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## Geographical Roots of the Coevolution of Cultural and Linguistic Traits

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# Geographical Roots of the Coevolution of Cultural and Linguistic Traits

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## ABSTRACT

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# Geographical Roots of the Coevolution of Cultural and Linguistic Traits\*

This research explores the geographical origins of the coevolution of cultural and linguistic traits in the course of human history, relating the geographical roots of long-term orientation to the structure of the future tense, the agricultural determinants of gender bias to the presence of sex-based grammatical gender, and the ecological origins of hierarchical orientation to the existence of politeness distinctions. The study advances the hypothesis and establishes empirically that: (i) geographical characteristics that were conducive to higher natural return to agricultural investment contributed to the existing cross-language variations in the structure of the future tense, (ii) the agricultural determinants of gender gap in agricultural productivity fostered the existence of sex-based grammatical gender, and (iii) the ecological origins of hierarchical societies triggered the emergence of politeness distinctions.

**JEL Classification:** O10, Z10, Z13

**Keywords:** comparative development, cultural evolution, language structures, future tense, politeness distinctions, long-term orientation, grammatical gender, gender bias, hierarchy, emergence of states

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# 1 Introduction

The origins of the vast inequality in the wealth of nations have been largely attributed to the persistent effect of an uneven distribution of pre-industrial geographical, cultural, institutional and human characteristics across the globe.<sup>1</sup> In particular, evidence suggests that regional variations in the geographical environment in the distant past have contributed to the differential formation of cultural traits and their lasting effect on comparative economic development across countries, regions and ethnic groups.<sup>2</sup> In light of the apparent coevolution of cultural and linguistic characteristics in the course of human history, emerging linguistic traits have conceivably reinforced the persistent effect of cultural factors on the process of development.<sup>3</sup> Nevertheless, the significance of these joint evolutionary processes, and their potential common geographical roots, for the understanding of the process of development and the uneven distribution of wealth of nations, has remained obscured.

This research explores the geographical origins of the coevolution of cultural and linguistic traits. It advances the hypothesis and establishes empirically that geographical characteristics that were conducive to the emergence and the persistence of fundamental cultural traits triggered the evolution of complementary linguistic traits that have fostered and reinforced the diffusion and the intergenerational transmission of these cultural traits in the course of human history.<sup>4</sup>

The research identifies the common geographical roots of cultural and linguistic traits, associating long-term orientation to the structure of the future tense, gender bias to the presence of sex-based grammatical gender, and hierarchical orientation to the existence of politeness distinctions. The study establishes that geographical characteristics that were conducive to higher natural return to agricultural investment, and thus to the emergence of long-term orientation, contributed to the emergence of a structure of the future tense that complements long-term oriented behavior. Furthermore, the analysis suggests that suitability of land for the adoption of agricultural technologies that contributed to a gender gap in productivity has been conducive to the emergence of sex-based grammatical gender. Moreover, the findings indicate that ecological diversity, which had been pivotal to specialization, trade, and thus to the emergence of hierarchical societies, fostered the presence of politeness distinctions.

The proposed hypothesis rests upon several fundamental building blocks. First, in light of the pivotal role of languages in the diffusion of knowledge and the transmission of values, emerging linguistic characteristics in the course of human history have conceivably affected the diffusion of cultural values, reinforcing existing cultural traits and their intergenerational transmission.<sup>5</sup> Second, the forces of natural selection across language structures have plausibly generated an evolutionary advantage to linguistic traits that reflected and reinforced the dominating cultural traits. Third, regional differences

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<sup>1</sup>Gallup et al. (1999), Guiso et al. (2004, 2006), Tabellini (2010), Acemoglu et al. (2001), Glaeser et al. (2004), and Ashraf and Galor (2013b).

<sup>2</sup>Alesina et al. (2013) and Galor and Özak (2016).

<sup>3</sup>Cavalli-Sforza et al. (1994), Cavalli-Sforza (2000), and Richerson et al. (2010).

<sup>4</sup>This hypothesis is in line with the Linguistic Niche Hypothesis (LNH), which “proposes that, just as the structure of biological organisms are affected by their ecological niche, the structure of society affects the evolutionary pressures on language structures” (Roberts and Winters, 2012).

<sup>5</sup>In particular, socio- and anthropological linguistics, have argued that language usage is central for social expression (Brown and Levinson, 1987).

in geographical characteristics that have contributed to the emergence of variations in cultural traits have conceivably contributed to the evolution of cross-language variations in complementary linguistic traits. Fourth, cultural traits that have been reflected in language structures have been more persistent across time and space, reflecting the view that deviations from existing language structures, rather than from the prevailing cultural traits, are less likely to occur in light of their adverse effect on the feasibility of communication across individuals.

The common geographical origins of cultural and linguistic traits are explored in three distinct settings. Consider historical societies characterized by hierarchical orientation (e.g., obedience, conformity, and power distance). Linguistic traits that had reinforced existing hierarchical structures and cultural norms had conceivably emerged and persisted in these stratified societies in the course of human history. In particular, politeness distinctions in pronouns (e.g., the differential use of “tu” and “usted” in the Spanish language, “Du” and “Sie” in German, and “tu” and “vous” in French) had conceivably appeared and endured in hierarchical societies.<sup>6</sup> Thus, geographical characteristics, such as ecological diversity that had been conducive to the emergence of hierarchical societies (Fenske, 2014), may have contributed to the emergence of politeness distinctions.

Further, consider ancient civilizations that had been characterized by a sexual division of labor and consequently by the existence of gender bias. Linguistic traits that had fortified the existing gender biases have plausibly emerged and persisted in these societies over time.<sup>7</sup> In particular, geographical characteristics that had been associated with the adoption of agricultural technology that had contributed to a gender gap in productivity, and thus to the emergence of distinct gender roles in society (e.g., the suitability of land for the usage of the plow (Pryor, 1985; Alesina et al., 2013)), may have fostered the emergence and the prevalence of sex-based grammatical gender in the course of human history.<sup>8</sup>

Finally, in societies characterized by long-term orientation in the distant past, a structure of the future tense that has reinforced long-term oriented behavior may have emerged and persisted over time. In particular, pre-industrial agro-climatic characteristics that were conducive to higher return to agricultural investment and therefore to the prevalence of long-term orientation (Galor and Özak, 2016), may have triggered the emergence and the prevalence of a long-term oriented structure of the future tense.

The empirical analysis explores the proposed hypothesis and examines the geographical origins of three language structures: the structure of the future tense, the presence of sex-based grammatical gender systems, and the existence of politeness distinctions in pronouns. Moreover, it further examines the proposed mediating channels that may have governed the associations between these geographic and linguistic traits. The analysis advances several strategies to mitigate potential concerns regarding the role of reverse causality, omitted variables, and sorting in the observed associations. First, overcoming potential concerns about reverse causality (i.e., the effect of periphrastic future tense and

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<sup>6</sup>Politeness distinctions may have emerged in order to mitigate the coordination cost in the interaction between individuals from various social strata (Brown and Levinson, 1987; Brown and Gilman, 1989; Helmbrecht, 2003, 2005).

<sup>7</sup>Indeed, socio-linguists as well as other scholars have argued that gender bias can be reinforced by a sex-based grammatical gender system (Lakoff, 1973; Eckert and McConnell-Ginet, 2003; Stahlberg et al., 2007).

<sup>8</sup>As discussed in section 5, the timing of the emergence of the plow is consistent with the subsequent emergence of sex-based grammatical gender in a significant number of languages.

the associated long-term orientation on cultivation methods, the choice of technologies, and thus the actual crop returns, or the effect of sex-based grammatical gender, and the associated gender roles, on the adoption of crops that are conducive for the use the plow), the analysis exploits potential crop return and potential yield of crops suitable for the adoption of the plow (associated with agro-climatic conditions that are orthogonal to human intervention), rather than the actual ones. Second, the empirical analysis exploits the well-established observation that daughter languages within a language family originated from a common proto-language (Bouckaert et al., 2012; Pagel et al., 2013; Wichmann, 2017), in order to establish the historical depth of the association between these geographical characteristics and language structures as well as to mitigate potential concerns about the effect of sorting on the observed relationships.<sup>9</sup> Third, mitigating the potential role of omitted institutional, cultural, geographical and human characteristics in the observed relationship, the analysis mirrors the epidemiological approach to cultural diffusion and identifies the geographical origins of each language structure based on variation across languages located outside the ancestral homeland of their proto-language (i.e., their *Urheimat*), accounting for the host region fixed-effects, and thus capturing unobserved time-invariant heterogeneity at the regional level. Furthermore, the analysis accounts for confounding geographical characteristics in the homelands of the proto-language and of the daughter languages, as well as for spatial auto-correlation, while alleviating concerns about selection on unobservables.

The first part of the empirical analysis examines whether agro-climatic characteristics that have governed the return to agricultural investment, and have been associated with the emergence of long-term orientation (Galor and Özak, 2016), have contributed to the structure of the future tense. Consistent with the view that periphrastic future tense reflects an intentional, future-orientated behavior, the analysis establishes that periphrastic future tense is more prevalent in languages that originated in geographical regions that have been characterized by higher potential crop returns and thus higher long-term orientation. The findings suggest that higher potential crop return in the ancestral homeland of the proto-language (i.e. the *Urheimat* of the language), rather than the potential return in the current geographical location of each daughter language, has been the trigger for the presence of periphrastic future tense in daughter languages, mitigating potential concerns about the effect of the potential sorting of individuals who use periphrastic future tense into regions with high crop return. Furthermore, the analysis suggests that long-term orientation is indeed more prevalent in communities whose languages are characterized by periphrastic future tense. Moreover, the findings indicate that the intensity of agriculture of ethnic groups in the contemporary geographical homeland of each language (i.e., the indigenous regions that spoke the language in the pre-colonial as well as in the post-colonial era) appears to be the mediating channel through which the return to agricultural investment has affected the presence of periphrastic future tense.

The second part of the empirical analysis examines whether geographical characteristics that had been associated with the the adoption of an agricultural technology that contributed to a gender gap in productivity, and thus to the emergence of distinct gender roles in society, have increased the

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<sup>9</sup>A proto-language is the ancestral language that gave rise to all daughter languages that belong to the same language family.

prevalence of sex-based grammatical gender in the language spoken in society. Consistent with the view that the emergence of the plow was associated with an increase in a gender gap in productivity (Pryor, 1985; Alesina et al., 2013), the analysis establishes that sex-based grammatical gender is more prevalent in languages that originated in geographical regions that have been characterized by greater suitability of land for the usage of the plow. Mitigating potential concerns about the effect of the potential sorting of individuals who use sex-based grammatical gender into regions suitable for the usage of the plow, while establishing the historical depth of this association, the findings further suggest that higher suitability of land for the usage of the plow in the Urheimat (i.e., the ancestral homeland of the proto-language), rather than in the current geographical location of each daughter language, has been the dominating force in the presence of sex-based grammatical gender in each of the daughter languages. Furthermore, the findings suggest that indeed gender bias is more prevalent in communities whose languages are characterized by sex-based grammatical gender. Moreover, the findings indicate that the actual usage of the plow within ethnic groups in the contemporary geographical homeland of each language appears to be the mediating channel through which suitability of land for the usage of the plow have affected the presence of sex-based grammatical gender.

The third part of the empirical analysis examines whether geographical characteristics, such as ecological diversity, that had been conducive to the emergence of hierarchical societies (Fenske, 2014), have contributed to the emergence of politeness distinctions. Consistent with the view that the presence of politeness distinctions has reinforced existing hierarchical structures and cultural norms (e.g., obedience, conformity, and power distance), the findings suggest that the presence of politeness distinctions in pronouns is more prevalent in languages that originated in geographical regions that have been characterized by greater ecological diversity. Furthermore, the findings suggest that hierarchical orientation is indeed more prevalent in communities whose languages are characterized by politeness distinctions. Moreover, the findings indicate that jurisdictional hierarchy of ethnic groups in the contemporary geographical homeland of each language appears to be the mediating channel through which ecological diversity has affected the presence of politeness distinctions.

Consistent with evidence about the greater adaptability of politeness distinctions (in comparison to the structure of the future tense and sex-based grammatical gender) to environmental and political changes, the findings suggest that while geographical characteristics in the Urheimat (i.e., the ancestral homeland of the proto-language) are associated with the existence of the periphrastic future tense and sex-based grammatical gender, the geographical characteristics in the contemporary homeland of the daughter languages are associated with the existence of politeness distinctions.

This research is the first to explore the geographical determinants of the coevolution of cultural and linguistic traits in the course of human history.<sup>10</sup> It contributes to the growing literature on the evolution of language (Pinker and Bloom, 1990; Christiansen and Kirby, 2003a,b; Bickerton, 2007),

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<sup>10</sup>Existing economic research predominantly views languages as an identifier of cultural and ethnic groups. Linguistic fractionalization as well as linguistic distance have been extensively used as a proxy for cultural fractionalization and cultural distance in the exploration of the effect of ethnic diversity on economic growth and the impact of cultural distance on the diffusion of development (Easterly and Levine, 1997; Fearon, 2003; Alesina et al., 2003; Alesina and Ferrara, 2005; Desmet et al., 2012; Harutyunyan and Özak, 2016). In particular, Michalopoulos (2012) and Ashraf and Galor (2013a) explore the geographical origins (i.e., diversity of soil quality and migratory distance from Africa) of existing variation in linguistic fractionalization within a geographical region.

providing evidence for the origins of language structures.<sup>11</sup> Moreover, it sheds a new light on the stability of some language structures (Wichmann and Holman, 2009; Greenhill et al., 2010; Dediu and Levinson, 2012; Dediu and Cysouw, 2013; Greenhill et al., 2017), underlying the dominance of geographical conditions in the Urheimat (i.e., the homeland of the proto-language) in observed contemporary structures. Furthermore, it proposes geographical foundations for the link between linguistic traits and socio-economic behavior as explored by Brown and Gilman (1960), Brown and Levinson (1987), Hellinger and Bufimann (2001), Eckert and McConnell-Ginet (2003), Roberts and Winters (2012), Chen (2013) and Davis and Abdurazokzoda (2016).<sup>12</sup>

The analysis sheds additional light on the geographical roots of comparative development (Diamond, 1997; Ashraf and Galor, 2013b), the interaction between the evolution of human traits and the process of development (Galor and Moav, 2002; Spolaore and Wacziarg, 2013), and the geographical origins of cultural traits as well as the determinants of their persistence in the course of human history (Bisin and Verdier, 2000; Nunn and Wantchekon, 2011; Fernández, 2012; Alesina et al., 2013; Galor and Özak, 2016).

## 2 Data

This section presents the data that is used in the empirical analysis of the geographical origins of language structures and the methodology that guided its construction. In particular, it introduces the data on cross-language variations in the structure of the future tense, the presence of sex-based grammatical gender, and the existence of politeness distinctions in pronouns, as well as the data on cross-regional variations in the hypothesized geographical determinants of these language structures.

The linguistic characteristics of each language are linked to: (i) the geographical characteristics of the contemporary homeland (i.e., the characteristics of the indigenous regions that spoke the language in the pre-colonial as well as in the post-colonial era),<sup>13</sup> (ii) the geographical characteristics of the ancestral homeland of the proto-language (i.e., the Urheimat), and (iii) the ethnographic characteristics of the groups that speak the language in the contemporary linguistic homeland. In particular, the linguistic data is mapped to the *Ethnologue* (Lewis et al., 2009) in order to identify the geographical characteristics of the contemporary linguistic homeland, and is linked to the Ethnographic Atlas (Murdock, 1967) and the Standard Cross Cultural Sample (Murdock and White, 1969) in order to identify the ethnographic characteristics of the aboriginal speakers of each language. The mapping of these datasets is based on the ISO code of each language, which is available in all three datasets.

Furthermore, in order to explore the deep historical roots of language structures, each language is mapped to the ancestral homeland of its proto-language (*Urheimat*). In particular, for each language family, the paper identifies the location of the Urheimat based on the frontier methodology used by

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<sup>11</sup>Earlier literature explored the spatial origins of languages, rather than the geographical determinants of language structures.

<sup>12</sup>See Ginsburgh and Weber (2018a,b) for surveys on the economics of language.

<sup>13</sup>This focus on the contemporary linguistic homeland is designed to capture the geographical roots of each daughter language (rather than the proto-language). For instance, Spain, rather than regions in Latin America and elsewhere that had adopted the Spanish language in the post-colonial era, is considered the contemporary linguistic homeland of the Spanish language.

linguists (Wichmann et al., 2010). This method, as explained further in Appendix E follows a similar strategy employed by geneticists to determine the location of the origin of domestication of crops.<sup>14</sup>

## 2.1 Dependent Variables: Language Structures

This subsection introduces the three language structures whose geographical origins will be explored: (i) periphrastic future tense, (ii) sex-based grammatical gender systems, and (iii) politeness distinctions in pronouns. In particular, based on The World Atlas of Language Structures (WALS) (Dryer, 2013), it presents the data about the existence of each of these structures across languages.

The existence of a structure  $S$  in language  $\ell$ ,  $S_\ell$ , is encoded such that:

$$S_\ell = \begin{cases} 1 & \text{if the structure exists in language } \ell \\ 0 & \text{if the structure does not exist in language } \ell. \end{cases}$$

### 2.1.1 Periphrastic Future Tense

Languages differ in the structure of their future tense. In particular, linguists distinguish between languages that are characterized by an *inflectional* versus *periphrastic* future tense (Dahl, 1985, 2000; Dahl and Velupillai, 2013). Inflectional future tense is associated with verbs that display morphological variation (i.e., a change in the verb form that is associated with the future tense). In contrast, periphrastic future tense is characterized by roundabout or discursive phrases, such as ‘will’, ‘shall’, ‘want to’, ‘going to’ in the English language (Bybee and Pagliuca, 1987; Bybee and Dahl, 1989; Bybee et al., 1994).

Bybee and Dahl (1989) argue that, unlike the inflectional future tense, the periphrastic future tense is formed by terms that express a desire, an intention, an obligation, a commitment as well as a movement towards a goal. In particular, in the English language, “*shall has developed from a main verb meaning ‘to owe’, will from a main verb meaning ‘to want’, and the source of be going to is still transparent*” (Bybee and Dahl, 1989, p.90). Moreover, “*intention and prediction are most commonly expressed by the periphrastic future, while the synthetic one is more common in generic statements, concessives, and suppositions*” (Bybee et al., 1994, p.235). Inflectional futures “*also appear systematically (often obligatorily) in sentences which express clear predictions about the future (which are independent of human intentions and planning), whereas less grammaticalized constructions [i.e., periphrastic] often tend to be predominantly used in talk of plans and intentions – a fact which is explainable from the diachronic sources of future tenses*” (Dahl and Velupillai, 2013, p.270). Thus, these views suggest that the use of periphrastic future tense conceivably reflects long-term oriented behavior.

The dataset on the existence of periphrastic future tense includes 275 contemporary languages, originated from 76 language families.<sup>15</sup> The classification of 222 of the languages in the sample is based on Dahl and Velupillai (2013), as reported in WALS, and the remaining 53 languages are

<sup>14</sup>The analysis excludes language families for which there is no data on the location of the Urheimat, or if the language family is unclassified, or the language is a Creole or language isolate (i.e., which has no identified sister languages).

<sup>15</sup>Importantly, 90% of the languages in the Ethnologue belong to these 76 language families.

classified based on Dahl (1985, 2000).<sup>16</sup> Figure 1 and Table D1 describe the prevalence and the spatial distribution of the structure of future tense in the dataset, portraying wide variations within regions in the existence of periphrastic future tense. In particular, in most regions about 50% of the languages in the sample are characterized by periphrastic future tense.

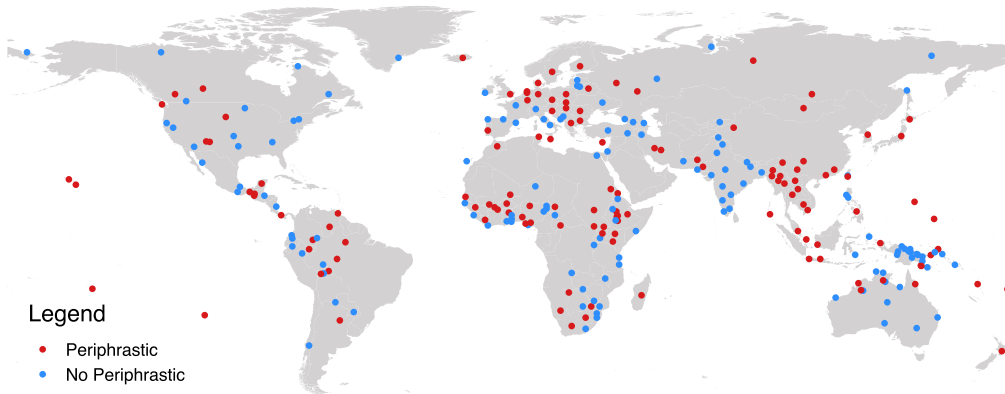


Figure 1: The Global Distribution of Periphrastic Future Tense

### 2.1.2 Sex-Based Grammatical Gender Systems

Languages differ in the existence and the form of grammatical gender. In particular, languages that are characterized by sex-based grammatical gender classify nouns according to biological gender. The presence of sex-based grammatical gender induces speakers to highlight gender distinctions even in situations in which gender may not play an intrinsic role. Moreover, linguists have argued that the presence of “masculine generics” in some languages (e.g., the use of the noun “adam” to describe “man” as well as “human being” in the Hebrew and Turkish languages) has reinforced gender biases in the course of human history, equating “maleness and humanness” (Stahlberg et al., 2007, p.169). Thus, perhaps not surprisingly, linguists as well as other scholars have persistently argued that gender biases have been reinforced by languages characterized by sex-based grammatical gender systems (Lakoff, 1973; Eckert and McConnell-Ginet, 2003; Stahlberg et al., 2007).

The study explores the geographical origins of sex-based grammatical gender based upon the existence of this language structure in 217 contemporary languages, originated from 74 language families (Corbett, 2013b).<sup>17</sup> Figure 2 and Table D2 describe the prevalence and the spatial distribution of sex-based grammatical gender systems in the dataset, demonstrating wide regional and cross-regional variations in the existence of these language structures. In particular, 37% of the languages in the sample are characterized by the presence of a sex-based grammatical gender system.

<sup>16</sup>These classifications identify languages that are characterized by an inflectional future tense. Languages that are not characterized by an inflectional future tense are considered to be characterized by a periphrastic future tense.

<sup>17</sup>While the WALS classifies the existence of grammatical gender for 245 contemporary languages, the classification of sex-based grammatical gender that is relevant for the main analysis restricts the sample to only 217 of them. In particular, the main analysis distinguishes between languages that have sex-based grammatical gender and those that do not have gender. Appendix B extends the analysis to the full sample by distinguishing between languages that have sex-based grammatical gender and those that do not have sex-based grammatical gender irrespective of whether they have grammatical gender.

To further explore the proposed hypothesis, the analysis examines two alternative aspects of grammatical gender: (i) the existence of gender distinctions in independent personal pronouns (Siewierska, 2013), and (ii) the intensity of the grammatical gender system (combining information on the number of genders, the existence of sex-based grammatical gender, the system of gender assignment, and the existence of gender distinctions in independent personal pronouns) based on Corbett (2013a,b,c) and Siewierska (2013). As established in Appendix B, the qualitative findings are independent of the measure used.

