-2.079	-2.268	0.363	0.545
	(1.469)	(1.440)	(0.616)	(0.627)
Female child	-144.422	-151.846	-78.108	-89.498
	(126.137)	(121.563)	(77.692)	(79.799)
# Children in HH	-22.820	-21.902	-6.880	-3.942
	(33.403)	(33.054)	(26.388)	(26.881)
Spouse not biological father	-37.486	-34.452	-85.288	-93.094
	(218.685)	(230.844)	(119.155)	(119.743)
Mother's cognitive ability	10.011	8.984	3.011	3.370
	(9.698)	(9.688)	(6.234)	(6.346)
Asset index	56.598	55.008	-20.923	-23.223
	(42.350)	(41.572)	(27.078)	(26.759)
Main income source: land	-110.749	-141.144	-42.738	-49.616
	(123.120)	(119.648)	(94.948)	(89.959)
Main income source: fish	6.844	-7.151	-97.876	-92.088
	(193.668)	(188.392)	(114.891)	(114.896)
Mean DV	2,782.89	2,782.89	1,312.15	1,312.15
SD DV	931.40	931.40	560.82	560.82

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Table presents all coefficients from Table 3. Columns (1)-(2) correspond to columns (3)-(4) of Panel A, and columns (3)-(4) correspond to columns (3)-(4) of Panel B. Unit of observation is a child. The variable *Bargaining power* is *1/Matriliny* in columns (1)-(2) and *Matriliny* in columns (3)-(4). All estimates include a province fixed effect. Missing observations imputed for beliefs, cognitive ability, and age, and all estimates include indicator variables for missing observations. Standard errors clustered at the village level in parentheses. All estimates are weighted by the total duration of recordings.

Table A5: Restricted Time Windows for Analysis

Time Restriction:	8am to 8pm	8am to 9pm	8am to 10pm
DV: Father Vocalizations	(1)	(2)	(3)
Matriliny × Mother's Returns	105.632**	138.323***	154.785***
	(44.201)	(51.202)	(51.564)
Mother's Returns	-29.803	-38.489	-37.025
	(24.133)	(27.089)	(29.090)
Father's Returns	-6.626	-9.133	-9.617
	(18.015)	(18.391)	(19.162)
Father's Costs	-15.884	-17.261	-17.506
	(12.707)	(13.039)	(12.984)
Matriliny	233.595	123.037	98.567
	(310.662)	(332.351)	(329.555)
Controls:	Y	Y	Y
Observations	196	196	196
R^2	0.24	0.24	0.23
# Clusters	41	41	41
Mean DV	1,735.23	1,892.70	1,974.90
SD DV	743.19	804.28	832.01

* p< 0.10, ** p<0.05, *** p < 0.01. Table presents results from the joint estimation of mother and father equations, and displays father's results only. Unit of observation is a child. The outcome is the weighted average (by duration of recording) of father vocalizations per day, restricted to specific time windows. The time window of analysis is restricted from 8am to 8pm in column (1), 8am to 9pm in column (2), and 8am to 10pm in column (3). All estimates control for the child's age, age squared, and gender, the number of children in the household, whether the recorded child is the father's biological child, the father's cognitive ability, age, age squared, and occupation, the household asset index, and a province fixed effect. Missing observations imputed for beliefs, cognitive ability, and father's age, and all estimates include indicator variables for missing observations. Standard errors clustered at the village level in parentheses. All estimates are weighted by the total duration of recordings.

Table A6: Father and Mother Characteristics by Mother's Returns and Matriliny

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Panel A: Fathers	Child BMI	Child Female	Returns of CDS	Costs of CDS	Age	Secondary School	Income: Land	Income: Fishing	Leisure Time	Trust	Reciprocity	Care from Mother	Care from MiL	Care from Friends	Ever Migrated
Mother's Returns × Matriliny	-0.015	-0.016	0.172	-0.192	-0.488	0.015	0.018	0.027	-0.068	0.099	-0.044	0.007	0.090	0.043	0.012
	(0.112)	(0.026)	(0.390)	(0.201)	(0.390)	(0.029)	(0.037)	(0.040)	(0.115)	(0.107)	(0.209)	(0.078)	(0.071)	(0.079)	(0.039)
Matriliny	0.226	0.134	-1.100	1.556	0.468	0.094	-0.198	-0.243	0.124	-0.436	-0.763	-0.162	0.150	-0.058	-0.057
	(0.891)	(0.176)	(1.689)	(1.180)	(1.776)	(0.173)	(0.224)	(0.171)	(0.456)	(0.499)	(1.143)	(0.427)	(0.399)	(0.388)	(0.232)
Mother's Returns	0.052	-0.035**	-0.045	-0.099	0.127	0.009	-0.014	-0.007	0.047	-0.023	0.126	-0.012	-0.004	0.002	0.004
	(0.080)	(0.016)	(0.162)	(0.143)	(0.250)	(0.015)	(0.021)	(0.015)	(0.046)	(0.042)	(0.103)	(0.038)	(0.045)	(0.042)	(0.020)
Observations	97	182	157	158	157	158	182	182	121	158	158	158	158	158	158
R^2	0.059	0.055	0.066	0.048	0.049	0.032	0.033	0.039	0.038	0.055	0.081	0.015	0.051	0.047	0.042
Mean DV	15.53	0.46	4.15	4.41	33.40	0.35	0.51	0.27	-0.00	2.47	7.67	-0.00	-0.00	0.00	0.53
SD DV	1.61	0.50	3.55	3.83	6.47	0.48	0.50	0.45	1.00	1.19	2.75	1.00	1.00	1.00	0.50
Panel B: Mothers	Child BMI	Child Female	Spouse Not Biofather	Fertility	Age	Secondary School	Income: Land	Income: Fishing	Leisure Time	Trust	Reciprocity	Care from Mother	Care from MiL	Care from Friends	Ever Migrated
Mother's Returns × Matriliny	-0.015	-0.016	-0.009	0.036	-0.101	0.001	0.018	0.019	0.080	0.044	-0.124	0.088	-0.021	0.084	-0.024
	(0.112)	(0.026)	(0.022)	(0.161)	(0.454)	(0.028)	(0.037)	(0.035)	(0.095)	(0.087)	(0.152)	(0.071)	(0.070)	(0.085)	(0.053)
Matriliny	0.226	0.134	0.096	-0.856	-1.759	0.171	-0.198	0.083	-0.406	-0.111	1.556*	-0.082	-0.042	-0.111	-0.135
	(0.891)	(0.176)	(0.109)	(0.656)	(2.149)	(0.171)	(0.224)	(0.176)	(0.443)	(0.450)	(0.891)	(0.332)	(0.315)	(0.323)	(0.213)
Mother's Returns	0.052	-0.035**	-0.007	0.004	0.092	-0.006	-0.014	-0.002	-0.017	-0.060*	0.143	-0.030	-0.030	-0.016	0.006
	(0.080)	(0.016)	(0.011)	(0.066)	(0.209)	(0.015)	(0.021)	(0.013)	(0.045)	(0.033)	(0.097)	(0.031)	(0.029)	(0.032)	(0.021)
Observations	97	182	182	182	181	182	182	182	115	182	182	182	182	182	182
R^2	0.059	0.055	0.042	0.044	0.033	0.027	0.033	0.041	0.075	0.061	0.129	0.016	0.028	0.026	0.049
Mean DV	15.53	0.46	0.16	3.14	29.38	0.31	0.51	0.17	0.00	2.53	7.41	-0.00	0.00	-0.00	0.60
SD DV	1.61	0.50	0.37	1.71	5.69	0.46	0.50	0.38	1.00	1.05	2.49	1.00	1.00	1.00	0.49