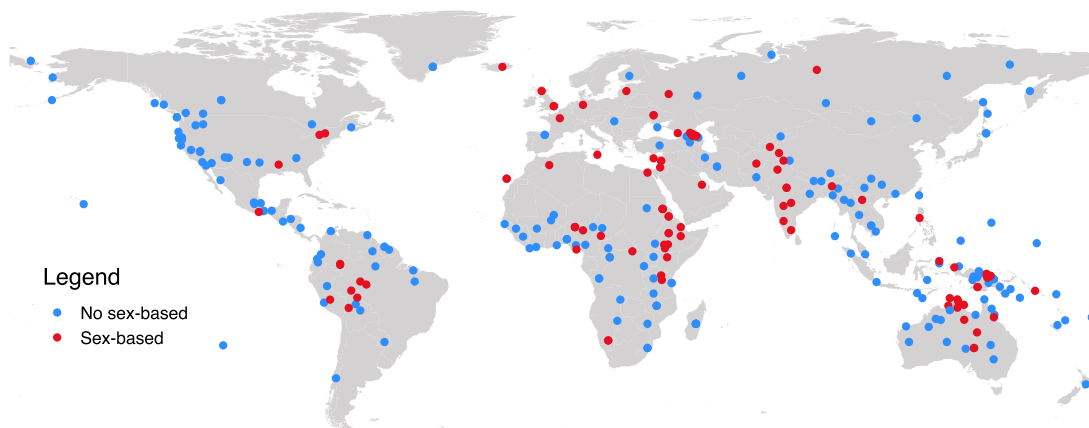


Figure 2: The Global Distribution of Sex-Based Grammatical Gender System

### 2.1.3 Politeness Distinctions in Pronouns

Languages differ in the existence and the form of politeness distinctions. In particular, politeness distinctions in pronouns are present in some languages (e.g., the differential use of “tu” and “usted” in the Spanish language, “Du” and “Sie” in German, and “tu” and “vous” in French) while being absent from others. Moreover, linguists have underlined that the differential use of these pronouns is associated with the speaker’s social class and is closely associated with power distance (Brown and Gilman, 1960).<sup>18</sup>

The study explores the geographical origins of politeness distinctions in pronouns based on the existence of second-person politeness distinctions in 207 contemporary languages, originated from 69 language families (Helmbrecht, 2013).<sup>19</sup> Figure 3 and Table D3 describe the prevalence and the spatial distribution of politeness distinctions in the dataset, demonstrating wide regional and cross-regional variations in the existence of these language structures. In particular, 34% of the languages in the sample are characterized by the presence of politeness distinctions. Moreover, to further explore the proposed hypothesis, the analysis considers two alternative specifications of politeness distinctions: (i)

<sup>18</sup>In some languages, earlier linguistic forms predated politeness distinctions. In particular, in the Spanish language “usted” evolved from “vuestra merced” – your grace (Solé, 1970; del Castillo Mathieu, 1982; Bentivoglio, 2003).

<sup>19</sup>Helmbrecht (2013) classifies politeness distinctions, as reflected in second person pronouns, into four categories: (i) no politeness distinction, (ii) binary politeness distinction, (iii) multiple politeness distinctions, and (iv) dominantly avoided for politeness reasons. Hence, politeness distinctions are present if either one of the categories (ii)-(iv) are present.



the degree (rather than the existence) of politeness distinctions, and (ii) the existence of a high degree of politeness distinctions.<sup>20</sup> As established in Appendix C, the qualitative findings are independent of the classification used.

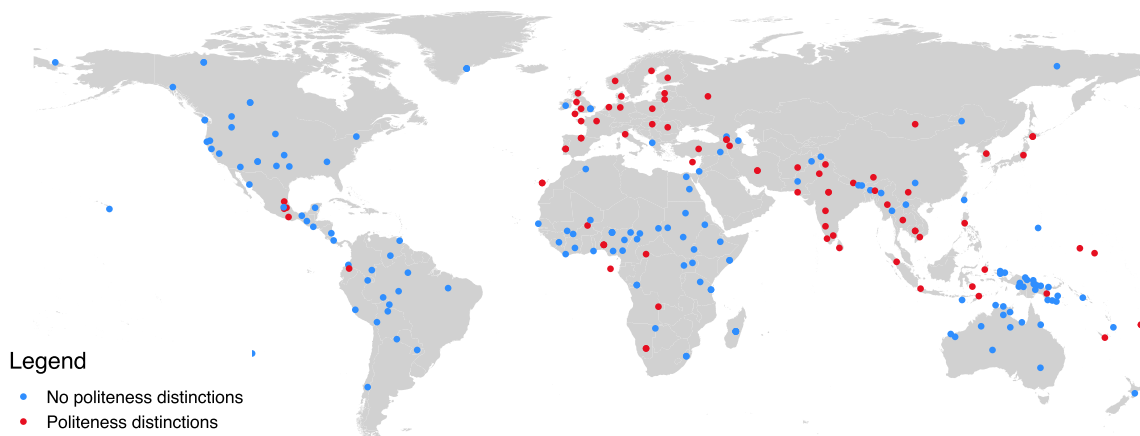


Figure 3: The Global Distribution of Politeness Distinctions

## 2.2 Main Independent Variables

In view of the hypothesized geographical origins of the explored language structures (i.e., the structure of the future tense, the presence of sex-based grammatical gender, and the existence of politeness distinctions), this subsection introduces the data on cross-regional variations in the hypothesized geographical determinants of these structures: (i) the historical levels of potential crop return, (ii) the historical levels of potential land suitability for the use of the plow, and (iii) the extent of ecological diversity.

### 2.2.1 Crop Return in the Linguistic Homeland and the Urheimat

The potential historical crop return in the contemporary homeland of each language, as well as in its Urheimat (i.e., the homeland of the proto-language from which the language descended), is used in order to establish the geographical determinants of the structure of the future tense.

The potential historical crop return in the homeland and the Urheimat of a language (i.e., the potential return to crops that were native to these locations in the pre-1500 period, prior to the Columbian exchange) is measured, following the methodology advanced by Galor and Özak (2016), by the potential daily calories that could be generated by cultivating the crops that would maximize potential caloric yield in each cell of the homeland or the Urheimat, in the pre-1500CE era, given the crop growth cycle. The estimates of potential crop yield (measured in tons, per hectare, per year) and the corresponding crop growth cycle (measured as the number of days elapsed from planting to

<sup>20</sup>Using the classification of Helmbrecht (2013), the degree of politeness distinctions are captured by its assigned category, ranging from the lowest category – (i) to the highest by category – (iv). Similarly, high degree of politeness distinctions are defined as being associated with categories (iii) or (iv).

harvesting), for each  $5' \times 5'$  cell in a global grid (i.e., approximately 100 square kilometers), are provided by the Global Agro-Ecological Zones (GAEZ) project of the Food and Agriculture Organization (FAO). These measures are based on agro-climatic estimates, under low level of inputs and rain-fed agriculture, capturing conditions that prevailed in early stages of development.<sup>21</sup> The conversion of these crop yields into caloric yield (measured in millions of kilo calories, per hectare, per year), produces comparable estimates of crop yields, permitting the identification of the caloric maximizing crop in each cell, and given the crop growth cycle, the caloric daily return in the cell.<sup>22</sup>

These estimates have several virtues in identifying the effect of crop return in the contemporary homeland of a language or its *Urheimat* on the structure of the future tense. First, the focus on the potential crop return, rather than the actual one, assures that the effect of the structure of the future tense (and the associated time preference) on the choice of technology has no impact of the estimated crop return. Second, the use of the agro-climatic estimates, which are arguably orthogonal to human intervention, mitigates potential concerns about the exogeneity of these estimates. Third, the use of estimates based on low level of inputs and rain-fed agriculture assures that the level of agricultural inputs, the irrigation method, and soil quality, do not reflect endogenous choices that could be potentially correlated with the structure of the future tense.

Hence, the average pre-1500CE potential daily caloric return (per hectare),  $R_\ell$ , in the homeland or in the *Urheimat* of a language,  $\ell$ , is

$$R_\ell = \frac{1}{|C_\ell|} \sum_{c \in C_\ell} \left( \frac{y_c}{g_c} \right), \quad (1)$$

where  $y_c$  is the cell specific pre-1500CE potential caloric yield of the crop that maximizes caloric output in cell  $c$ ,  $g_c$  is this crop's growth cycle,  $C_\ell$  is the set of cells in the language's homeland or *Urheimat*, and  $|C_\ell|$  is the cardinality of this set. Figure 4 depicts the global distribution of the pre-1500CE potential crop return at the cell level.

### 2.2.2 Geographical Determinants of Plow Usage in the Linguistic Homeland and *Urheimat*

The potential historical suitability of the land for the usage of the plow in the homeland of each language, as well as in its *Urheimat* (i.e., the homeland of the proto-language from which the language descended), is used in order to establish the geographical determinants of sex-based grammatical gender.

The potential historical suitability of the land for the usage of the plow can be captured by either

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<sup>21</sup>For each crop, GAEZ provides estimates for crop yield based on three alternative levels of inputs – high, medium, and low - and two possible sources of water supply – rain-fed and irrigation. Moreover, for each input-water source category, it provides two separate estimates for crop yield, based on agro-climatic conditions, that are arguably unaffected by human intervention, and agro-ecological constraints, that could potentially reflect human intervention. The FAO dataset provides for each cell in the agro-climatic grid the potential yield for each crop. These estimates account for the effect of temperature and moisture on the growth of the crop, the impact of pests, diseases and weeds on the yield, as well as climatic related “workability constraints”. In addition, each cell provides estimates of the growth cycle for each crop, capturing the days elapsed from the planting to harvesting.

<sup>22</sup>The caloric content of each crop is based on estimates of the United States Department of Agriculture Nutrient Database for Standard Reference.

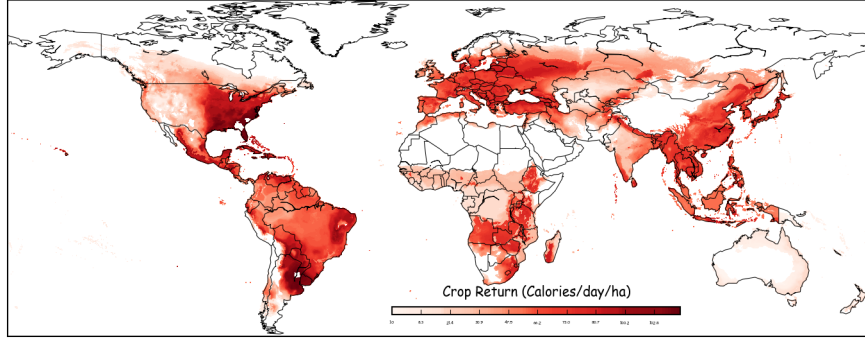


Figure 4: The Global Distribution of Potential Crop Return (Pre-1500CE)

the average potential caloric yield attainable by crops that are suitable for the use of the plow in the pre-1500CE period (i.e., plow positive crops), or those that are unsuitable for the use of the plow in the pre-1500CE period (i.e., plow negative crops), as classified by Pryor (1985).<sup>23</sup> Since plow positive crops are characterized by limited regional variation (e.g., they are entirely absent from the Americas in the pre-1500 period), the analysis will focus on the adverse effect of the average suitability of plow negative crops on the adoption of the plow, as well as the positive effect of the average suitability of all crops on the desirability of the adoption of agricultural technology such as the plow.<sup>24</sup>

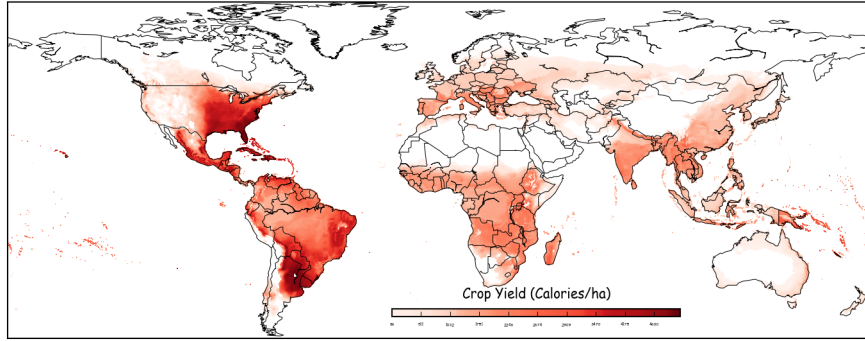


Figure 5: The Global Distribution of Potential pre-1500CE Caloric Yield (per Hectare) Across Plow Negative Crops

The average potential pre-1500CE caloric yield (per hectare) across plow negative crops in the homeland or in the Urheimat of a language,  $\ell$ ,  $P_\ell$ , is

$$P_\ell = \frac{1}{|C_\ell|} \sum_{c \in C_\ell} y_c, \quad (2)$$

<sup>23</sup>Plow positive crops include wheat, barley, rye, buckwheat, teff, and wet rice, while plow negative crops include grains (such as millet, sorghum, dry rice, and maize), as well as all root and tree crops. Measures of the (non-caloric) suitability of the land for the use of the plow were first introduced by Alesina et al. (2013). The conversion of the crop yields of plow negative and plow positive crops into caloric yield (measured in millions of kilo calories, per hectare, per year), produces comparable estimates of crop yields and permits the construction of an index of soil suitability for the usage of the plow.

<sup>24</sup>In particular, since plow positive crops are absent from the Americas this measure cannot capture any of the existing variation in sex-based grammatical gender in these continents.

where  $y_c$  is the average potential pre-1500CE caloric yield of plow negative crops in cell  $c$ ,  $C_\ell$  is the set of cells in the language’s homeland or Urheimat, and  $|C_\ell|$  is the cardinality of this set. Figure 5 depicts the global distribution of of the potential pre-1500CE average caloric yield (per hectare) across plow negative crops.

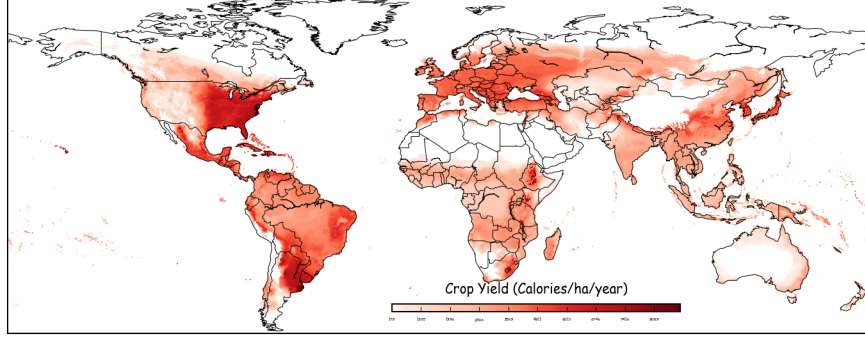


Figure 6: The Global Distribution of Potential pre-1500CE Caloric Yield (per Hectare) Across All Crops

Similarly, the average potential pre-1500CE caloric yield (per hectare) across all crops in the homeland or in the Urheimat of a language,  $\ell$ ,  $A_\ell$ , is

$$A_\ell = \frac{1}{|C_\ell|} \sum_{c \in C_\ell} y_c, \quad (3)$$

where  $y_c$  is the average potential pre-1500CE caloric yield of all crops in cell  $c$ ,  $C_\ell$  is the set of cells in the language’s homeland or Urheimat, and  $|C_\ell|$  is the cardinality of this set. Figure 6 depicts the global distribution of the average potential pre-1500CE caloric yield (per hectare) across all crops.

### 2.2.3 Ecological Diversity in the Linguistic Homeland and Urheimat

The extent of ecological diversity in the homeland of each language, as well as in its Urheimat (i.e., the homeland of the proto-language from which the language descended), is used in order to establish the geographical determinants of politeness distinctions.

The extent of ecological diversity, following Fenske (2014), is measured as a Herfindahl index of the share of each territory that is occupied by different ecological zones. In particular, ecological diversity,  $E_\ell$ , in the homeland or in the Urheimat of a language,  $\ell$ , is

$$E_\ell = 1 - \sum_{j=1}^{16} (\theta_{\ell j})^2 \quad (4)$$

where  $\theta_{\ell j}$  is the share of the homeland or the Urheimat of language  $\ell$  that is located in ecological zone  $j$ ,  $j = 1, \dots, 16$ .<sup>25</sup>

<sup>25</sup>Olson et al. (2001) provide a global dataset of biomes with 16 ecological zones: Boreal Forests/Taiga; Deserts and Xeric Shrublands; Flooded Grasslands and Savannas; Inland Water; Mangroves; Mediterranean Forests, Woodlands and Scrub; Montane Grasslands and Shrublands; Rock and Ice; Temperate Broadleaf and Mixed Forests; Temperate

### 2.3 Potentially Confounding Factors

The exploration of the geographical determinants of language structures accounts for the potentially confounding effects of a wide range of geographical factors, in the homeland of each language as well as in its Urheimat (i.e., the homeland of the proto-language from which the language descended). These factors may have affected the evolution of the structure of the future tense, sex-based grammatical gender, and politeness distinctions. In particular, it accounts for absolute latitude, average elevation, terrain ruggedness, coast length, as well as climatic conditions captured by the average, standard deviation, volatility, and spatial correlation of temperature and precipitation.<sup>26</sup>

The analysis further accounts for the length of the period in which no yield could be expected from the feasible set of crops (i.e., the expected number of days elapsed between the last potential harvest and the subsequent one). This unproductive period may have been central in the formation of cultural and linguistic characteristics since it had conceivably affected: (i) planning, intertemporal decisions, and therefore long-term orientation, (ii) the intensity of the use of the plow during the year as a whole and its implications for the emergence of gender roles, and (iii) cooperation in the development of storage technologies and its impact on the emergence of social hierarchy.

## 3 The Structure of the Empirical Analysis

This section presents the empirical strategy for the exploration of the relation between language structures and their hypothesized geographical determinants: (i) the historical levels of potential crop return to agricultural investment, in the language’s homeland and its Urheimat, and the existence of periphrastic future tense, (ii) the historical levels of potential land suitability for plow-based agriculture, in the language’s homeland and its Urheimat, and the existence of sex-based grammatical gender, and (iii) the extent of ecological diversity, in the language’s homeland and its Urheimat, and the existence of politeness distinctions.

### 3.1 The Empirical Model

The empirical analysis estimates the association between the hypothesized geographical determinants and linguistic traits using a linear probability model, given the binary nature of the dependent variables. In particular, it estimates the following empirical model using ordinary least squares (OLS):

$$S_\ell = \beta_0 + \beta_1 D_{\ell S} + \sum_j \gamma_{0j} X_{\ell j} + \sum_c \gamma_c \delta_{\ell c} + \varepsilon_\ell, \quad (5)$$

where  $S_\ell$  indicates whether structure  $S$  =(periphrastic future tense, sex-based grammatical gender, politeness distinctions) exists in language  $\ell$ ,  $D_{\ell S}$  is the hypothesized geographical determinant of structure  $S$  in the homeland of language  $\ell$  and in its Urheimat (i.e., pre-1500CE potential crop return,

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Conifer Forests; Temperate Grasslands, Savannas and Shrublands; Tropical and Subtropical Coniferous Forests; Tropical and Subtropical Dry Broadleaf Forests; Tropical and Subtropical Grasslands, Savannas and Shrublands; Tropical and Subtropical Moist Broadleaf Forests; Tundra.

<sup>26</sup>Table D4 provides description of the variables used in the analysis and their summary statistics.

$R_\ell$ , the average potential pre-1500CE caloric yield of plow negative crops,  $P_\ell$ , and all crops,  $A_\ell$ , and the extent of ecological diversity,  $E_\ell$ ),  $\{X_{\ell j}\}$  is a set of potentially confounding geographical characteristics in the homeland of language  $\ell$  and in its Urheimat,  $\{\delta_{\ell c}\}$  is a complete set of regional fixed-effects in the homeland of language  $\ell$  and in its Urheimat, and  $\varepsilon_\ell$  is a language-specific error term.

Moreover, given the binary coding of each language structure, an alternative specification is considered and estimated using a Probit model. As reported in the Appendix, this alternative estimation model generates qualitatively similar results.

### 3.2 The Empirical Strategy

The empirical analysis of the geographical determinants of language structures advances several strategies to mitigate potential concerns regarding the role of reverse causality, omitted variables, and sorting in the observed association between: (i) variations in geographical characteristics that were conducive to higher natural return to agricultural investment and the existing cross-language variations in the structure of the future tense, (ii) agricultural determinants of gender gap in agricultural productivity and the existence of sex-based grammatical gender, and (iii) the ecological origins of hierarchical societies and the emergence of politeness distinctions.

First, the observed associations between the hypothesized geographical determinants of linguistic traits and observed language structures may reflect reverse causality from language structures, and their associated cultural traits, to these geographical attributes. In particular, the conceivable effect of periphrastic future tense, and the associated long-term orientation, on the choice of agricultural technologies, may affect crop returns. Moreover, sex-based grammatical gender, and the associated gender bias, may have conceivably affected the adoption of the plow. Hence, in order to overcome these potential concerns about reverse causality, the empirical analysis exploits variations in potential crop return (associated with agro-climatic conditions that are orthogonal to human intervention), rather than the, potentially endogenous, actual crop return. Furthermore, the analysis is based upon the potential use of the plow (as captured by potential agro-climatic yield of crops suitable for the usage of the plow), rather than the actual usage.

Second, the associations between geographical and linguistic traits may be governed by omitted institutional, cultural, geographical and human characteristics. Thus, in order to mitigate these concerns, the empirical analysis mirrors the epidemiological approach to cultural diffusion and identifies the geographical origins of linguistic traits based on variation across languages located outside their Urheimat (i.e., outside the ancestral homeland of their proto-language), accounting for the host region fixed-effects and thus capturing unobserved time-invariant heterogeneity at the regional level. Moreover, the analysis accounts for the potentially confounding effects of a wide range of geographical factors, in the homeland of each language, as well as in its Urheimat, factors which may have affected the evolution of the structure of the future tense, sex-based grammatical gender, and politeness distinctions (e.g., absolute latitude, average elevation, terrain ruggedness, coast length, as well as climatic conditions captured by the average, standard deviation, volatility, and spatial correlation of temperature and precipitation). Furthermore, the empirical analysis accounts for spatial auto-correlation and

explores whether selection on unobservables is significant.<sup>27</sup>

Third, the observed associations between geographical and linguistic traits may reflect the sorting of individuals into geographical niches that complement their linguistic and cultural traits. While sorting would not affect the nature of the association between these geographical and linguistic characteristics (i.e., variations in geographical characteristics across the globe would still be the origin of cross-language variation in linguistic traits), it would weaken the cultural interpretation of the underlying mechanism. Hence, to alleviate concerns about the potential sorting of individuals who use periphrastic future tense into regions with high crop return, the analysis explores whether potential crop return in the Urheimat of a language, rather than its contemporary homeland, is associated with the presence periphrastic future tense. Similarly, to mitigate concerns about the potential sorting of individuals who use sex-based grammatical gender into regions suitable for the usage of the plow, the analysis explores whether the suitability of land for the usage of the plow in the Urheimat, rather than in the contemporary homeland of daughter languages, is associated with sex-based grammatical gender.<sup>28</sup>

Fourth, the hypothesized associations between geographical and linguistic traits may reflect a broader association between each of these geographical factors and a wide range of linguistic traits, rather than a unique association between each of these geographical characteristics and its hypothesized corresponding linguistic trait, weakening the proposed hypothesis. Hence, in order to overcome this potential concern, the empirical analysis explores whether alternative language structures (as reported by WALS), such as the existence of other temporal structures (e.g., the past tense and the perfect tense), as well as non-temporal structures (e.g., possessive, evidentiality, and the number of consonants and colors), are associated with each of the proposed geographical roots.

Fifth, the proposed hypothesis suggests that the evolution of linguistic traits is a by-product of the coevolution of cultural and linguistic traits in the course of human history, as governed by deeply rooted, culturally-embodied, common geographical roots. Hence, the proposed hypothesis rests upon the importance of the culturally-embodied effect of geographical characteristics. In order to explore the culturally-embodied effect, the empirical analysis examines whether the geographical characteristics in the Urheimat, rather than the homeland of daughter languages, are the significant factors that govern the evolution of language structures. Thus, it explores whether the culturally-embodied geographical determinants in the Urheimat, rather than the direct effect of geography (as would have been reflected by the significance of the geographical characteristics in the contemporary homeland of daughter languages), governed the evolution of linguistic traits.

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<sup>27</sup>It should be noted that since the available data for a large fraction of language families consists of only a few languages, a meaningful analysis based on variations in language structures within a linguistic family is precluded. Nevertheless, given the common ancestry of daughter languages, the analysis is based on standard errors estimates clustered at the language, language genus or language family levels. Specifically, the analysis based on the geographical characteristics of the Urheimat employs standard errors estimates clustered at the language family level.

<sup>28</sup>In light of the evidence about the greater adaptability of politeness distinctions to environmental and political changes (Wichmann and Holman, 2009; Greenhill et al., 2010; Dediu and Levinson, 2012; Dediu and Cysouw, 2013; Greenhill et al., 2017), this strategy does not fully mitigate concerns on the role of sorting in the observed association between ecological diversity and politeness distinctions.

## 4 Geographical Origins of Periphrastic Future Tense

The hypothesized coevolution of long-term orientation and the structure of the future tense suggests that in societies characterized by higher long-term orientation in the distant past, periphrastic future tense, and its associated future orientation, have emerged and persisted over time, reinforcing existing long-term oriented behavior. Thus, in view of the established positive effect of the natural return to agricultural investment, as captured by caloric crop return, on long-term orientation (Galor and Özak, 2016),<sup>29</sup> crop return is hypothesized to be associated with the prevalence of periphrastic future tense.

This section analyzes the relation between the existence of periphrastic future tense across contemporary languages and the historical levels of potential crop return in their contemporary geographical homelands (i.e., the indigenous regions that spoke the language in the pre-colonial as well as in the post-colonial era), as well as in their ancestral homeland (i.e., their *Urheimat*). In particular, Table 1 explores the association between pre-1500CE crop return and the existence of periphrastic future tense.<sup>30</sup> As established in column (1), the unconditional correlation between pre-1500CE crop return in the language’s contemporary homeland and the existence of periphrastic future tense is positive and statistically significant at the 5% level, suggesting that a one standard deviation increase in crop return in the language’s contemporary homeland is associated with a 6 percentage points increase in the probability that the language is characterized by a periphrastic future tense. Furthermore, as established in column (2) the estimated relationship remains stable once the potentially confounding effects of the geographical characteristics (i.e., absolute latitude, mean elevation, terrain ruggedness, and the length of its sea coast) in the contemporary homeland of each language, are accounted for.

Moreover, since crop return is estimated based on agro-climatic conditions, its association with the structure of the future tense might be capturing the potentially direct impact of climatic conditions on the existence of periphrastic future. In particular, variability of climatic conditions may affect the riskiness of agricultural investment, and therefore the effective crop return, while their spatial correlation may affect the potential for spatial diversification of risk. Nevertheless, as established in columns (3) and (4), accounting for the potentially confounding effects of average temperature and precipitation, as well as their standard deviations, volatility, and spatial correlation, does not alter the qualitative results.

Furthermore, the length of the period within each year in which the land is not suitable for agriculture – the unproductive period – may have conceivably triggered planning (e.g., storage and intertemporal trade) and may have therefore reinforced long-term orientation and the existence of periphrastic future tense. Nevertheless, as indicated by the estimates in column (5), accounting for the length of the unproductive period, reinforces the findings and the coefficient on crop return increases and becomes highly statistically significant.<sup>31</sup> Finally, as reported in column (6), accounting for regional fixed-effects, and therefore for unobserved time-invariant heterogeneity at the regional

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<sup>29</sup>See also, Figlio et al. (2016) and Falk et al. (2018).

<sup>30</sup>Table A1 reports the estimated coefficients on the control variables in Table 1 .

<sup>31</sup>Interestingly, as shown in the Appendix, the length of the unproductive period, as well, is significantly associated with the probability of existence of the periphrastic future tense. However, unlike the crop return, the relation between the unproductive period and the existence of periphrastic future tense is not robust to the other specifications and its semi-partial  $R^2$  is smaller than the one of crop return.



Table 1: Geographical Origins of the Future Tense (OLS)

	Existence of Future Tense					
	(1)	(2)	(3)	(4)	(5)	(6)
Crop Return (pre-1500CE)	0.06** (0.03)	0.06** (0.03)	0.07** (0.03)	0.07** (0.03)	0.09*** (0.03)	0.11*** (0.03)
Geographical Controls	No	Yes	Yes	Yes	Yes	Yes
Precipitation Controls	No	No	Yes	Yes	Yes	Yes
Temperature Controls	No	No	No	Yes	Yes	Yes
Unproductive Period	No	No	No	No	Yes	Yes
Regional FE	No	No	No	No	No	Yes
Adjusted- $R^2$	0.01	0.02	0.02	0.06	0.07	0.11
Observations	275	275	275	275	275	275

Notes: This table establishes the positive, statistically, and economically significant association between a region pre-1500CE potential crop return and the existence of periphrastic future tense in the language spoken in this region, accounting for regional fixed-effects and other geographical characteristics. Geographical controls include absolute latitude, mean elevation, terrain ruggedness, and coast length. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the impact of a one standard deviation in the independent variable on the probability of having a future tense in the language. Heteroskedasticity robust standard error estimates are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

level, reinforces the magnitude and the statistical significance of the association between pre-1500CE crop return and the existence of periphrastic future tense. In particular, a one standard deviation increase in pre-1500CE crop return in the language’s contemporary homeland is associated with an 11 percentage points increase in the probability that the language is characterized by a periphrastic future tense.

## 4.1 Robustness

The findings in Table 1 lend credence to the hypothesis that the natural return to agricultural investment in the language’s contemporary homeland, and its effect on time preference and long-term oriented behavior, contributed to the emergence of periphrastic future tense. Nevertheless, the results conceivably might be biased due to omitted institutional, cultural, and human characteristics, precluding a causal interpretation of the estimated coefficients. While concerns about omitted variables will be directly addressed and mitigated in the next subsection, the remaining analysis in this section establishes the robustness of the results to: (i) an alternative estimation method, (ii) spatial autocorrelation, and (iii) clustering of standard errors, while demonstrating that the findings are unlikely to be driven by selection on unobservables.

### 4.1.1 Estimation Method, Spatial-Autocorrelation and Selection on Unobservables

Table A2 (Panel A) establishes that the estimated average marginal effects of the Probit model are nearly identical to the estimated associations using OLS. Furthermore, Table A2 (Panel B) establishes the robustness of the results to the clustering of the standard errors at the level of the language genus (i.e., a group of phylogenetically related languages inside a linguistic family), as well as spatial

auto-correlation. In particular, the statistical significance is unaffected by the various methods used to mitigate the potential violation of the independence assumption.

Table A2 (Panel B) further explores the potential bias that could be generated by omitted variables. In particular, using statistics on selection on observables and unobservables (Altonji et al., 2005; Oster, 2014), it establishes that the degree of omitted variable bias is low and is unlikely to explain the magnitude of the estimated association between crop return and the existence of periphrastic future tense. In particular, omitted factors would need to be 2-3 times stronger and negatively correlated with crop return, in order to account for the estimated association between crop return and the emergence of periphrastic future tense. Thus, the estimated coefficients could be considered as the lower bound of the true association. The bias-adjusted estimated coefficient on pre-1500CE crop return is strictly positive and larger than the OLS estimate. In particular, as reported in column (6), following Oster (2014), the bias-corrected coefficient of crop return, assuming that the unobservables are as strongly correlated with pre-1500CE crop return as the set of observables that are accounted for, implies that a one standard deviation increase in crop return in the language’s contemporary homeland is associated with a 13 percentage points increase in the probability of the existence of periphrastic future tense in the language.<sup>32</sup>

#### 4.1.2 Crop Return and Other Language Structures

The associations between the return to agricultural investment in the language’s contemporary homeland, as captured by pre-1500CE crop return, and the existence of periphrastic future tense may reflect a broader association between crop return and a wide range of linguistic traits, rather than a unique association with periphrastic future tense, weakening the proposed hypothesis. Moreover, the association between crop return in the language’s homeland and the existence of periphrastic future tense in the language may reflect a broader association between a whole range of linguistic traits and long-term orientation.

Table A3 establishes, however, that alternative language structures (as reported by WALS), such as the existence of other temporal and non-temporal structures, are largely uncorrelated with the natural return to agricultural investment, suggesting that it is indeed uniquely associated with the structure of the future tense.<sup>33</sup> In particular pre-1500 crop return is not significantly associated with the existence of either the past or the perfect tense, and it is orthogonal to non-temporal linguistic characteristics such as: (i) the existence of possessive classifications, (ii) the existence of coding for evidentiality, (iii) the number of consonants, and (iv) the number of colors.<sup>34</sup> Furthermore, using all available data on language structures as reported in WALS, Figure A1 establishes the orthogonality

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<sup>32</sup>If the unobservables were assumed to explain all the remaining variation in the probability of existence of periphrastic future tense, then the estimated bias-adjusted impact of crop return would be even larger, implying that a one standard deviation increase in crop return in the language’s contemporary homeland would be associated with 40 percentage points increase in the probability of existence of periphrastic future tense in the language.

<sup>33</sup>This result reinforces earlier findings by Galor and Özak (2016) that pre-1500CE crop return only affects time preference and does not have a significant association with the other cultural traits.

<sup>34</sup>While the association between crop return and the existence of possessive classification is marginally significant in the OLS regressions, it is insignificant if Probit is used.

of crop return for nearly all language structures except for the structure of the future tense.<sup>35</sup> These results lend further support to the importance of the association between pre-1500 crop return and the emergence of the periphrastic future tense.

## 4.2 Geographical Origins: Contemporary Homeland vs. Urheimat

This subsection exploits the descent of contemporary (daughter) languages from proto-languages to explore the relative contribution of the return to agricultural investment in (i) the contemporary homeland of the language and (ii) the ancestral homeland of the language (i.e., its Urheimat) to the existence of a periphrastic future tense in daughter languages. Specifically, the proposed hypothesis suggests that the evolution of linguistic traits is a by-product of the coevolution of cultural and linguistic traits in the course of human history, as governed by deeply rooted, culturally-embodied, common geographical roots. In order to examine this hypothesis, the empirical analysis explores whether potential crop return in the Urheimat, rather than the homeland of daughter languages, is associated with the presence of periphrastic future tense. This setting permits the exploration of the role of culturally-embodied geographical determinants in the Urheimat, rather than the direct effect of geography in the evolution of linguistic traits.

Furthermore, this analysis mitigates concerns about the role of omitted variables in the established associations between the return to agricultural investment and the existence of periphrastic future tense, while overcoming concerns about the potential sorting of individuals into geographical niches that complement their linguistic and cultural traits. Moreover, the analysis sheds light on the historical depth of the observed relationship between the return to agricultural investment and the existence of periphrastic future tense, as well as on the role of the culturally-embodied geographical characteristics in the Urheimat, rather than the direct effect of geography, in the evolution of periphrastic future tense.

In particular, in order to further mitigate concerns about the importance of omitted institutional, cultural, geographical and human characteristics in the established associations between the return to agricultural investment and the existence of periphrastic future tense, the analysis mirrors the epidemiological approach to cultural diffusion, and explores the geographical origins of the existence of periphrastic future tense based on variation across languages located outside the Urheimat (i.e., the ancestral homeland of their proto-language). This approach permits the analysis to account for the host region fixed-effects and thus to capture unobserved time-invariant heterogeneity at the regional level.

Moreover, alleviating concerns about the potential sorting of individuals who use periphrastic future tense into regions with high crop return, the analysis explores whether potential crop return in

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<sup>35</sup>Specifically, the only other structures that are statistically associated with crop return are: existence of politeness distinctions (variables 45A in WALS), existence of cases (49A), number of cases (50A), existence of inflectional tenses (69A), and existence of purpose clauses (125A). The association with politeness distinctions reflects the positive impact of agricultural productivity, and the associated surplus, with the emergence of hierarchical societies. Furthermore, the association with inflectional tenses reflects by construction the negative association between the existence of a periphrastic future tense and the existence of an inflectional tense. Finally, the association with the remaining language structures reflects the common elements among certain aspects of language structures. For example, the existence of temporal case structures may be associated with the existence of tenses, and the future in particular (Lestrade and de Hoop, 2016).

the Urheimat, rather than in the contemporary homeland of daughter languages, is associated with the presence periphrastic future tense. While sorting would not affect the nature of the association between these geographical and linguistic characteristics (i.e., variations in geographical characteristics across the globe would still be the origin of cross-language variation in linguistic traits), it would weaken the cultural interpretation of the underlying mechanism. Finally, the distinction between the impact of the geographical characteristics in the Urheimat and the contemporary homeland, permit the analysis to explore the historical depth of the observed relationship between the return to agricultural investment and the existence of periphrastic future tense.

Table 2: The Persistent Impact of Geographical Characteristics in the Urheimat, rather than in the Contemporary Linguistic Homeland, on the Existence of Periphrastic Future Tense: Daughter Languages Outside the Urheimat

	The Existence of Periphrastic Future Tense					
	Migratory Distance to the Urheimat					
	Any Distance			At Least 1 Week		
	Homeland	Urheimat	Both	Homeland	Urheimat	Both
	(1)	(2)	(3)	(4)	(5)	(6)
Homeland's Crop Return (pre-1500CE)	0.12** (0.05)		-0.01 (0.06)	0.12** (0.06)		-0.01 (0.06)
Urheimat's Crop Return (pre-1500CE)		0.21** (0.10)	0.25** (0.10)		0.23*** (0.08)	0.24** (0.09)
Regional FE	Yes	Yes	Yes	Yes	Yes	Yes
Homeland's Geographical Characteristics	Yes	No	Yes	Yes	No	Yes
Urheimat's Geographical Characteristics	No	Yes	Yes	No	Yes	Yes
Adjusted- $R^2$	0.09	0.12	0.16	0.07	0.12	0.15
Observations	214	214	214	195	195	195
Language Families	38	38	38	32	32	32

Notes: This table establishes the importance of pre-1500CE crop return in the Urheimat, rather than the contemporary homeland, to the presence of periphrastic future tense in daughter languages located outside of the Urheimat, accounting for regional fixed-effects and other geographical characteristics. Geographical controls include absolute latitude, mean elevation, terrain ruggedness, and coast length. Columns (1)-(3) consider daughter languages who are located anywhere outside of the Urheimat, while column (4)-(6) those who are at least a week of migratory distance from the Urheimat. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the impact of a one standard deviation in the independent variable on the probability of having a future tense in the language. Heteroskedasticity robust standard error estimates clustered at the language family level are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table 2 explores the relative contributions of pre-1500CE crop return in the contemporary homeland of a language, in comparison to its ancestral homeland (i.e., its Urheimat), to the presence of periphrastic future tense in daughter languages. It establishes that the existence of periphrastic future tense among daughter languages located outside their Urheimat is governed predominantly by crop return in the Urheimat.<sup>36</sup> Considering daughter languages anywhere outside of the Urheimat, Columns (1) - (3) establish that while crop return in the contemporary homeland is significantly associated with the existence of periphrastic future tense among migrant languages (column (1)), the association

<sup>36</sup>Given the potential dependence of languages within the same language family, standard errors are clustered at this level.

between the Urheimat’s crop return and the existence of periphrastic future tense of daughter languages located outside of the Urheimat is much larger (column (2)). Moreover, considering jointly the contribution of crop return in the contemporary homeland and the Urheimat, the impact of the crop return in the Urheimat remains significant, while the impact of crop return in the contemporary homeland dissipates entirely, suggesting that that crop return in the Urheimat predominately influenced the existence of the future tense.<sup>37</sup> Furthermore, considering daughter languages at a migratory distance of one week from the Urheimat (i.e, approximately 1300km away from the Urheimat), and thus diminishing the association between the geographical characteristics in the contemporary homeland and the Urheimat, columns (3)-(6) reinforce the findings about the domination of the crop return in the Urheimat rather than in the contemporary homeland. In particular, accounting for regional fixed-effects and other geographical characteristics of the Urheimat, a one standard deviation increase in the crop return in the Urheimat is associated with a 21-25 percentage points increase in the probability that a migrant daughter language would have a periphrastic future tense.

The analysis suggests that periphrastic future tense began its formation in the distant past when the speakers of the proto-language still inhabited the Urheimat of the language, reflecting the portable culturally-embodied effect of crop return rather than the direct effect of these geographical characteristics. The findings further suggest that the established association is not driven by either omitted factors or geographical sorting, and they reflect the deep-historical culturally-embodied origins of the structure of the future tense.

### 4.3 Mechanism

This section presents additional supportive evidence for the hypothesized geographical origins of the structure of the future tense. In view of the evidence about the association between crop return and long-term orientation (Galor and Özak, 2016), a positive effect of crop return on the emergence of periphrastic future tense would necessitate the use of agriculture as the main source of subsistence. In particular, as illustrated in Figure 7, the proposed hypothesis would imply that: (i) higher crop return ought to be associated with a greater intensity of agriculture, and (ii) greater intensity of agriculture ought to be associated with the existence of periphrastic future tense.

Table 3 presents supporting evidence for the proposed mechanism. In particular, it establishes the robust positive association between crop return and the level of agricultural intensity in a pre-colonial society, which in turn is positively associated with the emergence of the periphrastic future tense. Using data from the Ethnographic Atlas (Murdock and White, 1969) on the importance of patterns of subsistence – hunting, gathering, fishing, animal husbandry and crop cultivation – the analysis explores the association between crop return and agricultural intensity (i.e., the level of dependence on agriculture) across ethnic groups, reflecting the effective crop return in the ethnic homeland. As established in Columns (1) and (2) in Table 3 societies inhabiting regions with higher crop return have higher levels of agricultural intensity. In particular, a one-standard deviation increase in crop return

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<sup>37</sup>Given the greater uncertainty about the geographical extent of the Urheimat, as opposed to the contemporary linguistic homeland, measurement errors in the estimates of crop return in the Urheimat are likely to be larger than those from crop return in the contemporary homeland and a-priori the horse race between the two variables should have resulted in fact in the decline in the significance of crop return in the Urheimat.

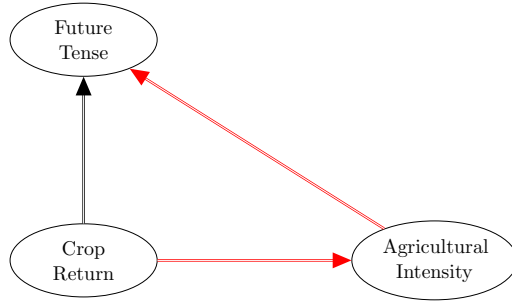


Figure 7: Crop Return, Agricultural Intensity & Future Tense

Table 3: Geographic Origins of Agricultural Intensity and Periphrastic Future Tense

	Mechanism			
	Agricultural Intensity		Periphrastic Future Tense	
	(1)	(2)	(3)	(4)
Crop Return (pre-1500CE)	0.21*** (0.03)	0.24*** (0.03)		
Agricultural Intensity			0.07** (0.03)	0.08* (0.04)
All Geographic Controls	No	Yes	No	Yes
Regional FE	No	Yes	No	Yes
Adjusted- $R^2$	0.04	0.64	0.02	0.17
Observations	1303	1303	263	263

Notes: This table establishes, based on OLS regression, the positive statistically and economically significant association between pre-1500 crop return and the existence of a periphrastic future tense in a language. The first two columns provide the results of the association between crop return and the intensity of agricultural, and columns (3) and (4) provide evidence on the association between agricultural intensity and the emergence of periphrastic future tense. Heteroskedasticity robust standard error estimates are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

is associated with a 0.24 standard deviations increase in agricultural intensity.<sup>38</sup> Moreover, columns (3) and (4) establish the positive association between the level of agricultural intensity in an ethnic group and the probability of existence of periphrastic future tense in the language it speaks. The results suggest that a one standard deviation increase in agricultural intensity is associated with an 8 percentage points increase in the probability of the existence of periphrastic future tense.

#### 4.4 Time Preference and Periphrastic Future Tense

This section explores the association between the level of long-term orientation of the community that speaks a certain language and the existence of periphrastic future tense in the language. In light of the proposed hypothesis that the periphrastic future tense is complementary to long-term oriented behavior, the prevalence of long-term orientation within a given society ought to be associated with

<sup>38</sup>Table A4 establishes the robustness of this result, by constraining the analysis to the set of societies that speak languages for which data on the existence of periphrastic future tense is available.

the presence of periphrastic future tense in the language used among members of this society. Indeed, the common geographical origins (i.e., the natural return to agricultural investment) of long-term orientation as well as periphrastic future tense suggest that this positive association is likely to be observed across speech communities.

Table 4: Long-Term Orientation and Periphrastic Future Tense

	Long-Term Orientation			
	All		Old World	
	(1)	(2)	(3)	(4)
Periphrastic Future Tense	0.12** (0.05)	0.15*** (0.04)	0.15*** (0.04)	0.17*** (0.05)
Crop Return (pre-1500CE)		0.29* (0.16)		0.26 (0.18)
Regional FE	Yes	Yes	Yes	Yes
Main Geographical Controls	No	Yes	No	Yes
Adjusted- $R^2$	0.16	0.24	0.18	0.26
Observations	106	106	100	100

Notes: This table establishes the statistically and economically significant positive association between periphrastic future tense and long-term orientation. The results account for the geographical origin of the periphrastic future tense and other geographical characteristics of the contemporary homeland of the language. Heteroskedasticity robust standard error estimates clustered at the language family level are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table 4 explores the association between the prevalence of long-term orientation within a given society and the presence of periphrastic future tense in the language used among members of this society.<sup>39</sup> It establishes the positive significant association between the existence of the periphrastic future tense and long-term orientation. This positive association is present among speakers of languages in the world as a whole (Columns (1) and (2)), as well as among speakers who reside in the Old World and speak languages originated in the Old World (Columns (3) and (4)). Moreover, as established in Columns (2) and (4), this association is highly significant and stable in magnitude if one accounts for the geographical origins (i.e., the natural return to agricultural investment) of these two traits. These findings lend credence to the proposed hypothesis that the prevalence of the trait of long-term orientation and the presence of periphrastic future tense have coevolved in the course of human history.