* p< 0.10, ** p<0.05, *** p < 0.01. OLS estimates. Unit of observation is the father (Panel A) or mother (Panel B) of a recorded child. Each column is the result of regressing the dependent variable indicated at the top of the column on mother's returns, matriliny, and the interaction, controlling for province fixed effects. *Returns* and *Costs* of CDS are our usual measures. *Fertility* is the number of children ever born to the mother. *Secondary School* is a binary variable equal to one if the parent completed secondary school. *Income* is a binary variable equal to one if the main income source is from agriculture or logging (column 7) or fishing (column 8). *Leisure* is the time spent on leisure, standardized to mean zero, standard deviation one. *Trust* measured as a response to the following question: "Generally speaking, would you say that most people can be trusted, or that you can't be too careful in dealing with people?", where 1=complete distrust and 5=complete trust. *Reciprocity* is measured as a response to the following question: "How well does the following statement describe you as a person? I try especially hard to help someone who has helped me in the past, where 0=not at all and 10=describes me perfectly". *Care from* is the amount of help with child care from the father's own mother, mother-in-law (MiL), and friends and neighbors, each measured as: 0=never, 1=less than once a month, 2=more than once a month, 3=once a week, 4=couple times a week, 5=every day, a little bit, 6=every day, for a large part of the day; values standardized to mean zero, standard deviation one. *Ever migrated* is a binary variable equal to one if the father is living in a different village from where he was born. Missing observations imputed for beliefs and all estimates include indicator variables for missing observations. Standard errors clustered at the village level in parentheses.

Table A7: Robustness: Controlling for Mother-Father Conversations

DV: Father's speech	Vocs (1)	Vocs at High Pitch (2)	Pitch (3)
Matriliny × Mother's Returns	101.791***	32.720**	0.262***
	(33.870)	(14.469)	(0.085)
Matriliny	223.554	167.883	-0.714
	(401.395)	(178.279)	(0.672)
Mother's Returns	-26.350	-9.186	-0.064
	(20.421)	(8.224)	(0.042)
Mother-Father Conversations	0.397	0.144	-0.000
	(0.346)	(0.142)	(0.000)
Observations	196	196	196
R^2	0.24	0.28	0.31
# Clusters	41	41	41
Mean DV	1312.15	567.08	22.56
SD DV	560.82	250.71	1.25

* p< 0.10, ** p<0.05, *** p < 0.01. Table presents results from the joint estimation of mother and father equations, and displays father's results only. Unit of observation is a child. In column (1), the dependent variable is the number of adult male vocalizations per day. In column (2), the dependent variable is the number of adult male vocalizations at high pitch per day, where the high pitch threshold is the speaker's median pitch within 1 second of child vocalization. In column (3), the dependent variable is the median pitch of the adult male speaker's voice within 1 second of a child vocalization. Each outcome is the weighted average of recordings (by duration of recording). All estimates control for the child's age, age squared, and gender, the number of children in the household, whether the recorded child is the father's biological child, the household asset index, the father's cognitive ability, age, age squared, and occupation, and a province fixed effect, as well as father's returns and costs, each interacted with *Matriliny*. Missing observations imputed for beliefs, cognitive ability, and father's age, and all estimates include indicator variables for missing observations. Standard errors clustered at the village level in parentheses. All estimates are weighted by the total duration of recordings.

Table A8: Heterogeneity by Child Gender

Measure of Matriliny:	Continuous Measure			Binary (Pure Matri = 1, 0 Otherwise)		
DV: Father's Speech	Vocs	Vocs at High Pitch	Pitch	Vocs	Vocs at High Pitch	Pitch
	(1)	(2)	(3)	(4)	(5)	(6)
Matriliny	852.949**	373.445**	-0.542	934.696**	465.997***	-0.460
	(372.811)	(163.076)	(0.704)	(421.878)	(156.820)	(0.606)
Matriliny × Mother's Returns	12.314	4.388	0.205**	15.234	-2.723	0.238***
	(37.630)	(15.142)	(0.104)	(32.732)	(13.392)	(0.089)
Female child × Matriliny	-847.339**	-245.789	-0.731	-1386.272***	-564.092***	-1.274**
	(374.513)	(154.906)	(0.700)	(308.784)	(96.738)	(0.625)
Female child × Matriliny × Mother's Returns	151.027*	43.206	0.182	187.713***	78.218***	0.202*
	(86.867)	(33.822)	(0.136)	(70.896)	(25.470)	(0.103)
Observations	196	196	196	196	196	196
R^2	0.29	0.33	0.34	0.33	0.37	0.36
# Clusters	41	41	41	41	41	41
Mean DV	1,312.15	567.08	22.56	1,312.15	567.08	22.56
SD DV	560.82	250.71	1.25	560.82	250.71	1.25

* p< 0.10, ** p<0.05, *** p < 0.01. Table presents results from the joint estimation of mother and father equations, and displays father's results only. Unit of observation is a child. In columns (1)-(3), the measure of *Matriliny* is a continuous variable. In columns (4)-(6), the measure of *Matriliny* is a binary variable equal to one for households in purely matrilineal villages (mean = 0.11, s.d. = 0.31, see Table A1). In columns (1) and (4), the dependent variable is adult male vocalizations per day. In columns (2) and (5), the dependent variable is the number of adult male vocalizations at high pitch per day, where the high pitch threshold is the speaker's median pitch within 1 second of a child vocalization. In columns (3) and (6), the dependent variable is the median pitch of the adult male speaker's voice within 1 second of a child vocalization. Each outcome is the weighted average of recordings (by duration of recording). All estimates control for father's returns and costs, interacted with *Matriliny*, as well as the child's age, age squared, and gender, the number of children in the household, whether the recorded child is the father's biological child, the asset index, the father's cognitive ability, age, age squared, and occupation, and a province fixed effect. Missing observations imputed for beliefs, cognitive ability, and father's age, and all estimates include indicator variables for missing observations. All estimates cluster standard errors at the village level in parentheses and weight estimates by the total duration of recordings.

Table A9: Between and Within Village Variation in Returns and Costs

	(1) Mother's Returns	(2) Mother's Costs	(3) Father's Returns	(4) Father's Costs
Between villages	1.91	2.00	1.98	1.90
Within villages	2.56	3.23	3.06	3.39

Table reports the between (top) and within (bottom) village standard deviations in beliefs.

Table A10: Model Fit

	Adult Female		Adult Male	
	Sample Mean (1)	Predicted Mean (2)	Sample Mean (3)	Predicted Mean (4)
Vocalizations	2782.89	2796.01	1312.15	1313.44
Conversational Turns	1415.36	1427.06	441.93	443.59
Vocs at High Pitch	1144.79	1150.68	567.08	567.98
Pitch	28.07	28.06	22.56	22.55

The table displays the sample mean (cols 1 and 3) and predicted mean (cols 2 and 4) for each measure of speech, by adult female and adult male speaker. The specification for *Vocalizations* comes from column (4) of Table 3. The specification for *Conversational Turns (CTC)* comes from column (1) of Table 4. The specification for *Vocs at High Pitch* comes from column (2) of Table 4. The specification for *Pitch* comes from column (3) of Table 4.

B Additional Robustness

B.1 Expectations about returns and cost

Data quality checks on the probabilistic expectations. We measure probabilistic expectations using a visual aid (Delavande, 2023). After a brief preamble explaining probabilities (Appendix D), respondents complete a practice question eliciting the likelihood that a woman in the community goes to the market (a) in the next two days and (b) in the next two weeks. Most respondents correctly report a higher probability over the longer horizon, though about 20% violate monotonicity—a rate similar across gender and matriliny.[39] This figure is slightly higher than in comparable young samples in other low-income countries (Delavande and Kohler, 2009; Bhalotra et al., 2025) and comparable to an older Indian sample (Delavande et al., 2017).

We then ask parental beliefs about the likelihood that a child puts 2-3 words together in speaking by age 2 if the carers frequently (vs. rarely) talk to the child directly. These questions are framed with a reference to a typical carer and child. The advantage of using this wording rather than the actual carer-child pair is that the latter may be correlated with unobserved carer or child characteristics, which could bias our estimates. For this reason, our approach is the standard (Cunha et al., 2013; Attanasio et al., 2024; Bhalotra et al., 2025). Respondents are willing to report their beliefs in a probabilistic manner. Non-response rates on the probabilistic and cost questions are low for mothers (9%). It is slightly higher for fathers (14% for returns, 13% for costs), which is primarily explained by the father being absent at the time of interview.

Our main results use the expected return of child-directed speech, which is the individual-level difference in the probability of reaching the language milestone between the high and low investment. 8% men and 5% of women report a negative return, a potential indication of lack of attention or difficulty with the question.

Robustness to measurement error in beliefs. In our main specification, we replace missing returns and costs with their sample average and include a dummy variable for missing. We also replace negative returns with zero. We keep all respon-

[39] The p-value of the difference between mothers and fathers is 0.46. The coefficient from a regression of monotonicity violation on M_h is -0.62 with a p-value of 0.36.

dents in our estimation sample, even those who violated the monotonicity property of probabilities in the preamble questions. We now investigate the robustness of our results to these modeling decisions. Our results for quantity of vocalizations and pitch are, if anything, larger in magnitude when we exclude monotonicity violators (Column 1 of Table B1). Our results are also robust to keeping the negative returns as negative (Column 2 of Table B1) and to excluding respondents with missing returns (Column 3 of Table B1). A potential concern is measurement error in expected returns, given the difficulty of precisely defining investment scenarios and outcomes. We address this by averaging our main return measure with two additional survey measures: beliefs about returns to speech for (i) school readiness by age 6 and (ii) educational performance in primary school (Appendix D). These refer to actual parent–child pairs rather than hypothetical ones and therefore are not our preferred measures, but they provide useful validation. Using this composite measure (Column 4), our findings closely match the main results in Tables 3 and 4.

B.2 Robustness to alternative theoretical assumptions

Model with time allocation decision. We now allow for time allocation decisions and explicitly model the trade-off between time spent in productive activities and time spent investing in children. Each parent $i \in \{m, d\}$ allocates their fixed time endowment $\bar{T}_i$ between productive work (T_i^w) and productive speech investment in children (T_i^c) such that $T_i^w + T_i^c = \bar{T}_i$. The parent i utility function is given by $U_i = w_i(M_i)T_i^w + \omega_i\Theta - C_i(T_i^c)$, where $w_i(M_i)$ denotes the shadow wage of parent i, which may depend on local matrilineal inheritance structures M_i, and $C_i(T_i^c)$ is the cost from speech investment in children (T_i^c). Substituting the time constraint, we can rewrite the utility as:

$$U_i = w_i(M_i)(\bar{T}_i - T_i^c) + \omega_i\Theta - C_i(T_i^c; M_i)$$

As in the main model, we assume that each parent has a subjective production function, given by: $\Theta_i = \eta_{i,0} + \eta_{i,1}\theta_0 + \eta_{i,2}(T_m^c + T_d^c) + \xi_i$, where $\eta_{i,j}$ are individual-specific beliefs about the production function parameters. The household utility function is a weigthed sum of the mother's and father's expected utility function such that

$\mathcal{U} = \alpha U_m + (1-\alpha)U_d$. The first-order conditions with respect to T_m^c and T_d^c are:

$$\frac{\partial \mathbb{E}\mathcal{U}}{\partial T_m^c} = \alpha\left(-w_m(M_m) + \omega_m \eta_{m,2} - \frac{\partial C_m}{\partial T_m^c}\right) + (1-\alpha)\omega_d \eta_{d,2} = 0$$

$$\frac{\partial \mathbb{E}\mathcal{U}}{\partial T_d^c} = \alpha \omega_m \eta_{m,2} + (1-\alpha)\left(-w_d(M_d) + \omega_d \eta_{d,2} - \frac{\partial C_d}{\partial T_d^c}\right) = 0$$

Assuming costs take the quadratic form $C_i(T_i^c) = \chi_{i,1} T_i^c + \chi_{i,2}\frac{(T_i^c)^2}{2}$, we obtain:

$$T_m^{c*} = \frac{\omega_m}{\chi_{m,2}}\eta_{m,2} + \left(\frac{1-\alpha}{\alpha}\right)\frac{\omega_d}{\chi_{m,2}}\eta_{d,2} - \frac{\chi_{m,1} + w_m(M_m)}{\chi_{m,2}}, \tag{14}$$

$$T_d^{c*} = \frac{\omega_d}{\chi_{d,2}}\eta_{d,2} + \left(\frac{\alpha}{1-\alpha}\right)\frac{\omega_m}{\chi_{d,2}}\eta_{m,2} - \frac{\chi_{d,1} + w_d(M_d)}{\chi_{d,2}} \tag{15}$$

Differentiating the first-order condition for T_d^c with respect to $\eta_{m,2}$ yields:

$$\frac{\partial T_d^{c*}}{\partial \eta_{m,2}} = \left(\frac{\alpha}{1-\alpha}\right)\frac{\omega_m}{\chi_{d,2}} \tag{16}$$

We thus have that $\frac{\partial T_d^{c*}}{\partial \eta_{m,2}} > 0$ and increasing in α. So, as in the model in the main text, paternal investment increases with the mother's expected returns, and the responsiveness of paternal investment to mothers' returns is increasing in her bargaining power α. Based on Equations (14) and (15), we estimate the following equations using Seemingly Unrelated Regressions:

$$\begin{aligned} Speech_{m,c,h} = {} & a_m + \delta_{1,m}\eta_{m,2} + \delta_{2,m}\eta_{d,2} + \delta_{3,m}\frac{1}{M_h}\eta_{d,2} + \delta_{4,m}\frac{1}{M_h} \\ & + \lambda_{1,m}\text{Occ}_m + \lambda_{2,m}\text{Occ}_m \times M_h + \kappa_m C_m + \gamma_m X_{m,c,h} + \epsilon_{m,c,h} \end{aligned} \tag{17}$$

$$\begin{aligned} Speech_{d,c,h} = {} & a_d + \delta_{1,d}\eta_{d,2} + \delta_{2,d}\eta_{m,2} + \delta_{3,d}M_h\eta_{m,2} + \delta_{4,d}M_h \\ & + \lambda_{1,d}\text{Occ}_d + \lambda_{2,d}\text{Occ}_d \times M_h + \kappa_d C_d + \gamma_d X_{d,c,h} + \epsilon_{d,c,h} \end{aligned} \tag{18}$$

$Speech_{i,c,h}$ denotes the time spent in productive speech investment by parent i in child c in household h. As before, $\eta_{i,2}$ is i's expected returns to speech and C_i is the reported perceived cost. M_h captures the prevalence of matriliny in the village. The $X_{i,c,h}$ vector includes parent, child, and household-level controls, as in our main specification. The variable Occ_i denotes the primary productive activity of parent i, such as tending horticultural gardens, fishing, or other (omitted category). Each occupation dummy equals one if parent i reports this activity as their main source of money. The coefficients on these dummies proxy for the shadow wage associated with each occupation. We treat occupation as exogenous and fixed in the short run, reflecting that it is typically determined by local resource endowments and not easily adjusted. Our goal is not to model occupational choice, but to capture how the shadow value of time—allocated between productive activities and child investment—varies with occupational type. To allow this opportunity cost to differ by inheritance type, we interact Occ_i with the prevalence of matriliny, M_h. In our sample, 51% of women (32% of men) report horticulture as their main source of income, while 17% of women (32% of men) report fishing as their main source of income.