<sup>39</sup>The measure of Long-Term Orientation is based on the following question in the World Values Survey (WVS): “Here is a list of qualities that children can be encouraged to learn at home. Which, if any, do you consider to be especially important?” Individuals are considered to have Long-Term Orientation if they answered “Thrift, saving money and things”.

## 5 The Origins of Sex-Based Grammatical Gender Systems

The hypothesized coevolution of gender biases and sex-based grammatical gender suggests that in societies characterized by distinct gender roles and consequently by the existence of gender biases in the distant past, sex-based grammatical gender has emerged and persisted over time, reinforcing existing gender biases in society. Thus, in view of the established positive association between the suitability of land for the usage of the plow and the emergence of distinct gender roles in society (Pryor, 1985; Alesina et al., 2013), the suitability of the land for the usage of the plow is hypothesized to affect the emergence and the prevalence of sex-based grammatical gender in the course of human history.

This section analyzes the relation between the existence of sex-based grammatical gender across contemporary languages and the potential historical suitability of the land for the usage of the plow in their contemporary geographical homelands (i.e., the indigenous regions that spoke the language in the pre-colonial as well as in the post-colonial era), as well as in their ancestral homeland (i.e., their *Urheimat*). As explained in section 2.2.2, since plow positive crops are characterized by limited regional variation (e.g., they are entirely absent from the Americas in the pre-1500 period), the analysis will focus on the adverse effect of the average suitability of plow negative crops on the adoption of the plow, as well as the positive effect of the average suitability of all crops on the desirability of the adoption of agricultural technology such as the plow.

Table 5 explores the association between the potential historical suitability of the land for the usage of the plow and the existence of sex-based grammatical gender.<sup>40</sup> As established in column (1), the association between the potential caloric yield of plow negative crops in the pre-1500CE period in the language’s contemporary homeland and the existence of sex-based grammatical gender is negative and statistically significant at the 5% level, suggesting that a one standard deviation increase in the potential caloric yield of plow negative crops in the language’s contemporary homeland is associated with a 13 percentage points decrease in the probability that the language is characterized by a sex-based grammatical gender. Moreover, the average caloric suitability of all crops in the pre-1500CE period in the language’s contemporary homeland is indeed positively and statistically significantly associated with the existence of sex-based grammatical gender, suggesting that a one standard deviation increase in the potential caloric yield of all crops in the language’s contemporary homeland is associated with a 17 percentage points increase in the probability that the language has sex-based grammatical gender. Furthermore, as established in column (2), the estimated relationship becomes more significant once the potentially confounding effects of the geographical characteristics (i.e., absolute latitude, mean elevation, terrain ruggedness, and the length of its sea coast) in the contemporary homeland of each language, are accounted for.

Since the potential historical agricultural determinants of plow usage are estimated based on agro-climatic conditions, they might be capturing the potentially direct impact of climatic conditions on the existence of sex-based grammatical gender. In particular, variability of climatic conditions may affect the riskiness of agricultural investment, and therefore the effective caloric yield of plow negative crops,

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<sup>40</sup>Table B1 reports the estimated coefficients on the control variables in Table 5.



Table 5: Geographic Origins of Sex-Based Grammatical Gender (OLS)

	Existence of Sex-Based Grammatical Gender					
	(1)	(2)	(3)	(4)	(5)	(6)
Plow Negative Crops (Average Caloric Yield, pre-1500)	-0.13** (0.06)	-0.19*** (0.06)	-0.25*** (0.06)	-0.26*** (0.06)	-0.29*** (0.06)	-0.23*** (0.08)
All Crops (Average Caloric Yield, pre-1500)	0.17*** (0.06)	0.21*** (0.06)	0.28*** (0.06)	0.29*** (0.06)	0.32*** (0.06)	0.25*** (0.08)
Geographical Controls	No	Yes	Yes	Yes	Yes	Yes
Precipitation Controls	No	No	Yes	Yes	Yes	Yes
Temperature Controls	No	No	No	Yes	Yes	Yes
Unproductive Period	No	No	No	No	Yes	Yes
Regional FE	No	No	No	No	No	Yes
Adjusted- $R^2$	0.03	0.06	0.14	0.15	0.15	0.21
Observations	217	217	217	217	217	217

Notes: This table establishes the statistically and economically significant association between the historical agricultural determinants of plow usage and the existence of sex-based grammatical gender in a language, accounting for regional fixed-effects and other geographical characteristics. All columns have the same specification and controls as Table 1. Geographical controls include absolute latitude, mean elevation, terrain ruggedness, and coast length, as well as other agriculture-related controls as precipitation and temperature means and standard deviations. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the impact of a one standard deviation in the independent variable on the probability of having a sex-based grammatical gender in the language. Heteroskedasticity robust standard error estimates are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

while their spatial correlation may affect the potential for spatial diversification of risk. Nevertheless, as established in columns (3) and (4), accounting for the potentially confounding effects of average temperature and precipitation, as well as their standard deviations, volatility, and spatial correlation, does not alter the qualitative results.

Furthermore, the length of the period within each year in which the land is not suitable for agriculture – the unproductive period – may have conceivably affected the desirability of the usage of the plow. Nevertheless, as indicated by column (5), accounting for the length of the unproductive period, reinforces the findings. Finally, as reported in column (6), accounting for regional fixed-effects, and therefore for unobserved time-invariant heterogeneity at the regional level does not alter the qualitative results. In particular, a one standard deviation increase in the pre-1500CE potential caloric yield of plow negative crops in the language’s contemporary homeland is associated with a 23 percentage points decrease in the probability that the language is characterized by a sex-based grammatical gender. Similarly, a one standard deviation increase in the pre-1500CE potential caloric yield of all crops in the language’s contemporary homeland is associated with a 25 percentage points increase in the probability that the language is characterized by a sex-based grammatical gender.

## 5.1 Robustness

The findings in Table 5 lend credence to the hypothesis that the potential historical agricultural determinants of plow usage in the language’s contemporary homeland, and their effect on gender biases, contributed to the emergence of sex-based grammatical gender. Nevertheless, the results conceivably might be biased due to omitted institutional, cultural, and human characteristics, precluding a causal

interpretation of the estimated coefficients. While concerns about omitted variables will be directly addressed and mitigated in the next subsection, the remaining analysis in this section establishes the robustness of the results to: (i) an alternative estimation method, (ii) spatial autocorrelation, and (iii) clustering of standard errors, while demonstrating that the findings are unlikely to be driven by selection on unobservables. Moreover, the robustness to alternative aspects of grammatical gender are also considered.

### **5.1.1 Estimation Method, Spatial-Autocorrelation and Selection on Unobservables**

Table B2 (Panel A) establishes that the estimated average marginal effects of the Probit model are nearly identical to the estimated coefficients using OLS. Furthermore, Table B2 (Panel B) establishes the robustness of the results to the clustering of the standard errors at the level of the language genus (i.e., a group of phylogenetically related languages inside a linguistic family), as well as spatial auto-correlation. In particular, the statistical significance is unaffected by the various methods used.

Table B2 (Panel B) further explores the potential bias that could be generated by omitted variables. In particular, using statistics on selection on observables and unobservables (Altonji et al., 2005; Oster, 2014), it establishes that the degree of omitted variable bias is low and is unlikely to explain the magnitude of the estimated association between the potential historical agricultural determinants of plow usage and the existence of sex-based grammatical gender. In particular, omitted factors would need to be 1.3-2.3 times more strongly and negatively correlated with the caloric yield of plow negative crops, in order to account for the estimated association between caloric yield of plow negative crops and the emergence of sex-based grammatical gender. Similarly, omitted factors would need to be 1.6-3 times more strongly and negatively correlated with the caloric yield of all crops, in order to account for the estimated association between caloric yield of all crops and the emergence of sex-based grammatical gender. Thus, the estimated coefficients could be considered as the lower bounds in absolute value of the true association. The bias-adjusted estimated associations between potential historical agricultural determinants of plow usage and the existence of sex-based grammatical gender are larger in absolute value than the OLS estimate. In particular, as reported in column (6), following Oster (2014), the bias-corrected association between caloric yield of plow negative crops and the existence of sex-based grammatical gender, assuming that the unobservables are as strongly correlated with pre-1500CE caloric yield of plow negative crops as the set of observables that are accounted for, implies that a one standard deviation increase in caloric yield of plow negative crops in the language's contemporary homeland is associated with a 27 percentage points decrease in the probability of the existence of sex-based grammatical gender in the language.

### **5.1.2 Alternative Aspects of Grammatical Gender**

Tables B4, B8 and B13 establish qualitatively similar associations between the geographical determinants of plow-based agriculture and (i) an alternative measure of sex-based grammatical gender, (ii) the intensity of grammatical gender in a language, and (iii) the existence of gender distinctions in personal pronouns, respectively. These results suggest that various aspects of grammatical gender that have reinforced gender biases, were associated with the geographical determinants of plow-based

agriculture. Moreover, Tables B2, B5, B9 and B14 establish the robustness of these alternative associations to: (i) an alternative estimation method, (ii) spatial autocorrelation, and (iii) clustering of standard errors, while demonstrating that the findings are unlikely to be driven by selection on unobservables.

### 5.1.3 Agricultural Determinants of Plow Usage and Other Language Structures

The associations between the potential historical agricultural determinants of plow usage and the existence of sex-based grammatical gender may reflect a broader association between plow-based agriculture and a wide range of linguistic traits, rather than its unique association with sex-based grammatical gender, weakening the proposed hypothesis. Moreover, the association between the suitability of land for the usage of the plow in the language's contemporary homeland and the existence of sex-based grammatical gender in the language may reflect a broader association between a whole range of linguistic traits and gender biases.

Table B3 establishes, however, that alternative language structures (as reported by WALS), such as the existence of other temporal and non-temporal structures, are largely uncorrelated with the geographical determinants of plow-based agriculture. In particular the potential historical agricultural determinants of plow usage is not significantly associated with the existence of the perfect tense, and it is orthogonal to non-temporal linguistic characteristics such as: (i) the existence of possessive classifications, (ii) the existence of coding for evidentiality, (iii) the number of consonants, and (iv) the number of colors. Furthermore, using all available data on language structures as reported in WALS, Figure B1 establishes the orthogonality of the potential historical agricultural determinants of plow usage for nearly all language structures except for sex-based grammatical gender.<sup>41</sup> These results lend further support to the hypothesis that the potential historical suitability of the land for the usage of the plow is associated with the emergence of the sex-based grammatical gender system.

## 5.2 Geographical Origins: Contemporary Homeland vs. Urheimat

This subsection exploits the descent of contemporary languages from proto-languages to explore the relative contributions of the potential suitability of land for the usage of the plow in (i) the contemporary homeland of the language and (ii) the ancestral homeland of the language (i.e., its *Urheimat*) to the existence of a sex-based grammatical gender in daughter languages.

This analysis mitigates concerns about the role of omitted variables in the established associations between the potential historical suitability of land for the usage of the plow and the existence of sex-based grammatical gender, and the sorting of individuals into geographical niches that complement their linguistic and cultural traits. Moreover, it sheds light on the historical depth of the observed relationship between the potential suitability of land for the usage of the plow and the existence of sex-based grammatical gender, and the role of the culturally-embodied effects of geographical characteristics, rather than the geography per se, in the evolution of sex-based grammatical gender.

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<sup>41</sup>Specifically, the only other structures that are statistically associated with the potential historical agricultural determinants of plow usage are: perfective and imperfective aspect (variable 65A in WALS) and existence of past tense (66A).

The analysis mirrors the epidemiological approach to cultural diffusion, and establishes the geographical origins of the existence of sex-based grammatical gender based on variation across languages located outside the Urheimat (i.e., ancestral homeland of their proto-language), permitting the analysis to account for host region fixed-effects and thus to capture unobserved time-invariant heterogeneity at the regional level, thus mitigating concerns about omitted variables.

Table 6: The Persistent Impact of Geographical Characteristics in the Urheimat, rather than in the Contemporary Linguistic Homeland, on the Existence of Sex-Based Grammatical Gender: Daughter Languages Outside the Urheimat

	The Existence of Sex-Based Gender System					
	Migratory Distance to the Urheimat					
	Any Distance			At Least 1 Week		
	Homeland	Urheimat	Both	Homeland	Urheimat	Both
	(1)	(2)	(3)	(4)	(5)	(6)
Homeland's Plow Negative Crops (Avg. Caloric Yield, pre-1500)	-0.17**		-0.10	-0.12		-0.13**
	(0.07)		(0.07)	(0.09)		(0.05)
Homeland's Crops (Average Caloric Yield, pre-1500)	0.14**		0.12**	0.11		0.09*
	(0.07)		(0.05)	(0.09)		(0.05)
Urheimat's Plow Negative Crops (Avg. Caloric Yield, pre-1500)		-0.50***	-0.44**		-0.51***	-0.47**
		(0.15)	(0.17)		(0.18)	(0.21)
Urheimat's Crops (Average Caloric Yield, pre-1500)		0.60***	0.54***		0.64***	0.60**
		(0.17)	(0.19)		(0.20)	(0.23)
Regional FE	Yes	Yes	Yes	Yes	Yes	Yes
Homeland's Geographical Characteristics	Yes	No	Yes	Yes	No	Yes
Urheimat's Geographical Characteristics	No	Yes	Yes	No	Yes	Yes
Adjusted- $R^2$	0.30	0.45	0.44	0.30	0.53	0.50
Observations	159	159	159	131	131	131
Language Families	38	38	38	29	29	29

Notes: This table establishes the importance of agricultural productivity and the suitability of the land for the usage of the plow in the Urheimat, rather than the contemporary homeland, to the existence of sex-based grammatical gender in daughter languages located outside of the Urheimat, accounting for regional fixed-effects and other geographical characteristics. Geographical controls include absolute latitude, mean elevation, terrain ruggedness, and coast length. Columns (1)-(3) consider daughter languages anywhere outside of the Urheimat while column (4)-(6) those who are at least a week of migratory distance from the Urheimat. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the impact of a one standard deviation in the independent variable on the probability of having a future tense in the language. Heteroskedasticity robust standard error estimates clustered at the language family level are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table 6 explores the relative contributions of the pre-1500CE potential suitability of land for the usage of the plow in the contemporary language's homeland vs. the Urheimat to the presence of sex-based grammatical gender in daughter languages. In particular, it establishes that the existence of sex-based grammatical gender among daughter languages located outside their Urheimat is associated predominantly with the potential suitability of land for the usage of the plow in the Urheimat.<sup>42</sup>

The analysis is conducted in two layers, distinguished by the geographical proximity of the daughter languages to their Urheimat. Columns (1)-(3) consider daughter languages anywhere outside of the Urheimat, while columns (4)-(6) consider languages at a migratory distance of one week from the

<sup>42</sup>Given the potential dependence of languages within the same language family, standard errors are clustered at this level.

Urheimat (i.e, approximately 1300km away from the Urheimat). The analysis establishes that while the association between potential suitability of land for the usage of the plow in the contemporary homeland of a language and the existence of sex-based grammatical gender among migrant languages is fragile (columns (1) and (4)), the association between the Urheimat’s crop return and the existence of sex-based grammatical gender among daughter languages located outside of the Urheimat is larger and highly significant (column (2) and (5)). Moreover, the impact of the potential suitability of land for the usage of the plow in the Urheimat remains significant, while the impact of crop return in the contemporary homeland remains fragile if the geographical characteristics of the contemporary homeland of the language and its Urheimat are considered jointly.<sup>43</sup>

The analysis suggests that the existence of sex-based grammatical gender began its formation in the distant past when the speakers of the proto-language still inhabited the Urheimat of the language, reflecting the portable culturally-embodied effect of the suitability of the land for the usage of the plow rather than the direct effect of geography.<sup>44</sup> As discussed in Appendix F, the timing of the emergence of the plow is consistent with the subsequent emergence of sex-based grammatical gender in a significant number of languages. The findings suggest that the results are driven by neither omitted factors nor geographical sorting, and it provides support for the deep-historical origins of the structure of sex-based grammatical gender.

### 5.3 Mechanism

This section presents additional supportive evidence for the hypothesized geographical origins of the sex-based grammatical gender. In view of the evidence about the effect of plow usage on gender biases (Pryor, 1985; Alesina et al., 2013), the effect of the geographical determinants of plow-based agriculture on the emergence of sex-based grammatical gender would necessitate the adoption and use of the plow. In particular, as illustrated in Figure 8, the proposed hypothesis would imply that: (i) the geographical determinants of plow-based agriculture ought to be associated with the adoption and use of the plow, and (ii) the use of the plow ought to be associated with the existence of sex-based grammatical gender.

Table 7 presents supporting evidence for the proposed mechanism. In particular, it establishes a significant association between the geographical determinants of plow-based agriculture and the usage of the plow in pre-colonial societies, which in turn is positively associated with the emergence of sex-based grammatical gender. Using data from the Ethnographic Atlas (Murdock and White, 1969) on the presence and use of aboriginal plows, the analysis explores the association between the geographical determinants of plow-based agriculture and a pre-colonial society’s plow usage. In particular, columns (1) and (2) establish that societies that resided in regions that were more suitable for the use of the plow are more likely to use an aboriginal plow. A one-standard deviation increase in pre-1500CE caloric suitability of plow negative crops is associated with a 6 percentage points decrease in the probability

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<sup>43</sup>Given the greater uncertainty about the geographical extent of the Urheimat, as opposed to the contemporary linguistic homeland, measurement errors in the estimates of crop return in the Urheimat are likely to be larger than those from crop return in the contemporary homeland and a-priori the horse race between the two variables should have resulted in fact in the decline in the significance of crop return in the Urheimat.

<sup>44</sup>Tables B7, B11 and B16 examine the robustness of this analysis to alternative aspects of grammatical gender.

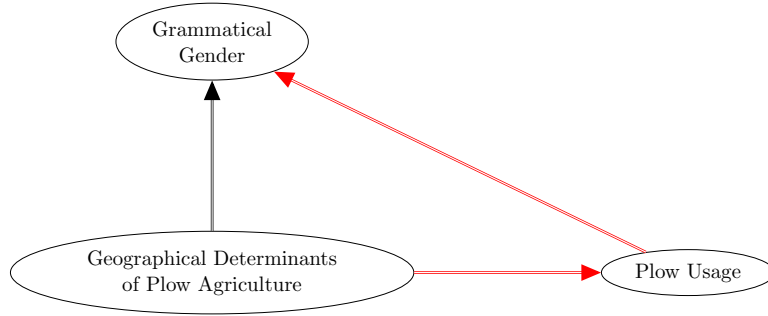


Figure 8: Geographical Determinants of Plow-based Agriculture, Plow Usage & Grammatical Gender

Table 7: Geographic Origins of Plow Usage and Sex-Based Grammatical Gender

	Mechanism			
	Plow Usage		Grammatical Gender	
	(1)	(2)	(3)	(4)
Plow Negative Crops (Average Caloric Yield, pre-1500)	-0.26*** (0.02)	-0.06** (0.02)		
All Crops (Average Caloric Yield, pre-1500)	0.26*** (0.02)	0.09*** (0.02)		
Plow Usage			0.38*** (0.08)	0.23** (0.11)
All Geographic Controls	No	Yes	No	Yes
Regional FE	No	Yes	No	Yes
Adjusted- $R^2$	0.19	0.47	0.14	0.31
Observations	1175	1175	145	145

Notes: This table establishes, based on OLS regression, the positive statistically and economically significant association between the geographical determinants of plow usage and the existence of sex-based grammatical gender in a language. The first two columns provide the associations between the geographical determinants of plow suitability and actual usage of the plow, and columns (3) and (4) provide evidence on the association between actual usage of the plow and the emergence of sex-based grammatical gender. Heteroskedasticity robust standard error estimates are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

of the usage of the plow. Similarly, a one-standard deviation increase in pre-1500CE caloric suitability of all crops is associated with a 9 percentage points increase in the probability of the usage of the plow. Moreover, columns (3) and (4) establish the positive association between the usage of the plow in a pre-colonial ethnic group and the probability of the existence of sex-based grammatical gender in the language used by this ethnic group. The results suggest that a one standard deviation increase in the usage of the plow is associated with a 23 percentage points increase in the probability of the existence of sex-based grammatical gender.

#### 5.4 Gender Bias and Sex-Based Grammatical Gender

This section explores the association between the existence of a gender bias in a given community and the existence of sex-based grammatical gender in the language the members of the community speak. In light of the proposed hypothesis that sex-based grammatical gender is complementary to gender biased behavior, the prevalence of gender biases within a given society is likely to be associated with the

presence of sex-based grammatical gender in the language used among members of this society. Indeed, the common geographical origins (i.e., the geographical determinants of plow-based agriculture) of gender bias as well as sex-based grammatical gender suggest that this positive association is likely to be observed across various speech communities.

Table 8: Gender Bias and Sex-based Grammatical Gender

	Gender Bias			
	All		Old World	
	(1)	(2)	(3)	(4)
Existence of Sex-Based Grammatical Gender	0.27 (0.23)	0.42** (0.16)	0.18 (0.23)	0.18* (0.09)
Plow Negative Crops (Average Caloric Yield, pre-1500)		0.16 (0.43)		-0.25 (0.29)
All Crops (Average Caloric Yield, pre-1500)		-0.35 (0.49)		0.19 (0.34)
Main Geographical Controls	No	Yes	No	Yes
Adjusted- $R^2$	0.04	0.33	-0.00	0.38
Observations	33	33	30	30

Notes: This table establishes the statistically and economically significant association between the existence of sex-based grammatical gender and gender bias in society. The analysis accounts for the geographical origins of sex-based grammatical gender and other geographical characteristics of the contemporary homeland of the language. Heteroskedasticity robust standard error estimates clustered at the language family level are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table 8 explores the association between the prevalence of gender biases within a given society and the presence of sex-based grammatical gender in the language used among members of this society.<sup>45</sup> It establishes a positive association between the existence of sex-based grammatical gender and gender biases.<sup>46</sup> This positive association is present among speakers of languages in the world as a whole (Columns (1) and (2)), as well as among speakers who reside in the Old World and speak languages originated in the Old World (Columns (3) and (4)). These findings lend credence to the proposed hypothesis that the prevalence of gender biases and the presence of sex-based grammatical gender have coevolved in the course of human history.

## 6 The Origins of Politeness Distinctions in Pronouns

The hypothesized coevolution of hierarchical orientation (e.g., obedience, conformity, and power distance) and politeness distinctions suggests that in societies characterized by higher hierarchical ori-

<sup>45</sup>The measure of gender bias is based on the first principal component to the answer of the following questions in the World Values Survey (WVS): (i) “When jobs are scarce men should have more right to a job than women”, (ii) “Men make better political leaders than women do”, (iii) “Women should have the same rights as men”, (iv) “A job is the best way for women to be independent”, (v) “It is a problem if women have more income than husband”, and (vi) “Men make better political leaders than women do”.

<sup>46</sup>The sample of languages in the WVS for which grammatical gender data exists is small and has little regional variation. This impedes the use of regional fixed-effects in the analysis and reduces the significance of the estimates.

entation in the distant past, politeness distinctions have emerged and persisted over time, reinforcing the existing hierarchical orientation in society. Thus, in view of the established positive association between the extent of ecological diversity and the emergence of hierarchical societies (Fenske, 2014), ecological diversity is hypothesized to affect the emergence and the prevalence of politeness distinctions in the course of human history.

Table 9: Geographic Origins of Politeness Distinctions (OLS)

	Existence of Politeness Distinctions					
	(1)	(2)	(3)	(4)	(5)	(6)
Ecological Diversity	0.15*** (0.03)	0.10*** (0.04)	0.10*** (0.04)	0.10** (0.04)	0.10** (0.04)	0.10** (0.04)
Geographical Controls	No	Yes	Yes	Yes	Yes	Yes
Precipitation Controls	No	No	Yes	Yes	Yes	Yes
Temperature Controls	No	No	No	Yes	Yes	Yes
Unproductive Period	No	No	No	No	Yes	Yes
Regional FE	No	No	No	No	No	Yes
Adjusted- $R^2$	0.09	0.18	0.20	0.20	0.21	0.32
Observations	198	198	198	198	198	198

Notes: This table establishes the positive, statistically, and economically significant association between ecological diversity and the existence of politeness distinctions in a language, accounting for regional fixed-effects and other geographical characteristics. All columns have the same specification and controls as Table 1. Geographical controls include absolute latitude, mean elevation, terrain ruggedness, and coast length, as well as other agriculture-related controls as precipitation and temperature means and standard deviations. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the impact of a one standard deviation in the independent variable on the probability of having a future tense in the language. Heteroskedasticity robust standard error estimates are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

This section analyzes the relation between the existence of politeness distinctions in pronouns across contemporary languages and the extent of ecological diversity in their contemporary geographical homelands (i.e., the indigenous regions that spoke the language in the pre-colonial as well as in the post-colonial era), as well as in their ancestral homeland (i.e., their *Urheimat*). In particular, Table 9 explores the association between the extent of ecological diversity in the contemporary homeland and the existence of politeness distinctions.<sup>47</sup> As established in column (1), the association between the extent of ecological diversity in the language’s contemporary homeland and the existence of politeness distinctions is positive and statistically significant at the 1% level, suggesting that a one standard deviation increase in the extent of ecological diversity in the language’s contemporary homeland is associated with a 15 percentage points increase in the probability that the language is characterized by the existence of politeness distinctions. Furthermore, as established in column (2), the estimated relationship remains highly significant once the potentially confounding effects of the geographical characteristics (i.e., absolute latitude, mean elevation, terrain ruggedness, and the length of its sea coast) in the contemporary homeland of each language, are accounted for. Moreover, since ecological diversity partly captures climatic conditions, it might be capturing the potentially direct impact of climatic conditions on the existence of politeness distinctions. Nevertheless, as established in columns (3) and (4), accounting for the potentially confounding effects of average temperature and precipitation,

<sup>47</sup>Table C1 reports the estimated coefficients on the control variables in Table 9.



as well as their standard deviations, volatility, and spatial correlation, does not alter the results qualitatively or quantitatively.

Furthermore, the length of the period within each year in which the land is not suitable for agriculture – the unproductive period – may have conceivably affected the profitability of trade and therefore the association between ecological diversity and the emergence of hierarchical societies. Nevertheless, as indicated by column (5), accounting for the length of the unproductive period has little impact on the estimated association. Finally, as reported in column (6), accounting for regional fixed-effects, and therefore for unobserved time-invariant heterogeneity at the regional level does not alter the qualitative results. In particular, a one standard deviation increase in the extent of ecological diversity in the language’s contemporary homeland is associated with a 10 percentage points increase in the probability that the language is characterized by politeness distinctions.

## 6.1 Robustness

The findings in Table 9 lend credence to the hypothesis that the extent of ecological diversity and its effect on the emergence of hierarchical societies, contributed to the emergence of politeness distinctions. Nevertheless, the results conceivably might be biased due to omitted institutional, cultural, and human characteristics, precluding a causal interpretation of the estimated coefficients. While concerns about omitted variables will be directly addressed and mitigated in the next subsection, the remaining analysis in this section establishes the robustness of the results to: (i) an alternative estimation method, (ii) spatial autocorrelation, and (iii) clustering of standard errors, while demonstrating that the findings are unlikely to be driven by selection on unobservables. Moreover, the robustness to alternative aspects of politeness distinctions are also considered.

### 6.1.1 Estimation Method, Spatial-Autocorrelation and Selection on Unobservables

Table C2 (Panel A) establishes that the estimated average marginal effects of the Probit model are nearly identical to the estimated coefficients using OLS. Furthermore, Table C2 (Panel B) establishes the robustness of the results to the clustering of the standard errors at the level of the language genus (i.e., a group of phylogenetically related languages inside a linguistic family), as well as spatial auto-correlation. In particular, the statistical significance is unaffected by the various methods used.

Table C2 (Panel B) further explores the potential bias that could be generated by omitted variables. In particular, using statistics on selection on observables and unobservables (Altonji et al., 2005; Oster, 2014), it establishes that the degree of omitted variable bias is low and is unlikely to explain the magnitude of the estimated association between ecological diversity and the existence of politeness distinctions. In particular, omitted factors would need to be 3-5 times more strongly correlated with ecological diversity, in order to account for the estimated association between ecological diversity and the emergence of politeness distinctions. Indeed, the bias-adjusted estimated coefficient of ecological diversity is only slightly smaller than the value of the OLS estimate. In particular, as reported in column (6), following Oster (2014), the bias-corrected coefficient of ecological diversity, assuming that the unobservables are as strongly correlated with ecological diversity as the set of observables that

are accounted for, implies that a one standard deviation increase in ecological diversity is associated with an 8 percentage points increase in the probability of the existence of politeness distinctions in pronouns.

### 6.1.2 Alternative Aspects of Politeness Distinctions

Tables C4 and C10 establish qualitatively similar associations between ecological diversity and (i) an alternative measure of politeness distinctions in pronouns, and (ii) the intensity of politeness distinctions in a language. These results suggest that various aspects of politeness distinctions that have reinforced hierarchical orientation, were associated with ecological diversity. Moreover, Tables C5 and C11 establish the robustness of these alternative associations to: (i) an alternative estimation method, (ii) spatial autocorrelation, and (iii) clustering of standard errors, while demonstrating that the findings are unlikely to be driven by selection on unobservables.

### 6.1.3 Ecological Diversity and Other Language Structures

The associations between the extent of ecological diversity and politeness distinctions may reflect a broader association between ecological diversity and a wide range of linguistic traits, rather than its unique association with politeness distinctions, weakening the proposed hypothesis. Moreover, the association between the extent of ecological diversity and politeness distinctions in the language may reflect a broader association between a whole range of linguistic traits and politeness distinctions.

Table C3 establishes, however, that alternative language structures (as reported by WALS), such as the existence of other temporal and non-temporal structures, are largely uncorrelated with the geographical determinants of hierarchical society. In particular the extent of ecological diversity is not significantly associated with the existence of the past and the perfect tense, and it is orthogonal to non-temporal linguistic characteristics such as: (i) the existence of possessive classifications, (ii) the existence of coding for evidentiality, (iii) the number of consonants, and (iv) the number of colors. Furthermore, using all available data on language structures as reported in WALS, Figure C1 establishes the orthogonality of ecological diversity for all language structures that are not related to politeness distinctions.<sup>48</sup> These results lend further support to the hypothesis that ecological diversity is uniquely associated with the emergence of politeness distinctions.

## 6.2 Geographical Origins: Contemporary Homeland vs. Urheimat

This subsection exploits the descent of contemporary languages from proto-languages to explore the relative contributions of ecological diversity in (i) the contemporary homeland of the language and (ii)

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<sup>48</sup>Specifically, the only other structures that are statistically associated with ecological diversity are: consonant-vowel ratio (variable 3A in WALS), inclusive/exclusive distinction in independent personal pronouns (39A), and existence of passive constructions (107A). The significant correlation with the consonant-vowel ratio may reflect the positive impact of this variable on the emergence of states (Depetris-Chauvin and Özak, 2016), and thus of hierarchical societies, which in turn are also associated with politeness distinctions. The association with inclusive/exclusive distinction in independent personal pronouns (39A) may reflect the commonality among certain aspects of languages or simply the fact that this variable is not ordinal, and as such the correlation is merely due to randomness in the ordering of this variable. Finally, the association with the existence of passive constructions seems to reflect its use as a politeness device (Brown and Levinson, 1987; Sifianou, 1992).

the ancestral homeland of the language (i.e., its *Urheimat*) to the existence of politeness distinctions.

Table 10: The Relative Contribution of Ecological Diversity in the Linguistic Homeland vs. the *Urheimat* to the Existence of Politeness Distinction: Daughter Languages Outside *Urheimat*

	The Existence of Politeness Distinctions					
	Migratory Distance to <i>Urheimat</i>					
	Any Distance			At Least 1 Week		
	Homeland	<i>Urheimat</i>	Both	Homeland	<i>Urheimat</i>	Both
	(1)	(2)	(3)	(4)	(5)	(6)
Homeland's Ecological Diversity	0.11*** (0.02)		0.11*** (0.02)	0.12*** (0.02)		0.10*** (0.02)
<i>Urheimat</i> 's Ecological Diversity		0.10*** (0.03)	0.05 (0.03)		0.16*** (0.04)	0.07 (0.05)
Regional FE	Yes	Yes	Yes	Yes	Yes	Yes
Homeland's Geographical Characteristics	Yes	No	Yes	Yes	No	Yes
<i>Urheimat</i> 's Geographical Characteristics	No	Yes	Yes	No	Yes	Yes
Adjusted- $R^2$	0.41	0.41	0.51	0.37	0.43	0.49
Observations	146	146	146	126	126	126
Language Families	36	36	36	28	28	28

Notes: This table establishes the importance of ecological diversity in the contemporary homeland rather than in the *Urheimat* to the presence of politeness distinctions in daughter languages located outside of the *Urheimat*, accounting for regional fixed-effects and other geographical characteristics. Geographical controls include absolute latitude, mean elevation, terrain ruggedness, and coast length. Columns (1)-(3) consider daughter languages anywhere outside of the *Urheimat* while column (4)-(6) those who are at least a week of migratory distance from the *Urheimat*. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the impact of a one standard deviation in the independent variable on the probability of having a future tense in the language. Heteroskedasticity robust standard error estimates clustered at the language family level are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table 10 explores the relative contributions of the extent of ecological diversity in the contemporary language's homeland vs. its *Urheimat* to the presence of politeness distinctions in daughter languages. It establishes that the existence of politeness distinctions in pronouns among daughter languages located outside their *Urheimat* are predominantly associated with ecological diversity in their contemporary homeland.<sup>49</sup> Columns (1) - (6) establish that the extent of ecological diversity in the contemporary homeland of a language has a highly significant positive association with the existence of politeness distinctions among migrant languages, dominating the association with the characteristics in the *Urheimat*. Accounting for regional fixed-effects and other geographical characteristics of the homeland, a one standard deviation increase in ecological diversity in the contemporary homeland of the language is associated with a 10-12 percentage points increase in the probability that a migrant daughter language would have politeness distinctions in pronouns. Similarly, Tables C7 and C13 establish analogous results of the association between ecological diversity and (i) an alternative measure of politeness distinctions in pronouns and (ii) the intensity of politeness distinctions in pronouns.

The analysis mirrors the epidemiological approach to cultural diffusion, and establishes the geo-

<sup>49</sup>Given the potential dependence of languages within the same language family, standard errors are clustered at this level.

geographical origins of the existence of politeness distinctions based on variation across languages located outside the *Urheimat* (i.e., ancestral homeland of their proto-language). This approach permits the analysis to account for host region fixed-effects and thus to capture unobserved time-invariant heterogeneity at the regional level, thus mitigating concerns about omitted variables.

These results suggests that politeness distinctions have emerged primarily during the demic diffusion of the language. Indeed, these results can be interpreted as an outcome of sorting of hierarchy-averse individuals into geographical locations where hierarchies are less likely to emerge. Interestingly, this would suggest that hierarchical structures and thus politeness distinctions would be more prevalent in geographical locations characterized by ecological diversity, where individuals are not freely mobile and could not flee oppression (Carneiro, 1970).

The evidence provided in this section supports the proposed hypothesis that ecological diversity affects the existence of politeness distinctions in a language, shedding light on the coevolution of language and culture. Furthermore, consistent with evidence about the greater adaptability of politeness distinctions to environmental and political changes (Wichmann and Holman, 2009; Greenhill et al., 2010; Dediu and Levinson, 2012; Dediu and Cysouw, 2013; Greenhill et al., 2017), in comparison to the structure of the future tense and sex-based grammatical gender, the findings suggest that while geographical characteristics in the *Urheimat* are associated with the existence of the periphrastic future tense and sex-based grammatical gender, the geographical characteristics in the homeland of the daughter languages are associated with the existence of politeness distinctions. In particular, in line with the conventional wisdom among linguists about the relative fluidity of politeness distinctions, the evidence suggests that the existence of politeness distinctions in contemporary languages are originated predominantly in cultural processes that took place after proto-languages were formed and daughter languages had started to emerge. Moreover, the evidence is consistent with the possible sorting of hierarchy-averse individuals into geographical locations that are less prone to be conducive for the emergence of hierarchical structures, which may have played a role in the positive association between ecological diversity in the contemporary homeland of the language and the existence of politeness distinctions.

### 6.3 Mechanism

This section presents additional supportive evidence for the hypothesized geographical origins of politeness distinctions. In view of the evidence about the effect of ecological diversity on the emergence of hierarchical structures (Fenske, 2014; Depetris-Chauvin and Özak, 2016), the effect of ecological diversity on the emergence of politeness distinctions would necessitate the emergence of hierarchical structures. In particular, as illustrated in Figure 9, the proposed hypothesis would imply that: (i) ecological diversity ought to be associated with more hierarchical structures, and (ii) more hierarchical structures ought to be associated with the existence of politeness distinctions.

Table 11 presents supporting evidence for the proposed mechanism. In particular, it establishes the robust positive association between ecological diversity and the level of jurisdictional hierarchy in a pre-colonial ethnic group, which in turn is positively associated with the emergence of politeness distinctions in pronouns. Using data from the *Ethnographic Atlas* (Murdock and White, 1969) on the

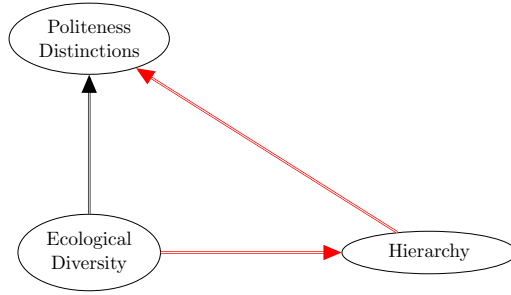


Figure 9: Ecological Diversity, Hierarchy & Politeness Distinctions

level of jurisdictional hierarchy above the local level – a proxy for the size and strength of the State and hierarchical structures – the analysis explores the association between ecological diversity and a pre-colonial ethnicity’s level of jurisdictional hierarchy. In particular, columns (1) and (2) establish that societies inhabiting regions with higher ecological diversity had higher levels of jurisdictional hierarchy. The results suggest that a one-standard deviation increase in ecological diversity is associated with 0.12 standard deviations increase in jurisdictional hierarchy. Moreover, columns (3) and (4) establish the positive association between the level of jurisdictional hierarchy in a pre-colonial ethnic group and the probability of existence of politeness distinctions in the language spoken by the ethnic group. The results suggest that a one standard deviation increase in jurisdictional hierarchy is associated with a 16 percentage points increase in the probability of existence of politeness distinctions in pronouns.

Table 11: Geographic Origins of Politeness Distinctions and Jurisdictional Hierarchy

	Mechanism			
	Jurisdictional Hierarchy		Politeness	
	(1)	(2)	(3)	(4)
Ecological Diversity	0.23*** (0.04)	0.12*** (0.03)		
Jurisdictional Hierarchy			0.21*** (0.02)	0.16*** (0.03)
All Geographic Controls	No	Yes	No	Yes
Regional FE	No	Yes	No	Yes
Adjusted- $R^2$	0.07	0.32	0.34	0.48
Observations	1154	1154	139	139

Notes: This table establishes the positive statistically and economically significant association between the geographical determinants of statehood, as measured by jurisdictional hierarchy beyond the local level, and politeness distinctions in a language. The first two columns provide the results of the association between ecological diversity and statehood, and columns (3) and (4) show the association between statehood and the emergence of politeness distinctions. The table shows the estimated coefficients in an OLS regression as the dependent variable in columns (1) and (2) is not binary. Heteroskedasticity robust standard error estimates are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

## 6.4 Hierarchical Orientation and Politeness Distinctions

This section explores the association between the hierarchical orientation in a given community and the existence of politeness distinctions in the language the members of the community speak. In light

of the proposed hypothesis that politeness distinctions in pronouns are complementary to hierarchical structures and cultures, the prevalence of hierarchical orientation within a given society is likely to be associated with the presence of politeness distinctions in the language used among members of this society. Indeed, the common geographical origins (i.e., ecological diversity) of hierarchical orientation as well as politeness distinctions suggest that this positive association is likely to be observed across various speech communities.

Table 12: Hierarchy and Politeness

	Hierarchy Index			
	All		Old World	
	(1)	(2)	(3)	(4)
Politeness Distinctions	0.37** (0.13)	0.23** (0.09)	0.45*** (0.10)	0.29*** (0.06)
Ecological Diversity		0.14 (0.13)		0.05 (0.14)
Main Geographical Controls	No	Yes	No	Yes
Adjusted- $R^2$	0.12	0.27	0.19	0.36
Observations	53	53	50	50

Notes: This table establishes the statistically and economically positive association between of politeness distinctions and preferences for hierarchy in society. The analysis accounts for the geographical origins of politeness distinctions and other geographical characteristics of the contemporary homeland of the language. Heteroskedasticity robust standard error estimates clustered at the language family level are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table 12 explores the association between the prevalence of hierarchical orientation within a given society and the presence of politeness distinctions in pronouns in the language used among members of this society.<sup>50</sup> It establishes the positive statistically and economically significant association between the existence of the politeness distinctions in pronouns and hierarchical orientation.<sup>51</sup> This significant positive association is present among speakers of languages in the world as a whole (Columns (1) and (2)), as well as among speakers who reside in the Old World and speak languages originated in the Old World (Columns (3) and (4)). These findings lend credence to the proposed hypothesis that the prevalence of hierarchical orientation and the presence of politeness distinctions have coevolved in the course of human history.

<sup>50</sup>The measure of hierarchical orientation is based on the following questions in the World Values Survey (WVS): “Here is a list of qualities that children can be encouraged to learn at home. Which, if any, do you consider to be especially important?” Individuals are considered to have higher hierarchical orientation if they answered “Obedience” or “Religious Faith” and lower if they answered “Independence” or “Determination, Perseverance”. This measure is the opposite of the Autonomy Index introduced in Welzel (2013).

<sup>51</sup>The sample of languages in the WVS for which politeness distinctions data exists has little regional variation. This impedes the use of regional fixed-effects in the analysis of the main measure of politeness distinctions. Reassuringly, as established in Tables C9 and C15, exploiting the larger regional variations present in the additional measures of politeness distinctions, permits the analysis to account for regional fixed-effects, obtaining qualitatively similar results.

## 7 Concluding Remarks

This research explores the geographical origins of the coevolution of cultural and linguistic traits in the course of human history, relating the geographical roots of long-term orientation to the structure of the future tense, the agricultural determinants of gender bias to the presence of sex-based grammatical gender, and the ecological origins of hierarchical orientation to the existence of politeness distinctions. The study advances the hypothesis and establishes empirically that: (i) variations in geographical characteristics that were conducive to higher natural return to agricultural investment contributed to the existing cross-language variations in the structure of the future tense, (ii) the agricultural determinants of gender gap in agricultural productivity fostered the existence of sex-based grammatical gender, and (iii) the ecological origins of hierarchical societies triggered the emergence of politeness distinctions.