Table B2 shows the estimation results of equations (17) and (18) are very similar to our main model estimates from Table 3. In particular, our main result that father speaks more when the mother expects high return and has more bargaining power remains unchanged and is actually larger in magnitude. The coefficients on the occupation dummies are imprecisely estimated, suggesting a limited average trade-off between productive work and speech-based investment in children. Nonetheless, the signs of the coefficients are consistent with theoretical expectations: both mothers and fathers tend to speak less to children when their time carries a higher opportunity cost. For mothers, however, the effect is muted or reversed in matrilineal villages.

Functional form assumptions of the bargaining power shifter and cost function. We explore different assumptions in the model presented in Section 4 with implications for the estimation procedure. From this point forward in this section, we normalize the cost function by setting $\chi_{i,2} = 1$ for $i = m, d$. Under this normalization, the optimal investments strategies x_m^* and x_d^* are given by:

$$x_m^* = \omega_m \eta_{m,2} + (\frac{1-\alpha}{\alpha})\omega_d \eta_{d,2} - \chi_{m,1} \tag{19}$$

$$x_d^* = \omega_d \eta_{d,2} + (\frac{\alpha}{1-\alpha})\omega_m \eta_{m,2} - \chi_{d,1} \tag{20}$$

With the normalization, the preference parameters ω_m and ω_d are both identified. We estimate Equations (19) and (20) under two different assumptions of the relationship between the mother's pareto weight and matriliny.

Linear Relationship. We first maintain the linearity assumption and further assume that $\frac{\alpha}{1-\alpha} = M$. Under this assumption, the preference parameters ω_m and ω_d are both identified from both equations. We estimate them jointly using maximum likelihood with the following equations:

$$\begin{aligned} Speech_{m,c,h} = a_m + \boldsymbol{\delta_1} R_m + \delta_{2,m} R_d + \boldsymbol{\delta_3} \frac{1}{M_h} R_d + \delta_{4,m} \frac{1}{M_h} \\ + \kappa_{1,m} C_m + \gamma_m X_{m,c,h} + \epsilon_{m,c,h} \end{aligned} \tag{21}$$

$$\begin{aligned} Speech_{d,c,h} = a_d + \boldsymbol{\delta_3} R_d + \delta_{2,d} R_m + \boldsymbol{\delta_1} M_h R_d + \delta_{4,d} M_h \\ + \kappa_{1,d} C_d + \gamma_m X_{d,c,h} + \epsilon_{d,c,h}. \end{aligned} \tag{22}$$

Note that δ_1, which estimates the structural parameter ω_m, and δ_3, which estimates the structural parameter ω_d, are identified through the joint estimation of both parental investment equations. We are primarily interested in δ_1 which measures the responsiveness of father's investment to mother's expected return when she has more bargaining power (in Equation 22).

Table B3 reports the results. Fathers' investments remain responsive to mothers' beliefs when mothers have greater bargaining power:δ_1 is positive and statistically significant across all paternal investment measures, including CTC. This demonstrates the robustness of our findings to alternative assumptions and estimation procedures. Logistic Relationship. Second, we relax the assumption of linearity of $\frac{\alpha}{1-\alpha}$ in matriliny. We consider instead that the mother's pareto weight is a logistic function of matriliny:

$$\alpha(M) = \frac{1}{1 + \exp -(\beta_0 + \beta_1 M)} \tag{23}$$

Under this assumption, the preference parameters ω_m and ω_d, as well as the parameters β_0 and β_1, are identified and included in both equations. As before, we estimate the equations jointly. The equations for estimations are similar to Equations (21) and (22), with the key difference that M_h takes the functional form specified by Equation (23). We employ feasible generalized nonlinear least squares for estimation. A subset of estimated parameters are displayed in Tables B4. We find a positive and precisely estimated δ_1, confirming that mothers' returns are a positive driver of paternal investments when she has higher bargaining power. The results are statistically significant for all quantitative measures of investments: total vocalizations, vocalizations at high pitch, as well as conversational turns.

Spousal altruism. In the utility function we posit in Equation (1), we assume that each parent derives utility about the child's human capital but does not internalize the cost of parental investment born by the other parent. This assumption would be violated if spouses are altruistic and care about each other's costs. The literature suggests that matrilineal inheritance may reduce spousal altruism (e.g. Lowes (2022)). To account for this possibility, we add the spouse's direct cost into the parent's cost function, interacted with our bargaining power shifter. Table B5 displays the estimation results for our three main measures of paternal investment. Our main results are robust.The estimated coefficients and standard errors hardly change when the cross direct cost is included. The coefficient associated with spousal cost is never statistically significant at conventional levels, either on its own or interacted with matriliny, suggesting that potential heterogeneity in spousal altruism across inheritance structures is not relevant in our context.

Relaxing linearity of the production function of language. In Section 4, we assume linearity in the subjective child language production function (see equation (4)). This assumption implies that the first-order conditions determining optimal parental investment are independent of the child's endowment θ_0. We now relax this assumption by examining how our results vary when conditioning on the child's language endowment. While we do not explicitly model optimal parental investment under alternative non-linear specifications of the subjective production function, the revised estimating equations can be interpreted as linear approximations to the true optimal decision rules (e.g., Keane and Wolpin 1997). We measure child language endowment using the child's *total daily vocalizations*. Prior work shows that vocalization rates rise with age and predict later language development (e.g., Wang et al. 2020). Vocalizations are recorded contemporaneously with parental speech, and we assume that a child's language ability at the start of age t influences parental speech investment at that same age. Table B6 reports results from our main specification augmented with this measure. Our findings are unchanged, indicating that conditioning on child endowment does not affect the estimated effect.

Assumptions on the structure of the error term and sample. We consider different assumptions on the error term and sample. First, we jointly estimate all outcomes in a seemingly unrelated regression to account for the possibility that the error terms are correlated across equations for each of the outcomes since they are all measured by the same recording. The results in Table B8 are almost identical to our main results. Next, because 14 of 182 households have multiple recorded children, we cluster standard errors at the household level and also implement a village-level block bootstrap (given 41 villages, the clustering level in our main specification). Finally, we retain only one recorded child per household—choosing the child closest to age 2, or randomly in the case of twins. Table B9 shows that our findings are robust to all these choices.