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# Appendix (Not for publication)

## A The Origins of Periphrastic Future Tense

### A.1 Crop Return and Periphrastic Future Tense

Table A1: Geographical Origins of Periphrastic Future Tense (OLS)

	Existence of Future Tense					
	(1)	(2)	(3)	(4)	(5)	(6)
Crop Return (pre-1500CE)	0.06** (0.03)	0.06** (0.03)	0.07** (0.03)	0.07** (0.03)	0.09*** (0.03)	0.11*** (0.03)
Absolute Latitude		-0.03 (0.03)	-0.03 (0.04)	0.03 (0.10)	0.05 (0.10)	0.15 (0.11)
Elevation		0.04 (0.04)	0.03 (0.04)	0.05 (0.05)	0.05 (0.04)	0.03 (0.05)
Ruggedness		-0.04 (0.04)	-0.03 (0.04)	-0.04 (0.04)	-0.05 (0.04)	-0.02 (0.04)
Coast Length		0.08*** (0.02)	0.07*** (0.02)	0.06*** (0.02)	0.06*** (0.02)	0.06*** (0.02)
Precipitation (mm/month)			0.01 (0.07)	0.02 (0.07)	0.01 (0.07)	0.01 (0.08)
Precipitation (mm/month) (std)			0.07** (0.03)	0.01 (0.05)	0.01 (0.05)	0.04 (0.05)
Precipitation Volatility			-0.04 (0.08)	-0.03 (0.08)	-0.03 (0.08)	-0.04 (0.08)
Precipitation Spatial Correlation			0.01 (0.04)	0.93*** (0.26)	0.91*** (0.26)	0.95*** (0.30)
Temperature (Daily Mean)				0.05 (0.07)	0.07 (0.06)	0.08 (0.08)
Temperature (Daily Mean) (std)				0.07 (0.05)	0.08* (0.05)	0.05 (0.04)
Temperature Volatility				-0.01 (0.08)	-0.06 (0.08)	-0.09 (0.09)
Temperature Spatial Correlation				-0.93*** (0.26)	-0.91*** (0.26)	-0.93*** (0.30)
Unproductive Period (pre-1500CE)					0.08** (0.03)	0.09*** (0.03)
Regional FE	No	No	No	No	No	Yes
Adjusted- $R^2$	0.01	0.02	0.02	0.06	0.07	0.11
Observations	275	275	275	275	275	275

Notes: This table establishes the positive, statistically, and economically significant association between pre-1500CE potential crop return and the existence of periphrastic future tense in the language spoken in this region, accounting for regional fixed-effects and other geographical characteristics. All specifications in this table are identical to the ones presented in Table 1, but here the coefficients of the controls are presented. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the impact of a one standard deviation in the independent variable on the probability of having a future tense in the language. Heteroskedasticity robust standard error estimates are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table A2: Crop Return and Periphrastic Future Tense

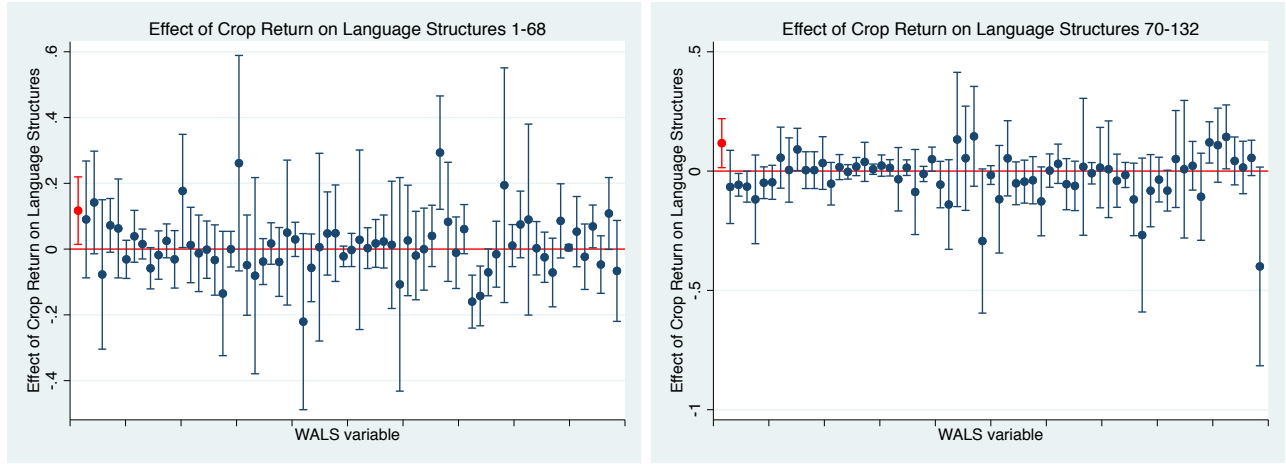
	Existence of Periphrastic Future Tense					
	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A: Probit					
Crop Return (pre-1500CE)	0.06** (0.03)	0.06** (0.03)	0.06** (0.03)	0.07** (0.03)	0.09*** (0.03)	0.12*** (0.03)
Geographical Controls	No	Yes	Yes	Yes	Yes	Yes
Regional FE	No	No	No	No	No	Yes
Pseudo- $R^2$	0.01	0.03	0.04	0.08	0.10	0.14
Observations	275	275	275	275	275	275
	Panel B: OLS - Spatial-Autocorrelation, Clustering and Selection On Unobservables					
Crop Return (pre-1500CE)	0.06** (0.03) ([0.04]) [0.04] {0.03}	0.06** (0.03) ([0.04]) [0.04] {0.03}	0.07** (0.03) ([0.03]) [0.03] {0.03}	0.07** (0.03) ([0.03]) [0.03] {0.03}	0.09*** (0.03) ([0.03]) [0.03] {0.03}	0.11*** (0.03) ([0.03]) [0.03] {0.03}
Altonji et al $\delta$						-2.09 -2.84
$\beta$ -Oster $R^2$	0.01	0.04	0.06	0.10	0.12	0.13 0.17

Notes: This table establishes the positive, statistically, and economically significant association between pre-1500CE potential crop return and the existence of periphrastic future tense in the language spoken in this region, accounting for regional fixed-effects and other geographical characteristics. All columns have the same specification and controls as Table 1. Geographical controls include absolute latitude, mean elevation, terrain ruggedness, and coast length, as well as other agriculture-related controls as precipitation and temperature means and standard deviations. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the impact of a one standard deviation in the independent variable on the probability of having a future tense in the language. Heteroskedasticity robust standard error estimates are reported in parentheses, clustered at the language genus in parentheses and squared brackets, spatial auto-correlation corrected standard errors (Conley, 1999) in squared brackets and Cliff-Ord ML in curly brackets; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table A3: Geographic Origins of Future and Language Structures

	Language Structure						
	Future	Temporal Structures		Non-Temporal Structures			
		Past	Perfect	Possessive	Evidentiality	Consonants	Colors
(1)	(2)	(3)	(4)	(5)	(6)	(7)	
Crop Return (pre-1500CE)	0.12*** (0.03)	-0.06 (0.04)	0.05 (0.04)	-0.07* (0.04)	0.00 (0.03)	0.08 (0.06)	0.06 (0.34)
All Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Regional FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted- $R^2$	0.11	0.08	0.14	0.15	0.20	0.31	-0.03
Observations	275	218	218	224	387	542	117

Notes: This table establishes the positive, statistically, and economically significant association between pre-1500CE potential crop return and the existence of periphrastic future tense in a language, and not with other language structures. The analysis accounts for regional fixed-effects and other geographical characteristics as in previous tables. Other language structures include the existence a past tense, a perfect tense, the existence of obligatory possessive inflections, semantic distinctions of evidentiality, the number of consonants, the ratio of consonants to vowels and the number of colors. Heteroskedasticity robust standard error estimates are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.



(a) WALS Structures 1-68

(b) WALS Structures 69-132

Figure A1: Orthogonality of Crop Return and Other Language Structures in WALS  
Impact of Crop Return on Periphrastic Future Tense in Red

Table A4: Agricultural Intensity and Crop Return

	Agricultural Intensity			
	Full Sample		Future Sample	
	(1)	(2)	(3)	(4)
Crop Return (pre-1500CE)	0.19*** (0.03)	0.22*** (0.02)	0.27*** (0.07)	0.30*** (0.06)
Regional FE	No	Yes	No	Yes
All Geographical Controls	No	Yes	No	Yes
Adjusted- $R^2$	0.04	0.64	0.07	0.61
Observations	1306	1306	264	264

Notes: This table establishes the positive statistically and economically significant association between a language's contemporary homeland's crop return and the level of agricultural intensity of a pre-colonial society that speaks that language. Standardized coefficients. Heteroskedasticity robust standard error estimates are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

## B Origins of Sex-Based Grammatical Gender

Table B1: Geographic Origins of Sex-Based Grammatical Gender (OLS)

	Existence of Sex-Based Grammatical Gender					
	(1)	(2)	(3)	(4)	(5)	(6)
Plow Negative Crops (Average Caloric Yield, pre-1500)	-0.13** (0.06)	-0.19*** (0.06)	-0.25*** (0.06)	-0.26*** (0.06)	-0.29*** (0.06)	-0.23*** (0.08)
All Crops (Average Caloric Yield, pre-1500)	0.17*** (0.06)	0.21*** (0.06)	0.28*** (0.06)	0.29*** (0.06)	0.32*** (0.06)	0.25*** (0.08)
Absolute Latitude		-0.10*** (0.04)	-0.19*** (0.04)	-0.06 (0.10)	-0.06 (0.10)	-0.13 (0.10)
Elevation		-0.01 (0.05)	-0.14*** (0.04)	-0.11** (0.05)	-0.11** (0.05)	-0.11** (0.05)
Ruggedness		-0.02 (0.05)	0.08 (0.05)	0.08 (0.05)	0.08 (0.05)	0.06 (0.05)
Coast Length		0.08*** (0.02)	0.09*** (0.02)	0.09*** (0.02)	0.08*** (0.02)	0.08*** (0.02)
Precipitation (mm/month)			-0.11* (0.07)	-0.11 (0.07)	-0.12 (0.07)	-0.08 (0.07)
Precipitation (mm/month) (std)			-0.02 (0.03)	0.03 (0.05)	0.04 (0.05)	0.03 (0.05)
Precipitation Volatility			0.03 (0.07)	-0.01 (0.08)	0.00 (0.08)	0.01 (0.08)
Precipitation Spatial Correlation			0.13*** (0.03)	0.14 (0.28)	0.15 (0.29)	0.12 (0.28)
Temperature (Daily Mean)				0.08 (0.07)	0.07 (0.07)	0.04 (0.07)
Temperature (Daily Mean) (std)				-0.07 (0.05)	-0.08* (0.04)	-0.07 (0.05)
Temperature Volatility				-0.08 (0.09)	-0.07 (0.09)	-0.10 (0.09)
Temperature Spatial Correlation				-0.01 (0.29)	-0.02 (0.29)	-0.02 (0.28)
Unproductive Period (pre-1500CE)					-0.06* (0.03)	-0.02 (0.03)
Regional FE	No	No	No	No	No	Yes
Adjusted- $R^2$	0.03	0.06	0.14	0.15	0.15	0.21
Observations	217	217	217	217	217	217

Notes: This table establishes the statistically and economically significant association between the historical agricultural determinants of plow usage and the existence of sex-based grammatical gender in the language spoken in this region, accounting for regional fixed-effects and other geographical characteristics. All columns have the same specification and controls as Table 5. Geographical controls include absolute latitude, mean elevation, terrain ruggedness, and coast length, as well as other agriculture-related controls as precipitation and temperature means and standard deviations. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the impact of a one standard deviation in the independent variable on the probability of having a future tense in the language. Heteroskedasticity robust standard error estimates are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table B2: Geographic Origins of Sex-Based Grammatical Gender

	Existence of Sex-Based Grammatical Gender					
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Probit						
Plow Negative Crops (Average Caloric Yield, pre-1500)	-0.13** (0.05)	-0.19*** (0.06)	-0.25*** (0.06)	-0.26*** (0.06)	-0.28*** (0.06)	-0.20** (0.08)
All Crops (Average Caloric Yield, pre-1500)	0.16*** (0.05)	0.21*** (0.06)	0.28*** (0.06)	0.30*** (0.06)	0.32*** (0.06)	0.22*** (0.07)
Geographical Controls	No	Yes	Yes	Yes	Yes	Yes
Regional FE	No	No	No	No	No	Yes
Pseudo- $R^2$	0.03	0.07	0.16	0.18	0.18	0.25
Observations	216	216	216	216	216	216
Panel B: OLS - Spatial-Autocorrelation, Clustering and Selection On Unobservables						
Plow Negative Crops (Average Caloric Yield, pre-1500)	-0.13** (0.06) ([0.07]) [0.06] {0.06}	-0.19*** (0.06) ([0.07]) [0.07] {0.06}	-0.25*** (0.06) ([0.07]) [0.07] {0.06}	-0.26*** (0.06) ([0.07]) [0.07] {0.06}	-0.29*** (0.06) ([0.07]) [0.07] {0.07}	-0.23*** (0.08) ([0.08]) [0.07] {0.09}
Altonji et al $\delta$						-2.26 -1.29
$\beta$ -Oster						-0.27
All Crops (Average Caloric Yield, pre-1500)	0.17*** (0.06) ([0.07]) [0.06] {0.06}	0.21*** (0.06) ([0.07]) [0.06] {0.06}	0.28*** (0.06) ([0.07]) [0.06] {0.06}	0.29*** (0.06) ([0.07]) [0.06] {0.06}	0.32*** (0.06) ([0.07]) [0.06] {0.06}	0.25*** (0.08) ([0.07]) [0.07] {0.08}
Altonji et al $\delta$						-3.02 -1.56
$\beta$ -Oster						0.28
$R^2$	0.04	0.09	0.18	0.20	0.21	0.28

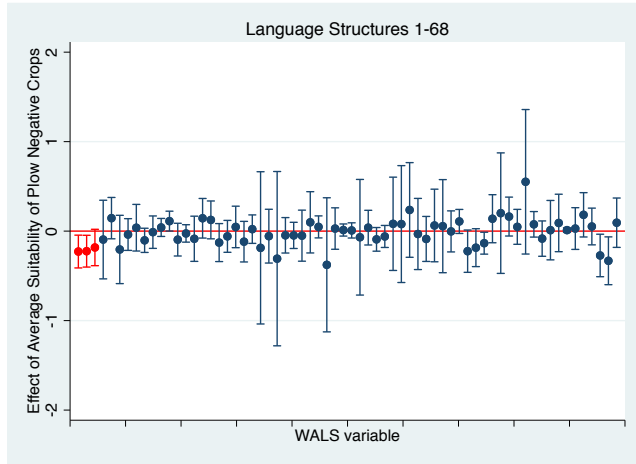
Notes: This table establishes the statistically and economically significant association between the historical agricultural determinants of plow usage and the existence of sex-based grammatical gender in the language spoken in this region, accounting for regional fixed-effects and other geographical characteristics. All columns have the same specification and controls as Table A2. Geographical controls include absolute latitude, mean elevation, terrain ruggedness, and coast length, as well as other agriculture-related controls as precipitation and temperature means and standard deviations. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the impact of a one standard deviation in the independent variable on the probability of having a future tense in the language. Heteroskedasticity robust standard error estimates are reported in parentheses, clustered at the language genus in parenthesis and squared brackets, spatial auto-correlation corrected standard errors (Conley, 1999) in squared brackets and Cliff-Ord ML in curly brackets; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.



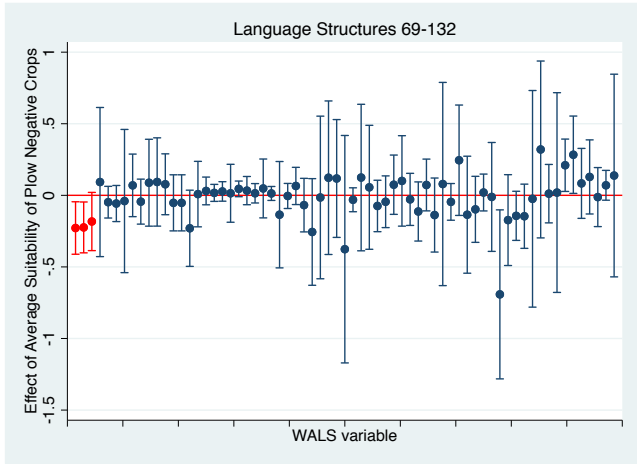
Table B3: Geographical Origins of Gender and Language Structures

	Language Structure						
	Temporal Structures			Non-Temporal Structures			
	Gender	Past	Perfect	Possessive	Evidentiality	Consonants	Colors
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Plow Negative Crops (Average Caloric Yield, pre-1500)	-0.23*** (0.08)	-0.33*** (0.11)	-0.09 (0.09)	0.02 (0.10)	-0.05 (0.07)	-0.11 (0.14)	-0.76 (0.83)
All Crops (Average Caloric Yield, pre-1500)	0.23*** (0.07)	0.24*** (0.08)	0.07 (0.08)	-0.06 (0.08)	0.02 (0.06)	0.08 (0.12)	0.73 (0.82)
All Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Regional FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted- $R^2$	0.21	0.12	0.14	0.14	0.20	0.30	-0.03
Observations	217	218	218	224	387	542	117

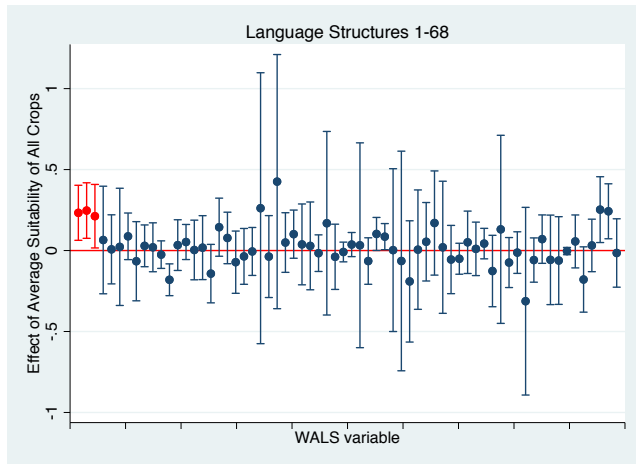
Notes: This table establishes the statistically and economically significant association between the historical agricultural determinants of plow usage and the existence of sex-based grammatical gender in a language, and compares their impact on other language structures. The analysis accounts for regional fixed-effects and other geographical characteristics as in previous tables. Other language structures include the existence a past tense, a perfect tense, the existence of obligatory possessive inflections, semantic distinctions of evidentiality, the number of consonants, the ratio of consonants to vowels and the number of colors. Heteroskedasticity robust standard error estimates are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.



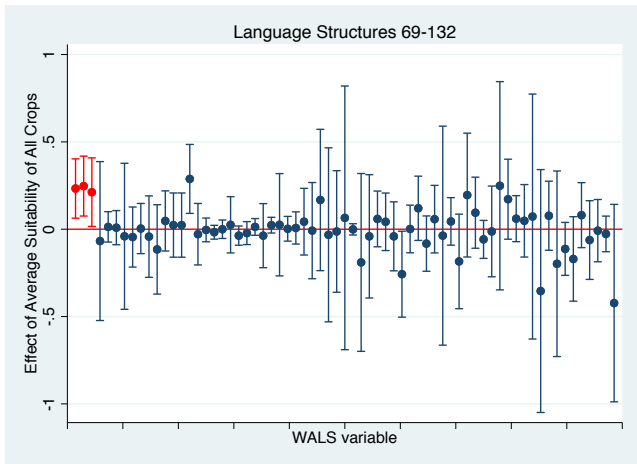
(a) Caloric Suitability of Plow Negative Crops and WALS Structures 1-68



(b) Caloric Suitability of Plow Negative Crops and WALS Structures 69-132



(c) Average Caloric Suitability and WALS Structures 1-68



(d) Average Caloric Suitability and WALS Structures 69-132

Figure B1: Orthogonality of Suitability for the Usage of the Plow and Other Language Structures in WALS  
(Impact of Determinants of Plow Usage on Sex-Based Grammatical Gender in Red)

## B.1 Alternative Measure for Sex-Based Grammatical Gender (Extensive Measure)

Table B4: Geographic Origins of Sex-Based Grammatical Gender (OLS)

	Existence of Sex-Based Grammatical Gender					
	(1)	(2)	(3)	(4)	(5)	(6)
Plow Negative Crops (Average Caloric Yield, pre-1500)	-0.03 (0.06)	-0.10 (0.06)	-0.16** (0.06)	-0.17*** (0.06)	-0.23*** (0.07)	-0.22*** (0.08)
All Crops (Average Caloric Yield, pre-1500)	0.09 (0.05)	0.14** (0.06)	0.21*** (0.06)	0.22*** (0.06)	0.27*** (0.06)	0.26*** (0.07)
Absolute Latitude		-0.10*** (0.04)	-0.20*** (0.04)	-0.09 (0.10)	-0.10 (0.10)	-0.15 (0.09)
Elevation		0.02 (0.05)	-0.11** (0.04)	-0.09* (0.05)	-0.11** (0.05)	-0.13*** (0.04)
Ruggedness		-0.05 (0.05)	0.04 (0.05)	0.04 (0.05)	0.05 (0.05)	0.05 (0.05)
Coast Length		0.07*** (0.02)	0.08*** (0.02)	0.08*** (0.02)	0.07*** (0.02)	0.07*** (0.02)
Precipitation (mm/month)			-0.09 (0.06)	-0.10 (0.07)	-0.11 (0.07)	-0.06 (0.07)
Precipitation (mm/month) (std)			-0.03 (0.03)	0.01 (0.05)	0.01 (0.05)	0.00 (0.05)
Precipitation Volatility			-0.00 (0.07)	-0.02 (0.08)	-0.00 (0.08)	0.02 (0.07)
Precipitation Spatial Correlation			0.13*** (0.03)	0.20 (0.28)	0.22 (0.28)	0.18 (0.26)
Temperature (Daily Mean)				0.03 (0.07)	0.02 (0.07)	-0.02 (0.07)
Temperature (Daily Mean) (std)				-0.06 (0.05)	-0.07 (0.04)	-0.06 (0.04)
Temperature Volatility				-0.08 (0.09)	-0.06 (0.09)	-0.08 (0.09)
Temperature Spatial Correlation				-0.07 (0.29)	-0.06 (0.29)	-0.06 (0.26)
Unproductive Period (pre-1500CE)					-0.08*** (0.03)	-0.03 (0.03)
Regional FE	No	No	No	No	No	Yes
Adjusted- $R^2$	0.01	0.04	0.13	0.13	0.15	0.24
Observations	245	245	245	245	245	245

Notes: This table establishes the statistically and economically significant association between the historical agricultural determinants of plow usage and the existence of sex-based grammatical gender in the language spoken in this region, accounting for regional fixed-effects and other geographical characteristics. All columns have the same specification and controls as Table 5. Geographical controls include absolute latitude, mean elevation, terrain ruggedness, and coast length, as well as other agriculture-related controls as precipitation and temperature means and standard deviations. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the impact of a one standard deviation in the independent variable on the probability of having a future tense in the language. Heteroskedasticity robust standard error estimates are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table B5: Geographic Origins of Sex-Based Grammatical Gender

	Existence of Sex-Based Grammatical Gender					
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Probit						
Plow Negative Crops (Average Caloric Yield, pre-1500)	-0.03 (0.05)	-0.10* (0.06)	-0.16** (0.06)	-0.17*** (0.06)	-0.22*** (0.06)	-0.21*** (0.07)
All Crops (Average Caloric Yield, pre-1500)	0.09 (0.05)	0.14** (0.06)	0.21*** (0.06)	0.22*** (0.06)	0.26*** (0.06)	0.24*** (0.07)
Geographical Controls	No	Yes	Yes	Yes	Yes	Yes
Regional FE	No	No	No	No	No	Yes
Pseudo- $R^2$	0.01	0.05	0.14	0.15	0.17	0.26
Observations	245	245	245	245	245	245
Panel B: OLS - Spatial-Autocorrelation, Clustering and Selection On Unobservables						
Plow Negative Crops (Average Caloric Yield, pre-1500)	-0.03 (0.06) ([0.07]) [0.06] {0.05}	-0.10 (0.06) ([0.08]) [0.07] {0.06}	-0.16** (0.06) ([0.08]) [0.07] {0.06}	-0.17*** (0.06) ([0.07]) [0.07] {0.06}	-0.23*** (0.07) ([0.07]) [0.07] {0.06}	-0.22*** (0.08) ([0.07]) [0.07] {0.08}
Altonji et al						-1.14
$\delta$						-0.89
$\beta$ -Oster						-0.29
All Crops (Average Caloric Yield, pre-1500)	0.09 (0.05) ([0.07]) [0.06] {0.05}	0.14** (0.06) ([0.07]) [0.06] {0.06}	0.21*** (0.06) ([0.07]) [0.06] {0.06}	0.22*** (0.06) ([0.07]) [0.06] {0.06}	0.27*** (0.06) ([0.07]) [0.06] {0.06}	0.26*** (0.07) ([0.07]) [0.07] {0.07}
Altonji et al						-1.51
$\delta$						-0.89
$\beta$ -Oster						0.31
$R^2$	0.02	0.07	0.17	0.18	0.20	0.31

Notes: This table establishes the statistically and economically significant association between the historical agricultural determinants of plow usage and the existence of sex-based grammatical gender in the language spoken in this region, accounting for regional fixed-effects and other geographical characteristics. All columns have the same specification and controls as Table A2. Geographical controls include absolute latitude, mean elevation, terrain ruggedness, and coast length, as well as other agriculture-related controls as precipitation and temperature means and standard deviations. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the impact of a one standard deviation in the independent variable on the probability of having a future tense in the language. Heteroskedasticity robust standard error estimates are reported in parentheses, clustered at the language genus in parenthesis and squared brackets, spatial auto-correlation corrected standard errors (Conley, 1999) in squared brackets and Cliff-Ord ML in curly brackets; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table B6: Geographical Origins of Gender and Language Structures