Table B1: Dropping Violators of Monotonicity, Including Negative Returns, Dropping Missing Observations, and Using Average Returns

DV: Father's speech	(1)	(2)	(3)	(4)
Panel A: Father's vocalizations				
Matrliny × Mother's Returns	102.350***	95.569***	83.063**	85.975**
	(33.991)	(31.311)	(36.935)	(39.193)
Observations	196	196	154	196
Mean DV	1312.15	1312.15	1345.97	1312.15
SD DV	560.82	560.82	576.39	560.82
Panel B: Father's vocalizations at high pitch				
Matrliny × Mother's Returns	32.971**	30.767**	25.962*	31.567*
	(14.407)	(12.765)	(14.840)	(16.225)
Observations	196	196	154	196
Mean DV	567.08	567.08	581.37	567.08
SD DV	250.71	250.71	254.70	250.71
Panel C: Father's pitch				
Matrliny × Mother's Returns	0.263***	0.227***	0.260***	0.197***
	(0.085)	(0.081)	(0.086)	(0.076)
Observations	196	196	154	196
Mean DV	22.56	22.56	22.45	22.56
SD DV	1.25	1.25	1.27	1.25
# Custers	41	41	41	41
Drop violators of monotonicity:	Y	N	N	N
Include negative returns:	N	Y	N	N
Drop missing observations:	N	N	Y	N
Use average returns:	N	N	N	Y

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Table presents results from the joint estimation of mother and father equations, and displays father's results only. Unit of observation is a child. Each panel heading A-C indicates the dependent variable. Each outcome is the weighted average of recordings (by duration of recording). Column (1) drops violators of monotonicity. Column (2) includes negative returns. Column (3) drops observations with missing returns and costs information. Column (4) uses the average of returns for speech, school readiness, and primary school performance. All estimates control for fathers returns and costs, each interacted with matriliny, as well as the child's age, age squared, and gender, the number of children in the household, whether the recorded child is the father's biological child, the asset index, the father's cognitive ability, age, age squared, and occupation, and a province fixed effect. Standard errors clustered at the village level in parentheses. All estimates are weighted by the total duration of recordings.

Table B2: Robustness to including proxies of shadow wages

DV: Vocalizations per day	Mothers		Father	
	(1)	(2)	(3)	(4)
Bargaining power	39.431	74.095	105.945	253.699
	(42.750)	(59.995)	(266.160)	(435.021)
Mother's Returns	42.074	68.748*	-21.734	-24.642
	(25.652)	(41.587)	(20.448)	(21.533)
Father's Returns	17.436	10.311	-5.331	1.633
	(29.675)	(33.581)	(13.373)	(16.863)
Own's Costs	11.393	37.250	-15.404	-11.565
	(19.227)	(35.415)	(9.361)	(10.868)
Bargaining power × Father's Returns	-2.391	-1.330		-22.715
	(4.076)	(5.024)		(47.774)
Bargaining power × Mother's Returns		-3.918	102.910***	109.838***
		(5.896)	(36.394)	(36.977)
Bargaining power × Own Costs		-3.712		-16.357
		(4.407)		(18.326)
Income from land	-206.827	-213.434	14.192	4.686
	(154.001)	(141.012)	(136.129)	(132.784)
Income from land × Matriliny	361.113	290.103	-171.738	-164.384
	(337.208)	(335.130)	(290.115)	(275.764)
Income from fish	-39.897	-46.908	-31.180	-33.166
	(245.066)	(240.366)	(146.064)	(145.048)
Income from fish × Matriliny	185.486	160.378	-232.410	-211.586
	(368.597)	(376.942)	(282.631)	(282.895)
Observations	196	196	196	196
# Clusters	41	41	41	41
R^2	0.30	0.30	0.17	0.17
Mean DV	2,782.89	2,782.89	1,312.15	1,312.15
SD DV	931.40	931.40	560.82	560.82

* p< 0.10, ** p<0.05, *** p < 0.01. The table presents results from the joint estimation of mother and father equations. Unit of observation is a child. Each outcome is the weighted (by duration of recording) average of recordings. All estimates control for the child's age, age squared, and gender, the number of children in the household, whether the recorded child is the father's biological child, the asset index, the parent's cognitive ability, age, and age squared (mother in cols 1-2 and father in cols 3-4), and a province fixed effect. Missing observations imputed for beliefs and cognitive ability, and all estimates include indicator variables for missing observations. Standard errors clustered at the village level in parentheses. All estimates weighted by the total duration of recordings.

Table B3: Robustness to Joint Estimation and Different Assumptions on Cost Parameters

DV: Adult speech	Vocs (1)	CTC (2)	Vocs at High Pitch (3)	Pitch (4)
Mother's return (δ_1)	65.261***	20.229	24.796***	0.211***
	(20.370)	(12.594)	(8.704)	(0.077)
Father's return (δ_3)	-3.673	0.783	-1.856	0.055
	(3.886)	(2.289)	(1.692)	(0.036)
Mother's cost ($\kappa_{1,m}$)	10.101	10.363	6.512	-0.022
	(19.006)	(16.023)	(8.132)	(0.016)
Father's cost ($\kappa_{1,f}$)	-16.365*	-5.323	-6.029	0.038**
	(8.583)	(4.801)	(3.906)	(0.018)
Observations	196	196	196	196
# Clusters	41	41	41	41
R^2 Father equation	0.20	0.32	0.24	0.31
Mean DV	1,312.15	441.93	567.08	22.56
SD DV	560.82	260.99	250.71	1.25

* p< 0.10, ** p<0.05, *** p < 0.01. Table presents results from the joint estimation of mother and father equations. The parameters δ_1 and δ_3 are estimated simultaneously from both equations. Unit of observation is a child. The dependent variables are: the number of adult vocalizations per day (column 1), the number of conversational turns per day between the child and adult speakers (column 2), the number of adult vocalizations at high pitch per day, where the high pitch threshold is the speakers' median pitch within 1 second of a child vocalization (column 3), and the median pitch of the adult speaker's voice within 1 second of a child vocalization (column 4). Each outcome is the weighted average of recordings (by duration of recording). All estimates control for a province fixed effect and the standard controls of the main specification: the recorded child's age, age squared, and gender, the number of children in the household, whether the recorded child is the father's biological child, the mother's and father's age, age squared, cognitive ability, and occupation, and the household asset index. Missing observations imputed for beliefs, cognitive ability, and age, and all estimates include indicator variables for missing observations. Standard errors clustered at the village level in parentheses. All estimates are weighted by the total duration of recordings.

Table B4: Robustness to Joint Estimation and Non-Linear Assumptions on Pareto Weights

DV: Adult speech	Vocs	CTC	Vocs at High Pitch	Pitch
	(1)	(2)	(3)	(4)
Mother's returns (δ_1)	48.433*	40.963**	22.001*	0.046**
	(26.543)	(19.671)	(12.308)	(0.021)
Father's returns (δ_3)	0.000	0.000	0.000	0.001
	(0.000)	(0.000)	(0.001)	(0.009)
Mother's cost ($\kappa_{1,m}$)	7.523	10.193	4.766	-0.018
	(21.003)	(16.959)	(8.904)	(0.018)
Father's cost ($\kappa_{1,f}$)	-20.894**	-8.631*	-8.394*	0.036*
	(9.653)	(5.091)	(4.428)	(0.021)
Pareto Weight				
β_0	-15.866	-16.838	-16.783	-3.158
	(28.170)	(48.008)	(39.327)	(6.389)
β_1 (Matriliny)	18.393	17.951	19.273	4.288
	(31.418)	(53.529)	(43.873)	(6.530)
Observations	196	196	196	196
R^2 Mother	0.175	0.262	0.218	0.207
R^2 Father	0.173	0.260	0.217	0.261
# Clusters	41	41	41	41

* p< 0.10, ** p<0.05, *** p < 0.01. Table presents results from the non-linear joint estimation of mother and father equations. The parameters δ_1 and δ_3 are estimated simultaneously from both equations. Unit of observation is a child. The dependent variables are: the number of adult vocalizations per day (column 1), the number of conversational turns per day between the child and adult speakers (column 2), the number of adult vocalizations at high pitch per day, where the high pitch threshold is the speakers' median pitch within 1 second of a child vocalization (column 3), and the median pitch of the adult speaker's voice within 1 second of a child vocalization (column 4). Each outcome is the weighted average of recordings (by duration of recording). All estimates control for the child's age, age squared, and gender, the number of children in the household, whether the recorded child is the father's biological child, the household asset index, the mother's and father's cognitive ability, age, age squared, and occupation, and a province fixed effect. Standard errors clustered at the village level in parentheses. All estimates are weighted by the total duration of recordings.

Table B5: Robustness to Spousal Altruism

DV: Father's speech	Vocs (1)	Vocs at High Pitch (2)	Pitch (3)
Matriliny × Mother's Returns	99.199***	32.240**	0.281***
	(32.669)	(14.299)	(0.090)
Matriliny × Mother's Costs	-55.054*	-13.261	0.018
	(32.903)	(14.215)	(0.085)
Mother's Returns	-25.323	-8.558	-0.066
	(21.057)	(8.498)	(0.040)
Mother's Costs	9.486	1.148	0.027
	(12.434)	(5.362)	(0.033)
Father's Returns	1.626	-1.343	0.074*
	(17.604)	(7.896)	(0.041)
Father's Costs	-19.328	-6.663	0.033
	(13.209)	(5.860)	(0.028)
Matriliny	305.093	175.449	-0.861
	(498.061)	(216.530)	(0.804)
Observations	196	196	196
R^2	0.22	0.26	0.32
# Clusters	41	41	41
Mean DV	1,312.15	567.08	22.56
SD DV	560.82	250.71	1.25

* p< 0.10, ** p<0.05, *** p < 0.01. Table presents results from the joint estimation of mother and father equations, and presents father results, only. Unit of observation is a child, and outcomes are the weighted average of recordings (by duration of recording). All estimates control for the interaction of father's returns and costs with matriliny, the child's age, age squared, and gender, the number of children in the household, whether the recorded child is the father's biological child, the household asset index, the father's cognitive ability, age, age squared, and occupation, and a province fixed effect. Missing observations imputed for beliefs cognitive ability, and age, and all estimates include indicator variables for missing observations. Standard errors clustered at the village level in parentheses. All estimates are weighted by the total duration of recordings.

Table B6: Robustness to Conditioning on Key Child's Vocalizations

DV: Father's speech	Vocs (1)	Vocs at High Pitch (2)	Pitch (3)
Matriliny × Mother's Returns	101.068***	32.695**	0.267***
	(34.307)	(14.386)	(0.084)
Mother's Returns	-29.255	-10.957	-0.068*
	(21.615)	(8.693)	(0.041)
Father's Returns	0.072	-2.537	0.066
	(17.488)	(8.268)	(0.042)
Father's Costs	-11.135	-4.930	0.033
	(10.530)	(4.623)	(0.022)
Matriliny	239.945	171.422	-0.714
	(409.052)	(177.707)	(0.663)
Observations	196	196	196
R^2	0.23	0.28	0.32
# Clusters	41	41	41
Mean DV	1,312.15	567.08	22.56
SD DV	560.82	250.71	1.25

* p< 0.10, ** p<0.05, *** p < 0.01. Table presents results from the joint estimation of mother and father equations, and presents father results, only. Unit of observation is a child, and outcomes are the weighted average of recordings (by duration of recording). All estimates control for the key child's vocalizations per day, as well as the interaction of father's returns and costs with matriliny, the child's age, age squared, and gender, the number of children in the household, whether the recorded child is the father's biological child, the household asset index, the father's cognitive ability, age, age squared, and occupation, and a province fixed effect. Missing observations imputed for beliefs cognitive ability, and age, and all estimates include indicator variables for missing observations. Standard errors clustered at the village level in parentheses. All estimates are weighted by the total duration of recordings.

Table B7: Robustness: Alternative Cost Function

DV: Father's speech	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Panel A: Father's vocalizations													
Matriliny × Mother's Returns	106.589***	105.200***	102.350***	97.300**	95.499***	96.270***	113.568**	95.816***	104.715***	100.983***	99.134***	118.459***	100.921***
	(35.069)	(35.483)	(33.991)	(39.621)	(32.962)	(32.311)	(44.830)	(32.269)	(33.939)	(34.009)	(32.465)	(31.327)	(35.497)
Observations	196	196	196	196	196	196	196	196	196	196	196	196	196
Mean DV	1312.15	1312.15	1312.15	1312.15	1312.15	1312.15	1312.15	1312.15	1312.15	1312.15	1312.15	1312.15	1312.15
SD DV	560.82	560.82	560.82	560.82	560.82	560.82	560.82	560.82	560.82	560.82	560.82	560.82	560.82
Panel B: Father's vocalizations at high pitch													
Matriliny × Mother's Returns	35.866**	34.640**	32.971**	34.190**	29.892**	30.138**	32.830*	25.497*	34.376**	32.321**	31.298**	38.136***	26.887*
	(14.732)	(14.832)	(14.407)	(17.185)	(13.889)	(13.573)	(17.545)	(13.359)	(13.908)	(14.346)	(14.064)	(12.913)	(15.950)
Observations	196	196	196	196	196	196	196	196	196	196	196	196	196
Mean DV	567.08	567.08	567.08	567.08	567.08	567.08	567.08	567.08	567.08	567.08	567.08	567.08	567.08
SD DV	250.71	250.71	250.71	250.71	250.71	250.71	250.71	250.71	250.71	250.71	250.71	250.71	250.71
Panel C: Father's pitch during conversational turns													
Matriliny × Mother's Returns	0.254***	0.261***	0.263***	0.261***	0.275***	0.271***	0.142*	0.284***	0.270***	0.274***	0.274***	0.268***	0.303***
	(0.085)	(0.082)	(0.085)	(0.083)	(0.087)	(0.088)	(0.073)	(0.075)	(0.083)	(0.088)	(0.095)	(0.085)	(0.091)
Observations	196	196	196	196	196	196	196	196	196	196	196	196	196
Mean DV	22.56	22.56	22.56	22.56	22.56	22.56	22.56	22.56	22.56	22.56	22.56	22.56	22.56
SD DV	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
# Clusters	41	41	41	41	41	41	41	41	41	41	41	41	41
Controls:	None	Child	Full	All interactions	Full+Care	Full+Care+Sister	Full+Date	Full+Language	Full+Child Vocs	Market	Community	School	Elected

* p< 0.10, ** p<0.05, *** p < 0.01. Table presents results from the joint estimation of mother and father equations, and displays father's results only. Unit of observation is a child, and outcomes are the weighted average of recordings (by duration of recording). Each panel heading A-C indicates the dependent variable. Column (1) shows our main result in an uncontrolled regression. Column (2) adds only the following child controls: the child's age, age squared, and gender, as well as a dummy variable for the household's randomized treatment assignment in the child-directed speech intervention baseline. Columns (3)-(9) add the following controls: the number of children in the household, whether the recorded child is the father's biological child, the household asset index, and the father's cognitive ability, age, age squared, and occupation. Column (3) thus displays our baseline coefficient. Column (4) interacts all controls with matriliny. Column (5) adds to the full controls in column (3) the total amount of help with child care that the mother receives from female and male caregivers, separately. Column (6) additionally controls for whether the recorded child has an older sister. Column (7) controls for date of recording fixed effects. Column (8) controls for language fixed effects. Column (9) controls for total vocalizations from children who are not the key child. Columns (10)-(13) include village-level characteristics, interacted with mothers' and fathers' returns and costs, in the following order: market in village (10), community center in village (11), primary school in village (12), village leader is elected (13). In all specifications, standard errors are clustered at the village level. Missing observations imputed for beliefs, cognitive ability, and age, and all estimates include indicator variables for missing observations. All estimates are weighted by the total duration of recordings.