	Language Structure						
	Gender	Temporal Structures		Non-Temporal Structures			
		Past	Perfect	Possessive	Evidentiality	Consonants	Colors
(1)	(2)	(3)	(4)	(5)	(6)	(7)	
Plow Negative Crops (Average Caloric Yield, pre-1500)	-0.22*** (0.08)	-0.33*** (0.11)	-0.09 (0.09)	0.01 (0.10)	-0.05 (0.07)	-0.09 (0.14)	-0.83 (0.83)
Average Caloric Yield (All Crops, pre-1500)	0.25*** (0.07)	0.24*** (0.08)	0.07 (0.08)	-0.06 (0.08)	0.02 (0.06)	0.07 (0.12)	0.76 (0.82)
All Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Regional FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted- $R^2$	0.24	0.12	0.14	0.14	0.20	0.31	-0.03
Observations	245	218	218	223	386	538	116

Notes: This table establishes the statistically and economically significant association between the historical agricultural determinants of plow usage and the existence of sex-based grammatical gender in a language, and compares their impact on other language structures. The analysis accounts for regional fixed-effects and other geographical characteristics as in previous tables. Other language structures include the existence a past tense, a perfect tense, the existence of obligatory possessive inflections, semantic distinctions of evidentiality, the number of consonants, the ratio of consonants to vowels and the number of colors. Heteroskedasticity robust standard error estimates are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table B7: Persistent Impact of Geographical Characteristics on Gender: Linguistic Homeland vs. Urheimat (Languages Outside Urheimat)

	Existence of Sex-Based Gender System					
	Migratory Distance to Urheimat					
	Any Distance			At Least 1 Week		
	Homeland	Urheimat	Both	Homeland	Urheimat	Both
(1)	(2)	(3)	(4)	(5)	(6)	
Homeland Plow Negative Crops (Average Caloric Yield, pre-1500)	-0.17** (0.07)		-0.11 (0.07)	-0.11 (0.08)		-0.10* (0.06)
Homeland All Crops (Average Caloric Yield, pre-1500)	0.16** (0.07)		0.13** (0.06)	0.13 (0.09)		0.11* (0.06)
Urheimat Plow Negative Crops (Average Caloric Yield, pre-1500)		-0.54*** (0.13)	-0.50*** (0.13)		-0.52*** (0.17)	-0.54** (0.20)
Urheimat All Crops (Average Caloric Yield, pre-1500)		0.67*** (0.14)	0.63*** (0.13)		0.71*** (0.21)	0.71*** (0.24)
Regional FE	Yes	Yes	Yes	Yes	Yes	Yes
Homeland Geographical Characteristics	Yes	No	Yes	Yes	No	Yes
Urheimat Geographical Characteristics	No	Yes	Yes	No	Yes	Yes
Adjusted- $R^2$	0.31	0.51	0.50	0.34	0.57	0.54
Observations	183	183	183	155	155	155
Language Families	38	38	38	30	30	30

Notes: This table explores the relative contributions of agricultural productivity in the contemporary homeland vs. the Urheimat to the presence of sex-based grammatical gender in a daughter language. Heteroskedasticity robust standard error estimates clustered at the language family level are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

## B.2 Alternative Measure for Sex-Based Grammatical Gender (Intensive Measure)

Table B8: Geographic Origins of Intensity of Sex-Based Grammatical Gender System (OLS)

	Intensity of Sex-Based Grammatical Gender System					
	(1)	(2)	(3)	(4)	(5)	(6)
Plow Negative Crops (Average Caloric Yield, pre-1500)	-0.25*** (0.09)	-0.32*** (0.10)	-0.40*** (0.11)	-0.39*** (0.11)	-0.47*** (0.12)	-0.36** (0.14)
All Crops (Average Caloric Yield, pre-1500)	0.26** (0.10)	0.32*** (0.11)	0.41*** (0.12)	0.39*** (0.12)	0.47*** (0.14)	0.40*** (0.14)
Absolute Latitude		-0.04 (0.04)	-0.21*** (0.07)	0.15 (0.16)	0.14 (0.16)	0.04 (0.15)
Elevation		0.06 (0.08)	-0.10 (0.09)	-0.02 (0.08)	-0.03 (0.08)	-0.07 (0.08)
Ruggedness		-0.14* (0.07)	-0.01 (0.07)	-0.04 (0.09)	-0.03 (0.08)	-0.00 (0.08)
Coast Length		0.03 (0.05)	0.03 (0.05)	0.03 (0.06)	0.02 (0.06)	0.04 (0.06)
Precipitation (mm/month)			-0.29** (0.11)	-0.25** (0.11)	-0.28** (0.11)	-0.20* (0.10)
Precipitation (mm/month) (std)			0.03 (0.04)	-0.01 (0.08)	-0.00 (0.08)	0.01 (0.08)
Precipitation Volatility			0.07 (0.11)	0.03 (0.13)	0.06 (0.12)	0.08 (0.12)
Precipitation Spatial Correlation			0.09** (0.05)	-0.09 (0.43)	-0.02 (0.45)	0.08 (0.47)
Temperature (Daily Mean)				0.22* (0.12)	0.20 (0.14)	0.08 (0.13)
Temperature (Daily Mean) (std)				0.03 (0.08)	0.02 (0.08)	-0.02 (0.08)
Temperature Volatility				-0.20 (0.14)	-0.17 (0.14)	-0.13 (0.14)
Temperature Spatial Correlation				0.17 (0.43)	0.13 (0.44)	0.00 (0.46)
Unproductive Period (pre-1500CE)					-0.14** (0.07)	-0.07 (0.06)
Regional FE	No	No	No	No	No	Yes
Adjusted- $R^2$	0.03	0.03	0.06	0.07	0.09	0.17
Observations	181	181	181	181	181	181

Notes: This table establishes the statistically and economically significant association between the historical agricultural determinants of plow usage and the existence of sex-based grammatical gender in the language spoken in this region, accounting for regional fixed-effects and other geographical characteristics. All columns have the same specification and controls as Table 5. Geographical controls include absolute latitude, mean elevation, terrain ruggedness, and coast length, as well as other agriculture-related controls as precipitation and temperature means and standard deviations. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the impact of a one standard deviation in the independent variable on the probability of having a future tense in the language. Heteroskedasticity robust standard error estimates are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table B9: Geographic Origins of Intensity of Sex-Based Grammatical Gender System

	Intensity of Sex-Based Grammatical Gender System					
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: OLS - Spatial-Autocorrelation, Clustering and Selection On Unobservables						
Plow Negative Crops (Average Caloric Yield, pre-1500)	-0.25*** (0.09) ([0.11]) [0.10] {0.10}	-0.32*** (0.10) ([0.12]) [0.10] {0.11}	-0.40*** (0.11) ([0.14]) [0.11] {0.12}	-0.39*** (0.11) ([0.13]) [0.11] {0.12}	-0.47*** (0.12) ([0.15]) [0.12] {0.12}	-0.36** (0.14) ([0.14]) [0.12] {0.15}
Altonji et al						-3.22
$\delta$						-1.95
$\beta$ -Oster						-0.40
All Crops (Average Caloric Yield, pre-1500)	0.26** (0.10) ([0.12]) [0.11] {0.10}	0.32*** (0.11) ([0.13]) [0.11] {0.11}	0.41*** (0.12) ([0.14]) [0.12] {0.11}	0.39*** (0.12) ([0.14]) [0.11] {0.11}	0.47*** (0.14) ([0.15]) [0.12] {0.12}	0.40*** (0.14) ([0.14]) [0.12] {0.14}
Altonji et al						-2.85
$\delta$						-1.36
$\beta$ -Oster						0.45
$R^2$	0.04	0.06	0.12	0.14	0.16	0.26
Observations	181	181	181	181	181	181

Notes: This table establishes the statistically and economically significant association between the historical agricultural determinants of plow usage and the existence of sex-based grammatical gender in the language spoken in this region, accounting for regional fixed-effects and other geographical characteristics. All columns have the same specification and controls as Table A2. Geographical controls include absolute latitude, mean elevation, terrain ruggedness, and coast length, as well as other agriculture-related controls as precipitation and temperature means and standard deviations. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the impact of a one standard deviation in the independent variable on the probability of having a future tense in the language. Heteroskedasticity robust standard error estimates are reported in parentheses, clustered at the language genus in parenthesis and squared brackets, spatial auto-correlation corrected standard errors (Conley, 1999) in squared brackets and Cliff-Ord ML in curly brackets; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.



Table B10: Geographical Origins of Gender and Language Structures

	Language Structure						
	Temporal Structures			Non-Temporal Structures			
	Gender	Past	Perfect	Possessive	Evidentiality	Consonants	Colors
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Plow Negative Crops	-0.36**	-0.33***	-0.09	0.01	-0.05	-0.09	-0.83
(Average Caloric Yield, pre-1500)	(0.14)	(0.11)	(0.09)	(0.10)	(0.07)	(0.14)	(0.83)
Average Caloric Yield	0.39***	0.24***	0.07	-0.06	0.02	0.07	0.76
(All Crops, pre-1500)	(0.14)	(0.08)	(0.08)	(0.08)	(0.06)	(0.12)	(0.82)
All Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Regional FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted- $R^2$	0.17	0.12	0.14	0.14	0.20	0.31	-0.03
Observations	181	218	218	223	386	538	116

Notes: This table establishes the statistically and economically significant association between the historical agricultural determinants of plow usage and the intensity of grammatical gender in a language, and compares their impact on other language structures. The analysis accounts for regional fixed-effects and other geographical characteristics as in previous tables. Other language structures include the existence a past tense, a perfect tense, the existence of obligatory possessive inflections, semantic distinctions of evidentiality, the number of consonants, the ratio of consonants to vowels and the number of colors. Heteroskedasticity robust standard error estimates are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table B11: Persistent Impact of Geographical Characteristics on Intensity of Sex-Based Grammatical Gender System  
Linguistic Homeland vs. Urheimat  
(Languages Outside Urheimat)

	Existence of Sex-Based Gender System					
	Migratory Distance to Urheimat					
	Any Distance			At Least 1 Week		
	Homeland	Urheimat	Both	Homeland	Urheimat	Both
	(1)	(2)	(3)	(4)	(5)	(6)
Homeland Plow Negative Crops (Avg. Caloric Yield, pre-1500)	-0.32*		-0.11	-0.31		-0.39
	(0.18)		(0.16)	(0.23)		(0.26)
Homeland All Crops (Average Caloric Yield, pre-1500)	0.34*		0.20	0.30		0.22
	(0.20)		(0.16)	(0.23)		(0.19)
Urheimat Plow Negative Crops (Avg. Caloric Yield, pre-1500)		-0.46*	-0.46**		-0.61	-0.42
		(0.25)	(0.22)		(0.41)	(0.39)
Urheimat All Crops (Average Caloric Yield, pre-1500)		0.53**	0.56***		0.73*	0.60
		(0.21)	(0.20)		(0.39)	(0.42)
Regional FE	Yes	Yes	Yes	Yes	Yes	Yes
Homeland Geographical Characteristics	Yes	No	Yes	Yes	No	Yes
Urheimat Geographical Characteristics	No	Yes	Yes	No	Yes	Yes
Adjusted- $R^2$	0.15	0.35	0.32	0.11	0.42	0.42
Observations	129	129	129	109	109	109
Language Families	37	37	37	30	30	30

Notes: This table explores the relative contributions of agricultural productivity in the contemporary homeland vs. the Urheimat to the presence of sex-based grammatical gender in a daughter language. Heteroskedasticity robust standard error estimates clustered at the language family level are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table B12: Geographic Origins of Usage of the Plow and Intensive Sex-Based Grammatical Genders

	Mechanism			
	Plow		Grammatical Gender	
	(1)	(2)	(3)	(4)
Plow Negative Crops (Average Caloric Yield, pre-1500)	-0.26*** (0.02)	-0.06** (0.02)		
All Crops (Average Caloric Yield, pre-1500)	0.26*** (0.02)	0.09*** (0.02)		
Aboriginal Plow			0.65*** (0.20)	0.56** (0.27)
All Geographic Controls	No	Yes	No	Yes
Regional FE	No	Yes	No	Yes
Adjusted- $R^2$	0.19	0.47	0.09	0.21
Observations	1175	1175	133	133

Notes: This table establishes the statistically and economically significant association between the historical agricultural determinants of plow usage and the existence of sex-based grammatical gender in a language. The first two columns provide the association between the geographical determinants of plow suitability and actual usage of the plow, and columns (3) and (4) provide evidence on the association between actual usage of the plow and the emergence of sex-based grammatical gender. Heteroskedasticity robust standard error estimates are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

### B.3 Origins of Gender Distinctions in Pronouns

Table B13: Geographic Origins of Gender Distinctions in Pronouns (OLS)

	Existence of Gender Distinctions in Pronouns					
	(1)	(2)	(3)	(4)	(5)	(6)
Plow Negative Crops (Average Caloric Yield, pre-1500)	-0.08*	-0.12**	-0.13***	-0.15***	-0.17***	-0.18***
	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)	(0.06)
All Crops (Average Caloric Yield, pre-1500)	0.10**	0.14***	0.15***	0.18***	0.19***	0.21***
	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)	(0.06)
Absolute Latitude		-0.04	-0.08**	0.06	0.05	0.01
		(0.03)	(0.03)	(0.07)	(0.07)	(0.08)
Elevation		0.03	-0.03	-0.01	-0.02	-0.03
		(0.03)	(0.03)	(0.04)	(0.04)	(0.04)
Ruggedness		-0.11***	-0.05	-0.07*	-0.07*	-0.06*
		(0.03)	(0.03)	(0.04)	(0.04)	(0.04)
Coast Length		0.07***	0.07***	0.07***	0.07***	0.08***
		(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Precipitation (mm/month)			0.02	-0.01	-0.02	0.01
			(0.05)	(0.06)	(0.06)	(0.06)
Precipitation (mm/month) (std)			-0.00	0.02	0.02	0.01
			(0.03)	(0.04)	(0.04)	(0.04)
Precipitation Volatility			-0.09*	-0.09*	-0.09	-0.08
			(0.05)	(0.05)	(0.05)	(0.05)
Precipitation Spatial Correlation			0.04	0.24	0.26	0.34
			(0.03)	(0.23)	(0.23)	(0.25)
Temperature (Daily Mean)				0.01	0.01	-0.03
				(0.06)	(0.06)	(0.06)
Temperature (Daily Mean) (std)				-0.04	-0.04	-0.04
				(0.04)	(0.04)	(0.04)
Temperature Volatility				-0.16***	-0.16**	-0.19***
				(0.06)	(0.06)	(0.06)
Temperature Spatial Correlation				-0.19	-0.20	-0.29
				(0.23)	(0.23)	(0.25)
Unproductive Period (pre-1500CE)					-0.03	-0.02
					(0.03)	(0.03)
Regional FE	No	No	No	No	No	Yes
Adjusted- $R^2$	0.01	0.06	0.08	0.10	0.10	0.13
Observations	354	354	354	354	354	354

Notes: This table establishes the statistically and economically significant association between the historical agricultural determinants of plow usage and the existence of gender distinctions in independent personal pronouns in the language spoken in this region, accounting for regional fixed-effects and other geographical characteristics. All columns have the same specification and controls as Table 5. Geographical controls include absolute latitude, mean elevation, terrain ruggedness, and coast length, as well as other agriculture-related controls as precipitation and temperature means and standard deviations. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the impact of a one standard deviation in the independent variable on the probability of having a future tense in the language. Heteroskedasticity robust standard error estimates are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table B14: Geographic Origins of Gender Distinctions in Pronouns (Probit)

	Existence of Gender Distinctions in Pronouns					
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Probit						
Plow Negative Crops (Average Caloric Yield, pre-1500)	-0.06 (0.04)	-0.10** (0.05)	-0.11** (0.05)	-0.13*** (0.05)	-0.14*** (0.05)	-0.16** (0.06)
All Crops (Average Caloric Yield, pre-1500)	0.09** (0.04)	0.12*** (0.05)	0.14*** (0.05)	0.16*** (0.05)	0.17*** (0.05)	0.19*** (0.06)
Geographical Controls	No	Yes	Yes	Yes	Yes	Yes
Regional FE	No	No	No	No	No	Yes
Pseudo- $R^2$	0.01	0.07	0.09	0.11	0.11	0.15
Observations	350	350	350	350	350	350
Panel B: OLS - Spatial-Autocorrelation, Clustering and Selection On Unobservables						
Plow Negative Crops (Average Caloric Yield, pre-1500)	-0.08* (0.04) ([0.05]) [0.05] {0.04}	-0.12** (0.05) ([0.06]) [0.05] {0.05}	-0.13*** (0.05) ([0.05]) [0.05] {0.05}	-0.15*** (0.05) ([0.05]) [0.05] {0.05}	-0.17*** (0.05) ([0.05]) [0.05] {0.05}	-0.18*** (0.06) ([0.07]) [0.06] {0.07}
Altonji et al						-1.77
$\delta$						-1.12
$\beta$ -Oster						-0.21
All Crops (Average Caloric Yield, pre-1500)	0.10** (0.04) ([0.05]) [0.05] {0.04}	0.14*** (0.05) ([0.06]) [0.05] {0.05}	0.15*** (0.05) ([0.05]) [0.05] {0.05}	0.18*** (0.05) ([0.05]) [0.04] {0.05}	0.19*** (0.05) ([0.05]) [0.05] {0.05}	0.21*** (0.06) ([0.06]) [0.06] {0.06}
Altonji et al						-1.89
$\delta$						-0.90
$\beta$ -Oster						0.24
$R^2$	0.01	0.08	0.11	0.13	0.14	0.18

Notes: This table establishes the statistically and economically significant association between the historical agricultural determinants of plow usage and the existence of gender distinctions in pronouns in the language spoken in this region, accounting for regional fixed-effects and other geographical characteristics. All columns have the same specification and controls as Table A2. Geographical controls include absolute latitude, mean elevation, terrain ruggedness, and coast length, as well as other agriculture-related controls as precipitation and temperature means and standard deviations. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the impact of a one standard deviation in the independent variable on the probability of having a future tense in the language. Heteroskedasticity robust standard error estimates are reported in parentheses, clustered at the language genus in parenthesis and squared brackets, spatial auto-correlation corrected standard errors (Conley, 1999) in squared brackets and Cliff-Ord ML in curly brackets; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table B15: Geographical Origins of Gender and Language Structures

	Language Structure						
	Temporal Structures			Non-Temporal Structures			
	Gender	Past	Perfect	Possessive	Evidentiality	Consonants	Colors
(1)	(2)	(3)	(4)	(5)	(6)	(7)	
Plow Negative Crops (Average Caloric Yield, pre-1500)	-0.18*** (0.07)	-0.33*** (0.11)	-0.09 (0.09)	0.01 (0.10)	-0.05 (0.07)	-0.09 (0.14)	-0.83 (0.83)
Average Caloric Yield (All Crops, pre-1500)	0.21*** (0.06)	0.24*** (0.08)	0.07 (0.08)	-0.06 (0.08)	0.02 (0.06)	0.07 (0.12)	0.76 (0.82)
All Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Regional FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted- $R^2$	0.13	0.12	0.14	0.14	0.20	0.31	-0.03
Observations	355	218	218	223	386	538	116

Notes: This table establishes the statistically and economically significant association between the historical agricultural determinants of plow usage and the existence of gender distinctions in pronouns in a language, and compares their impact on other language structures. The analysis accounts for regional fixed-effects and other geographical characteristics as in previous tables. Other language structures include the existence a past tense, a perfect tense, the existence of obligatory possessive inflections, semantic distinctions of evidentiality, the number of consonants, the ratio of consonants to vowels and the number of colors. Heteroskedasticity robust standard error estimates are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table B16: Persistent Impact of Geographical Characteristics on Gender Distinctions in Pronouns  
Linguistic Homeland vs. Urheimat  
(Languages Outside Urheimat)

	Existence of Gender Distinctions in Independent Personal Pronouns					
	Migratory Distance to Urheimat					
	Any Distance			At Least 1 Week		
	Homeland	Urheimat	Both	Homeland	Urheimat	Both
	(1)	(2)	(3)	(4)	(5)	(6)
Homeland Plow Negative Crops (Avg. Caloric Yield, pre-1500)	-0.14*		-0.06	-0.11		-0.07
	(0.08)		(0.07)	(0.10)		(0.08)
Homeland All Crops (Average Caloric Yield, pre-1500)	0.16**		0.11**	0.12		0.08
	(0.07)		(0.05)	(0.09)		(0.07)
Urheimat Plow Negative Crops (Avg. Caloric Yield, pre-1500)		-0.31***	-0.32***		-0.21**	-0.20**
		(0.08)	(0.09)		(0.08)	(0.08)
Urheimat All Crops (Average Caloric Yield, pre-1500)		0.33***	0.33***		0.23***	0.22***
		(0.07)	(0.07)		(0.08)	(0.07)
Regional FE	Yes	Yes	Yes	Yes	Yes	Yes
Homeland Geographical Characteristics	Yes	No	Yes	Yes	No	Yes
Urheimat Geographical Characteristics	No	Yes	Yes	No	Yes	Yes
Adjusted- $R^2$	0.17	0.30	0.34	0.17	0.34	0.37
Observations	245	245	245	207	207	207
Language Families	51	51	51	36	36	36

Notes: This table explores the relative contributions of agricultural productivity in the contemporary homeland vs. the Urheimat to the presence of sex-based grammatical gender in a daughter language. Heteroskedasticity robust standard error estimates clustered at the language family level are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table B17: Geographic Origins of Usage of the Plow and Gender Distinctions in Pronouns

	Mechanism			
	Plow		Grammatical Gender	
	(1)	(2)	(3)	(4)
Plow Negative Crops (Average Caloric Yield, pre-1500)	-0.26*** (0.02)	-0.06** (0.02)		
All Crops (Average Caloric Yield, pre-1500)	0.26*** (0.02)	0.09*** (0.02)		
Aboriginal Plow			0.24*** (0.08)	0.22** (0.11)
All Geographic Controls	No	Yes	No	Yes
Regional FE	No	Yes	No	Yes
Adjusted- $R^2$	0.19	0.47	0.04	0.10
Observations	1175	1175	220	220

Notes: This table establishes the statistically and economically significant association between the historical agricultural determinants of plow usage and the existence of gender distinctions in independent personal pronouns in a language. The first two columns provide the association between the geographical determinants of plow suitability and actual usage of the plow, and columns (3) and (4) provide evidence on the association between actual usage of the plow and the emergence of sex-based grammatical gender. Heteroskedasticity robust standard error estimates are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.