Table B8: Joint Estimation of All Outcomes

DV: Father's Speech	Vocs	CTC	Vocs at High Pitch	Pitch
	(1)	(2)	(3)	(4)
Matriliny × Mother's Returns	107.718***	16.276	35.660**	0.251***
	(35.045)	(16.996)	(14.924)	(0.084)
Matriliny × Father's Returns	-26.931	-21.957	-20.054	-0.059
	(45.496)	(15.863)	(20.917)	(0.080)
Matriliny × Father's Costs	-14.874	-9.184	-4.638	0.025
	(15.867)	(8.319)	(8.113)	(0.045)
Mother's Returns	-26.581	-10.153	-9.653	-0.061
	(21.998)	(8.010)	(8.847)	(0.042)
Father's Returns	3.946	3.007	-0.415	0.069*
	(16.290)	(7.245)	(7.616)	(0.041)
Father's Costs	-8.653	-4.138	-3.911	0.033
	(8.339)	(5.024)	(3.635)	(0.022)
Matriliny	146.849	168.962	131.174	-0.672
	(377.442)	(155.424)	(163.291)	(0.644)
Observations	196	196	196	196
R^2	0.205	0.267	0.252	0.313
Mean DV	1312.15	441.93	567.08	22.56
SD DV	561.83	260.99	250.72	1.25

* p< 0.10, ** p<0.05, *** p < 0.01. Table presents results from the joint estimation of the mother and father equations across all outcomes, and displays father's results only. Unit of observation is a child. Outcomes are measures of adult male speech, indicated at the top of each column, which are the weighted average of recordings (by duration of recording). All estimates control for father's returns and costs, each interacted with matriliny, as well as the the child's age, age squared, and gender, the number of children in the household, whether the recorded child is the father's biological child, the father's cognitive ability, age, age squared, and occupation, the household asset index, and a province fixed effect. Missing observations imputed for beliefs, cognitive ability, and father's age, and all estimates include indicator variables for missing observations. Standard errors clustered at the village level in parentheses. All estimates are weighted by the total duration of recordings.

Table B9: Robustness: Clustering by Household, Block Bootstrapping, Dropping Second Recorded Child, and Duration Thresholds

DV: Father's speech	(1)	(2)	(3)	(4)	(5)
Panel A: Father's vocalizations					
Matriliny × Mother's Returns	102.350**	102.350**	114.143***	94.602***	91.323**
	(46.681)	(48.249)	(32.674)	(33.043)	(38.079)
Observations	196	196	182	186	176
Mean DV	1312.15	1312.15	1319.39	1306.72	1297.91
SD DV	560.82	560.82	564.79	560.96	552.78
Panel B: Father's vocalizations at high pitch					
Matriliny × Mother's Returns	32.971*	32.971	38.987***	30.850**	28.763*
	(18.841)	(20.889)	(13.385)	(14.036)	(16.545)
Observations	196	196	182	186	176
Mean DV	567.08	567.08	569.67	564.30	561.89
SD DV	250.71	250.71	252.15	250.31	247.39
Panel C: Father's pitch during conversational turns					
Matriliny × Mother's Returns	0.263***	0.263*	0.269***	0.226***	0.254***
	(0.083)	(0.139)	(0.075)	(0.076)	(0.072)
Observations	196	196	182	186	176
Mean DV	22.56	22.56	22.49	22.57	22.56
SD DV	1.25	1.25	1.22	1.23	1.21
Sample:	Full	Full	One Child	> 5th ptile	> 10th ptile
Clustering:	Household	Block Bootstrap	Village	Village	Village
# Clusters	182	41	41	40	40

* p< 0.10, ** p<0.05, *** p < 0.01. Table presents results from the joint estimation of mother and father equations, and displays father's results only. Unit of observation is a child. Each panel heading A-C indicates the dependent variable, a specific measure of adult male speech, which is the weighted average of recordings (by duration of recording). All estimates control for father's returns and costs, each interacted with matriliny, as well as the the child's age, age squared, and gender, the number of children in the household, whether the recorded child is the father's biological child, the father's cognitive ability, age, age squared, and occupation, the household asset index, and a province fixed effect. Missing observations imputed for beliefs, cognitive ability, and father's age, and all estimates include indicator variables for missing observations. Standard errors are clustered by household in column (1), block bootstrapped at the village level in column (2), and clustered by village in columns (3)-(5). Column (3) is additionally restricted to one recorded child per household (keeping the one closest to 24 months or, in the case of twins, a randomly selected child. In columns (4) and (5), we restrict the sample to children whose recording durations are above the 5th and 10th percentiles, respectively. All estimates are weighted by the total duration of recordings.

C Details on the measurement of speech

We measure speech from child-centered long-form recordings collected using a minimally intrusive wearable device, picture in Figure C1. In urban conditions, with reliable access to electricity and the internet, a hardware-software combined solution called LENA is frequently used. LENA is suboptimal for the current approach for two key reasons. First, the lack of electricity and internet connection found in the remote communities of the Solomon Islands imply that the licenses promoted by LENA are inappropriate: to recover the audio-recordings, one needs to connect the recording device to a computer, have enough power and internet to extract and upload the recording (which is meanwhile stored in a proprietary format) before the recording device can be used again. Second, LENA's software was trained in urban conditions among monolingual American English learners, which raised questions about whether the software would be sufficiently accurate in our population of largely multilingual infants (children in our sample are exposed to one or more of 12 different languages). Our solution also offers substantial cost-saving and transparency benefits.[40]

Figure C1: Wearable recording device

(a) Child T-shirt with USB recorders (inside out)

(b) Recorded child

As we explain in Section 3.2, the Voice Type Classifier (VTC; Lavechin et al. (2020)) was trained with a combination of various child-centered corpora of children aged 0-4 years exposed to one or more of a variety of languages (including Minn,

[40]Each USB recorder worth around 2 USD, compared to around 200-400 USD per LENA device, and the analysis code for VTC is open-source, while LENA charges additional recording processing costs.

French, Jul'hoan, Tsimané, English, and several others, in approximate order of data quantity). These corpora included children growing up in multilingual settings, as well as languages spoken in the Pacific, with a wide variety of typological characteristics. The multi-corpus training was done to improve the generalizability of the network to unseen data sets. The corpora were divided internally into independent training, developmental, and testing sets. As reported in Lavechin et al. (2020), F-score performance on the test set of this multilingual corpus was 77.3% for recognizing the key child.[41] Lavechin et al. (2020) also reports on performance for a wholly independent, unseen, test set comprised on monolingual English learners, for which LENA performance was also available. In that comparative dataset, LENA's performance for the key child was 54.9%. The VTC scored nearly 25% higher, at 68.7%. VTC also outperformed LENA for male (F-score of 43% versus 37%) and female voices (F-score of 63% versus 43%; Lavechin et al., 2020).

To ensure our automatic measures accurately reflected children's speech environment, we compared VTC classification to human annotations of a subset of 1-minute clips sampled periodically from the recordings. In total, 8 research assistants annotated 384 minutes of audio for speech and speaker type. These gold standard annotations were compared to VTC automatic outputs to compute measures of recall (how well the VTC distinguishes true positives from false negatives for each speaker class) and precision (how well the VTC distinguishes true positives from false positives for each speaker class.) We found F-scores of 58% for female and 57% for male. These rates are comparable to those previously found using VTC in Vanuatu (female = 60%, male = 56%, Cristia et al., 2023) and are slightly better than averages found in previous validations of long-form audio (Cristia et al., 2021). We also checked recording measures for internal consistency by checking their split-half reliability. To do this, we calculated each speech measure on every hour of audio and took the correlation between even and odd recording hours. We found high split-half reliability for all categories (r=0.83 for female, r=0.81 for male).

Another limitation of LENA consists of measurement error in automated measures

[41] F-score is a measure of accuracy that goes from 0 to 100%, higher is better. In technical terms, it is the harmonic mean of precision and recall, with precision being the percentage of retrieved elements that are true positives, and recall the percentage of relevant elements that were indeed retrieved. For instance, if the "key child" category has a precision of 70%, that means that 30% of the times that the system returned "key child", it was wrong, and it was a different category (e.g., female adult). A recall of 70% means that 30% of the times the key child vocalized, the system did not spot this (e.g., missed the speech altogether or put it in the "female adult" category).

of conversational turn counts (CTC). In a meta-analysis looking at the reliability of automated measures, Cristia et al. (2020) found that LENA's CTC had only a .35 correlation with human coded counts for conversational turns. In contrast, the measures of child or adult vocalization counts correlated highly with human estimates (r>.7), suggesting that vocalizations are more precise measure of language compared with CTC turns. To some extent, this may be explained by the fact that LENA uses a 5-second frame to code adult-child or child-adult sequence. 5 seconds may be too long, considering that a recent meta-analysis suggests most child-adult and adult-child turn transitions occur within 2 seconds. To account for this, we use a 1 second threshold in our CTC measure, although we check that our results are similar using the 5 seconds LENA threshold. Another difference between our measure of CTC and the LENA measure of CTC is that LENA throws out overlapping speech between adult and speech, while our measure counts it as CTC. This explains why mean CTC is higher in our sample compared to, e.g., Dupas et al. (2025).

We detail below how our specific speech measures are constructed:

Total Vocalization: for every 10 ms frame, the Voice Type Classifier (VTC) returns whether the key child (i.e., the child wearing the USB device), adult female, adult male, or other child was vocalizing. A vocalization is defined as a sequence of frames in which a speaker vocalizes. We count the number of vocalizations attributed to the relevant speaker (i.e., key child, other child, adult female, or adult male) over the whole recording. We then divide that measure by the length of the recording to control for variation in recording length, and scale it to a 12-hour day to produce a normalized per day figure.

Conversational turn count (CTC): counts the number of inter-turn intervals between the speaker and the child using some simple assumptions. A vocalization is considered a turn if: 1) the vocalization is from the key child or the speaker (or a list of speakers), 2) the previous vocalization was from the other (if the vocalization is key child, the previous one has to be the speaker and vice versa), 3) the vocalization must have begun less than one second after the previous one ended (it can also begin before the previous one ended i.e. the new speaker 'interrupts' the previous one). We then divide that measure by the length of the recording to control for variation in recording length, and scale it to a 12-hour day to produce a normalized per day figure.

Pitch: For each adult speaker type (adult female, adult male), we identify all adult vocalizations occurring within one second of a child vocalization. For each such adult vocalization, we compute its average pitch. Median pitch (or "pitch") is defined as the median of these average-pitch values for a given speaker type. Pitch is measured in semitones. In our main analyses, median pitch for a given speaker type serves as a proxy for the quality of child-directed adult speech.

Vocalizations at High Pitch: we count the number of vocalizations for each speaker type (adult female, adult male) that exceed our key median pitch measure just defined, regardless of whether the vocalization itself occurs close to a child vocalization. In our main analyses, we use this measure as a proxy for child-directed adult speech quantity. We then divide that measure by the length of the recording to control for variation in recording length, and scale it to a 12-hour day to produce a normalized per day figure.

Mother-Father Conversations: We count the number of conversations that include only adult female and adult male vocalizations. Conversations are sequences of vocalizations bounded by silences longer than 5 seconds. We then divide that measure by the length of the recording to control for variation in recording length and scale it to a 12-hour day to produce a normalized per day figure.

Father's time with children: We count the number of hours with at least 10 adult male vocalizations to proxy for the number of hours the father spends near the child.

D Data and Questionnaire

We conducted household surveys with mothers and fathers, individually. We also collected experimental measures of cooperation and competition. The share sent to the spouse in an incentivized dictator game is a measure of intra-household cooperation. In the competition game, subjects completed an incentivized task (completion of visual puzzles, similar to Raven's Tests) for which they could decide to be paid a piecemeal rate or compete against an opponent in a tournament. Parents' decision to compete against their spouses provides a measure of intra-household discord. The number of correct puzzles (out of 24) is a measure of cognitive ability. Finally, we interviewed village leaders, who provided information on inheritance, post-marital residence, governance, public goods, and predominant languages spoken in the village.

Beliefs Questionnaire. "Now I am going to ask you some questions about your beliefs regarding certain behaviours that adults in your community could have and its effect on children. Before that, let's talk about how I am going to understand your answers better.

I will ask you several questions about the chance or likelihood that certain events are going to happen. There are 10 beans in the cup. I would like you to choose some beans out of these 10 beans and put them in the plate to express what you think the likelihood or chance is of a specific event happening. 1 bean represents 1 chance out of 10. If you do not put any beans in the plate, it means you are sure that the event will NOT happen. As you add beans, it means that you think the likelihood that the event happens increases. For example, if you put 1 or 2 beans, it means you think the event is not likely to happen, but it is still possible. If you pick 5 beans, it means that it is just as likely it happens as it does not happen (50-50, like flipping a coin). If you pick 6 beans, it means the event is slightly more likely to happen than not to happen. If you put 10 beans in the plate, it means you are SURE the event will happen. There is no right or wrong answer, we just want to know what you think. Let me ask you a couple of questions to make sure you understand how to answer using the beans.

Pick the number of beans that reflects how likely you think it is that (a) A woman in your village will go to the market at least once within the next 2 days? (b) A woman in your village will go to the market at least once within the next 2 weeks?

We now ask you to think about a hypothetical child born in your village this year and what may happen to this child depending on his/her carers' behavior.

Pick the number of beans that reflects how likely you think it is that a child puts 2-3 words together in speaking by age 2 years of his/her life (a) if the carers frequently talk to the child directly? (b) if the carers rarely talk to the child directly?

Now, I would like you to think about your child (*ENUMERATOR: be sure to reference the child we are recording*) and how s/he compares to other children in your community. Pick the number of beans that reflects how likely you think it is that

(1) child will be ready for school at age 6 (a) if the carers frequently talk to the child directly? (b) if the carers rarely talk to the child directly?

(2) child will learn well at primary school (a) if the carers frequently talk to the child directly? (b) if the carers rarely talk to the child directly?

(3) child will go to secondary school (a) if the carers frequently talk to the child

directly? (b) if the carers rarely talk to the child directly?

We would like you to think about all the constraints regarding talking directly to your child. You may be too tired to do it or you may have no time to do it. All those things make being talkative costly. On the contrary, you may find that talking directly to your child is really easy and fun, and you easily find the time to do it. On a scale from 0 to 10, where zero means not costly at all and 10 means very costly, how costly do you think it is to talk directly to your child?"

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