## C Origins of Politeness Distinctions

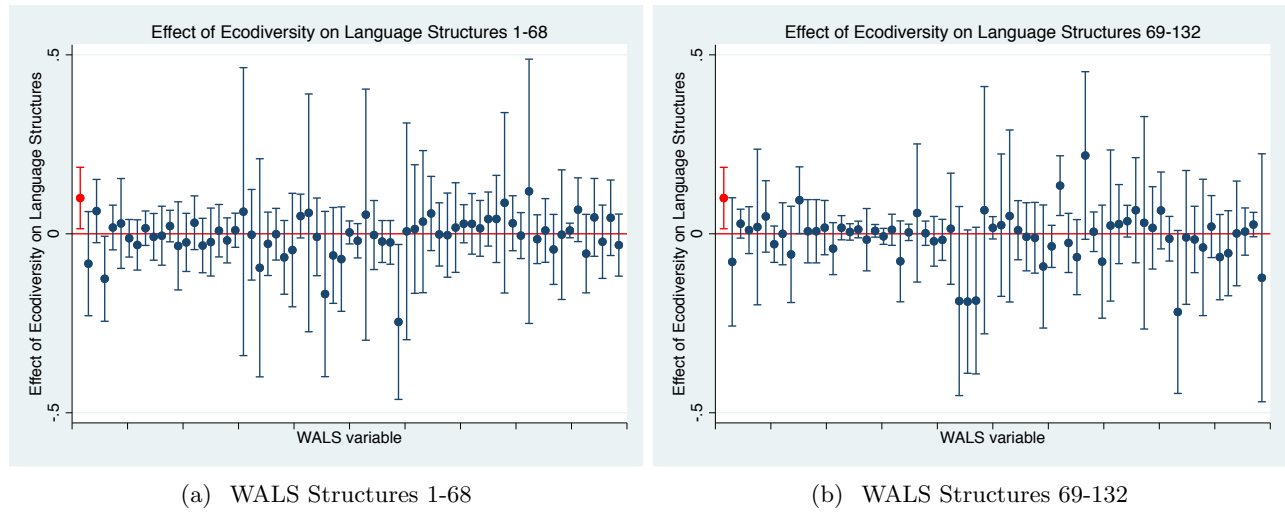


Figure C1: Orthogonality of Ecological Diversity and Other Language Structures (WALS)  
(Impact of Ecological Diversity on Politeness Distinctions in Red)

Table C1: Geographic Origins of Politeness Distinctions (OLS)

	Existence of Politeness Distinctions					
	(1)	(2)	(3)	(4)	(5)	(6)
Ecological Diversity	0.15*** (0.03)	0.10*** (0.04)	0.10*** (0.04)	0.10** (0.04)	0.10** (0.04)	0.10** (0.04)
Average Caloric Yield (All Crops, pre-1500)		0.11*** (0.03)	0.10*** (0.03)	0.11*** (0.03)	0.11*** (0.03)	0.12*** (0.03)
Absolute Latitude		0.07** (0.03)	0.09** (0.04)	0.23** (0.11)	0.24** (0.11)	0.07 (0.11)
Elevation		0.01 (0.05)	0.05 (0.05)	0.09* (0.05)	0.09* (0.05)	0.10** (0.05)
Ruggedness		-0.04 (0.04)	-0.06* (0.04)	-0.07* (0.04)	-0.06* (0.04)	-0.09** (0.04)
Coast Length		0.07* (0.04)	0.06 (0.04)	0.06 (0.05)	0.06 (0.05)	0.04 (0.05)
Precipitation (mm/month)			0.03 (0.06)	0.03 (0.06)	0.04 (0.06)	-0.02 (0.06)
Precipitation (mm/month) (std)			0.04 (0.04)	0.05 (0.07)	0.06 (0.07)	0.07 (0.07)
Precipitation Volatility			-0.06 (0.07)	-0.07 (0.07)	-0.08 (0.06)	-0.04 (0.07)
Precipitation Spatial Correlation			-0.08** (0.04)	0.31 (0.28)	0.31 (0.29)	0.35 (0.27)
Temperature (Daily Mean)				0.07 (0.08)	0.07 (0.08)	0.04 (0.07)
Temperature (Daily Mean) (std)				-0.01 (0.07)	-0.03 (0.07)	-0.07 (0.06)
Temperature Volatility				-0.09 (0.09)	-0.07 (0.08)	0.03 (0.08)
Temperature Spatial Correlation				-0.39 (0.29)	-0.39 (0.30)	-0.42 (0.28)
Unproductive Period (pre-1500CE)					-0.06* (0.04)	-0.07* (0.04)
Regional FE	No	No	No	No	No	Yes
Adjusted- $R^2$	0.09	0.18	0.20	0.20	0.21	0.32
Observations	198	198	198	198	198	198

Notes: This table establishes the positive, statistically, and economically significant association between ecological diversity and the existence of politeness distinctions in the language spoken in this region, accounting for regional fixed-effects and other geographical characteristics. All columns have the same specification and controls as Table A1. Geographical controls include absolute latitude, mean elevation, terrain ruggedness, and coast length, as well as other agriculture-related controls as precipitation and temperature means and standard deviations. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the impact of a one standard deviation in the independent variable on the probability of having a future tense in the language. Heteroskedasticity robust standard error estimates are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table C2: Geographic Origins of Politeness Distinctions

	Existence of Politeness Distinctions					
	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A: Probit					
Ecological Diversity	0.14*** (0.03)	0.09*** (0.03)	0.09*** (0.03)	0.10*** (0.03)	0.10*** (0.03)	0.10*** (0.03)
Geographical Controls	No	Yes	Yes	Yes	Yes	Yes
Regional FE	No	No	No	No	No	Yes
Pseudo- $R^2$	0.07	0.21	0.23	0.24	0.25	0.36
Observations	180	180	180	180	180	180
	Panel B: OLS - Spatial-Autocorrelation, Clustering and Selection On Unobservables					
Ecological Diversity	0.15*** (0.03) ([0.04]) [0.03] {0.03}	0.10*** (0.04) ([0.04]) [0.04] {0.03}	0.10*** (0.04) ([0.04]) [0.04] {0.03}	0.10** (0.04) ([0.04]) [0.04] {0.03}	0.10** (0.04) ([0.04]) [0.04] {0.03}	0.10** (0.04) ([0.03]) [0.04] {0.03}
Altonji et al $\delta$						3.10 5.02
$\beta$ -Oster $R^2$	0.10	0.21	0.24	0.26	0.27	0.08 0.39

Notes: This table establishes the positive, statistically, and economically significant association between ecological diversity and the existence of politeness distinctions in the language spoken in this region, accounting for regional fixed-effects and other geographical characteristics. All columns have the same specification and controls as Table 1. Geographical controls include absolute latitude, mean elevation, terrain ruggedness, and coast length, as well as other agriculture-related controls as precipitation and temperature means and standard deviations. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the impact of a one standard deviation in the independent variable on the probability of having a future tense in the language. Heteroskedasticity robust standard error estimates are reported in parentheses, clustered at the language genus in parenthesis and squared brackets, spatial auto-correlation corrected standard errors (Conley, 1999) in squared brackets and Cliff-Ord ML in curly brackets; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table C3: Geographical Origins of Politeness and Language Structures

	Language Structure						
	Politeness	Temporal Structures		Non-Temporal Structures			
		Past	Perfect	Possessive	Evidentiality	Consonants	Colors
(1)	(2)	(3)	(4)	(5)	(6)	(7)	
Ecological Diversity	0.10** (0.04)	0.04 (0.04)	0.05 (0.04)	-0.03 (0.04)	0.01 (0.03)	-0.10* (0.05)	-0.49 (0.37)
All Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Regional FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted- $R^2$	0.32	0.07	0.14	0.14	0.20	0.31	-0.02
Observations	198	218	218	224	387	542	117

Notes: This table establishes the positive, statistically, and economically significant association between ecological diversity and the existence of politeness distinctions in a language, and compares their impact on other language structures. The analysis accounts for regional fixed-effects and other geographical characteristics as in previous tables. Other language structures include the existence a past tense, a perfect tense, the existence of obligatory possessive inflections, semantic distinctions of evidentiality, the number of consonants, the ratio of consonants to vowels and the number of colors. Heteroskedasticity robust standard error estimates are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

## C.1 Alternative Measure of Politeness Distinctions (Extensive Margin)

Table C4: Geographic Origins of Politeness Distinctions (Alternative measure - OLS)

	Existence of politeness Distinctions (Alt. Measure)					
	(1)	(2)	(3)	(4)	(5)	(6)
Ecological Diversity	0.08*** (0.03)	0.09*** (0.03)	0.07** (0.03)	0.09*** (0.03)	0.09*** (0.03)	0.08*** (0.03)
Average Caloric Yield (All Crops, pre-1500)		0.03 (0.02)	0.04 (0.02)	0.04 (0.02)	0.03 (0.02)	0.06** (0.03)
Absolute Latitude		-0.03 (0.02)	-0.04 (0.03)	-0.05 (0.06)	-0.05 (0.06)	-0.10 (0.07)
Elevation		-0.06** (0.02)	-0.08*** (0.03)	-0.07* (0.04)	-0.07* (0.04)	-0.06* (0.03)
Ruggedness		0.01 (0.02)	0.02 (0.02)	0.03 (0.02)	0.04 (0.02)	-0.00 (0.03)
Coast Length		0.01 (0.03)	0.01 (0.03)	0.01 (0.03)	0.02 (0.03)	0.02 (0.03)
Precipitation (mm/month)			-0.04 (0.03)	-0.05 (0.05)	-0.05 (0.04)	-0.07 (0.04)
Precipitation (mm/month) (std)			0.06* (0.03)	0.12** (0.05)	0.12** (0.06)	0.12** (0.05)
Precipitation Volatility			0.01 (0.04)	-0.00 (0.04)	-0.01 (0.04)	-0.01 (0.04)
Precipitation Spatial Correlation			0.02 (0.02)	0.05 (0.19)	0.05 (0.19)	0.00 (0.19)
Temperature (Daily Mean)				-0.03 (0.07)	-0.03 (0.06)	-0.06 (0.06)
Temperature (Daily Mean) (std)				-0.08 (0.05)	-0.09* (0.05)	-0.11** (0.05)
Temperature Volatility				-0.01 (0.05)	0.00 (0.05)	0.06 (0.05)
Temperature Spatial Correlation				-0.03 (0.19)	-0.04 (0.19)	0.01 (0.19)
Unproductive Period (pre-1500CE)					-0.03* (0.02)	-0.04* (0.02)
Regional FE	No	No	No	No	No	Yes
Adjusted- $R^2$	0.06	0.09	0.09	0.09	0.10	0.25
Observations	198	198	198	198	198	198

Notes: This table establishes the positive, statistically, and economically significant association between ecological diversity and the existence of politeness distinctions in the language spoken in this region, accounting for regional fixed-effects and other geographical characteristics. All columns have the same specification and controls as Table A1. Geographical controls include absolute latitude, mean elevation, terrain ruggedness, and coast length, as well as other agriculture-related controls as precipitation and temperature means and standard deviations. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the impact of a one standard deviation in the independent variable on the probability of having a future tense in the language. Heteroskedasticity robust standard error estimates are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table C5: Geographic Origins of Politeness Distinctions (Alternative measure - Probit)

	Existence of Politeness Distinctions (Alternative Measure)					
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Probit						
Ecological Diversity	0.09*** (0.02)	0.11*** (0.03)	0.08*** (0.02)	0.08*** (0.02)	0.08*** (0.02)	0.07*** (0.02)
Geographical Controls	No	Yes	Yes	Yes	Yes	Yes
Regional FE	No	No	No	No	No	Yes
Pseudo- $R^2$	0.09	0.21	0.26	0.27	0.29	0.51
Observations	140	140	140	140	140	140
Panel B: OLS - Spatial-Autocorrelation, Clustering and Selection On Unobservables						
Ecological Diversity	0.08*** (0.03) ([0.04]) [0.03] {0.02}	0.09*** (0.03) ([0.05]) [0.04] {0.02}	0.07** (0.03) ([0.04]) [0.04] {0.02}	0.09*** (0.03) ([0.05]) [0.04] {0.02}	0.09*** (0.03) ([0.05]) [0.04] {0.02}	0.08*** (0.03) ([0.03]) [0.03] {0.02}
Altonji et al $\delta$						-7.30 -12.31
$\beta$ -Oster $R^2$						0.09 0.33
Observations	198	198	198	198	198	198

Notes: This table establishes the positive, statistically, and economically significant association between ecological diversity and the existence of politeness distinctions in the language spoken in this region, accounting for regional fixed-effects and other geographical characteristics. All columns have the same specification and controls as Table 1. Geographical controls include absolute latitude, mean elevation, terrain ruggedness, and coast length, as well as other agriculture-related controls as precipitation and temperature means and standard deviations. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the impact of a one standard deviation in the independent variable on the probability of having a future tense in the language. Heteroskedasticity robust standard error estimates are reported in parentheses, clustered at the language genus in parenthesis and squared brackets, spatial auto-correlation corrected standard errors (Conley, 1999) in squared brackets and Cliff-Ord ML in curly brackets; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table C6: Geographical Origins of Politeness and Language Structures

	Language Structure							
	Politeness	Temporal Structures			Non-Temporal Structures			
		Past	Perfect	Possessive	Evidentiality	Consonants	Colors	
		(1)	(2)		(3)	(4)	(5)	(6)
Ecological Diversity	0.09*** (0.03)	0.04 (0.04)	0.05 (0.04)	-0.04 (0.04)	0.01 (0.03)	-0.08 (0.05)	-0.49 (0.38)	
All Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Regional FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Adjusted- $R^2$	0.25	0.07	0.14	0.15	0.20	0.31	-0.02	
Observations	198	218	218	223	386	538	116	

Notes: This table establishes the positive, statistically, and economically significant association between ecological diversity and the existence of strong politeness distinctions in a language, and compares their impact on other language structures. The analysis accounts for regional fixed-effects and other geographical characteristics as in previous tables. Other language structures include the existence a past tense, a perfect tense, the existence of obligatory possessive inflections, semantic distinctions of evidentiality, the number of consonants, the ratio of consonants to vowels and the number of colors. Heteroskedasticity robust standard error estimates are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table C7: Persistent Impact of Geographical Characteristics on Politeness (Alternative Measure)  
Linguistic Homeland vs. Urheimat  
(Languages Outside Urheimat)

	Existence of Politeness Distinctions					
	Migratory Distance to Urheimat					
	Any Distance			At Least 1 Week		
	Homeland	Urheimat	Both	Homeland	Urheimat	Both
	(1)	(2)	(3)	(4)	(5)	(6)
Homeland Ecological Diversity	0.11** (0.04)		0.11*** (0.04)	0.10** (0.04)		0.08** (0.03)
Urheimat Ecological Diversity		-0.01 (0.04)	-0.06* (0.03)		0.05 (0.05)	-0.01 (0.04)
Regional FE		Yes	Yes	Yes	Yes	Yes
Homeland Geographical Characteristics	Yes	No	Yes	Yes	No	Yes
Urheimat Geographical Characteristics	No	Yes	Yes	No	Yes	Yes
Adjusted- $R^2$	0.29	0.13	0.33	0.34	0.23	0.41
Observations		146	146	126	126	126
Language Families		36	36	28	28	28

Notes: This table explores the relative contributions of ecological diversity in the contemporary homeland vs. the Urheimat to the presence of politeness distinctions in a daughter language. Heteroskedasticity robust standard error estimates clustered at the language family level are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table C8: Geographic Origins of Jurisdictional Hierarchy and Politeness Distinctions

	Mechanism			
	Jurisdictional Hierarchy		Politeness	
	(1)	(2)	(3)	(4)
Ecological Diversity	0.23*** (0.04)	0.12*** (0.03)		
Average Caloric Yield (All Crops, pre-1500)	0.17*** (0.03)	0.23*** (0.03)		
Jurisdictional Hierarchy Beyond Local Community			0.11*** (0.02)	0.10*** (0.02)
All Geographic Controls	No	Yes	No	Yes
Regional FE	No	Yes	No	Yes
Adjusted- $R^2$	0.07	0.32	0.18	0.41
Observations	1154	1154	139	139

Notes: This table establishes the positive statistically and economically significant association between the geographical determinants of statehood, as measured by jurisdictional hierarchy beyond the local level, and politeness distinctions in a language. The first two columns provide the evidence on the association between ecological diversity and statehood, and columns (3) and (4) show the association between statehood and the emergence of politeness distinctions. The table shows the estimated coefficients in an OLS regression as the dependent variable in columns (1) and (2) is not binary. Heteroskedasticity robust standard error estimates are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table C9: Hierarchy and Politeness (Alternate Measure)

	Hierarchy Index			
	All		Old World	
	(1)	(2)	(3)	(4)
Politeness Distinctions	0.31*** (0.07)	0.37*** (0.11)	0.36*** (0.09)	0.43*** (0.12)
Ecological Diversity		0.18* (0.10)		0.08 (0.08)
Regional FE	Yes	Yes	Yes	Yes
Main Geographical Controls	No	Yes	No	Yes
Adjusted- $R^2$	0.42	0.49	0.42	0.57
Observations	53	53	50	50

Notes: This table establishes the statistically and economically positive association between of politeness distinctions and preferences for hierarchy in society. The analysis accounts for the geographical origins of politeness distinctions and other geographical characteristics of the contemporary homeland of the language. Heteroskedasticity robust standard error estimates clustered at the language family level are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

## C.2 Alternative Measure of Politeness Distinctions (Intensive Margin)

Table C10: Geographic Origins of Politeness Distinctions (Intensive measure - OLS)

	Intensity of Politeness Distinctions					
	(1)	(2)	(3)	(4)	(5)	(6)
Ecological Diversity	0.26*** (0.06)	0.21*** (0.07)	0.20*** (0.07)	0.21*** (0.08)	0.21*** (0.08)	0.22*** (0.07)
Average Caloric Yield (All Crops, pre-1500)		0.14*** (0.05)	0.14*** (0.05)	0.14*** (0.05)	0.14*** (0.05)	0.19*** (0.06)
Absolute Latitude		0.02 (0.05)	0.02 (0.06)	0.16 (0.16)	0.17 (0.15)	-0.01 (0.15)
Elevation		-0.08 (0.07)	-0.06 (0.07)	-0.02 (0.09)	-0.01 (0.08)	0.01 (0.08)
Ruggedness		-0.01 (0.05)	-0.02 (0.06)	-0.01 (0.06)	-0.00 (0.06)	-0.06 (0.06)
Coast Length		0.12 (0.09)	0.11 (0.09)	0.12 (0.10)	0.12 (0.10)	0.10 (0.09)
Precipitation (mm/month)			-0.01 (0.08)	-0.02 (0.10)	-0.01 (0.09)	-0.10 (0.10)
Precipitation (mm/month) (std)			0.12 (0.08)	0.22 (0.14)	0.23 (0.14)	0.26** (0.13)
Precipitation Volatility			-0.06 (0.09)	-0.10 (0.10)	-0.10 (0.09)	-0.06 (0.10)
Precipitation Spatial Correlation			-0.03 (0.06)	0.45 (0.44)	0.46 (0.45)	0.41 (0.45)
Temperature (Daily Mean)				0.05 (0.14)	0.04 (0.13)	-0.03 (0.13)
Temperature (Daily Mean) (std)				-0.13 (0.12)	-0.15 (0.12)	-0.23** (0.11)
Temperature Volatility				-0.10 (0.12)	-0.06 (0.12)	0.11 (0.12)
Temperature Spatial Correlation				-0.51 (0.45)	-0.52 (0.46)	-0.44 (0.46)
Unproductive Period (pre-1500CE)					-0.10** (0.05)	-0.12** (0.05)
Regional FE	No	No	No	No	No	Yes
Adjusted- $R^2$	0.11	0.17	0.17	0.17	0.18	0.32
Observations	198	198	198	198	198	198

Notes: This table establishes the positive, statistically, and economically significant association between ecological diversity and an intensive measure of politeness distinctions in the language spoken in this region, accounting for regional fixed-effects and other geographical characteristics. All columns have the same specification and controls as Table A1. Geographical controls include absolute latitude, mean elevation, terrain ruggedness, and coast length, as well as other agriculture-related controls as precipitation and temperature means and standard deviations. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the impact of a one standard deviation in the independent variable on the probability of having a future tense in the language. Heteroskedasticity robust standard error estimates are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.



Table C11: Geographical Origins of and Politeness Distinctions (Intensive Measure - OLS)  
Robustness to Spatial-Autocorrelation, Clustering and Selection

	Intensity of Politeness Distinctions					
	(1)	(2)	(3)	(4)	(5)	(6)
Ecological Diversity	0.26*** (0.06) ([0.07]) [0.07] {0.05}	0.21*** (0.07) ([0.09]) [0.09] {0.05}	0.20*** (0.07) ([0.09]) [0.09] {0.05}	0.21*** (0.08) ([0.09]) [0.09] {0.06}	0.21*** (0.08) ([0.09]) [0.09] {0.06}	0.22*** (0.07) ([0.07]) [0.08] {0.05}
Geographical Controls	No	Yes	Yes	Yes	Yes	Yes
Regional FE	No	No	No	No	No	Yes
Altonji et al						28.16
$\delta$						49.64
$\beta$ -Oster						0.22
$R^2$	0.11	0.19	0.21	0.23	0.25	0.39
Observations	198	198	198	198	198	198

Notes: This table establishes the positive, statistically, and economically significant association between ecological diversity and the existence of politeness distinctions in the language spoken in this region, accounting for regional fixed-effects and other geographical characteristics. All columns have the same specification and controls as Table 1. Geographical controls include absolute latitude, mean elevation, terrain ruggedness, and coast length, as well as other agriculture-related controls as precipitation and temperature means and standard deviations. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the impact of a one standard deviation in the independent variable on the probability of having a future tense in the language. Heteroskedasticity robust standard error estimates are reported in parentheses, clustered at the language genus in parenthesis and squared brackets, spatial auto-correlation corrected standard errors (Conley, 1999) in squared brackets and Cliff-Ord ML in curly brackets; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table C12: Geographical Origins of Politeness and Language Structures

	Language Structure						
	Politeness	Temporal Structures		Non-Temporal Structures			
		Past	Perfect	Possessive	Evidentiality	Consonants	Colors
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Ecological Diversity	0.23*** (0.07)	0.04 (0.04)	0.05 (0.04)	-0.04 (0.04)	0.01 (0.03)	-0.08 (0.05)	-0.49 (0.38)
All Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Regional FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted- $R^2$	0.32	0.07	0.14	0.15	0.20	0.31	-0.02
Observations	198	218	218	223	386	538	116

Notes: This table establishes the positive, statistically, and economically significant association between ecological diversity and the existence of politeness distinctions in a language, and compares their impact on other language structures. The analysis accounts for regional fixed-effects and other geographical characteristics as in previous tables. Other language structures include the existence a past tense, a perfect tense, the existence of obligatory possessive inflections, semantic distinctions of evidentiality, the number of consonants, the ratio of consonants to vowels and the number of colors. Heteroskedasticity robust standard error estimates are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table C13: Persistent Impact of Geographical Characteristics on Politeness (Intensive Measure)  
Linguistic Homeland vs. Urheimat  
(Languages Outside Urheimat)

	Intensity of Politeness Distinctions					
	Migratory Distance to Urheimat					
	Any Distance			At Least 1 Week		
	Homeland	Urheimat	Both	Homeland	Urheimat	Both
	(1)	(2)	(3)	(4)	(5)	(6)
Homeland Ecological Diversity	0.28*** (0.07)		0.27*** (0.06)	0.28*** (0.08)		0.26*** (0.07)
Urheimat Ecological Diversity		0.03 (0.08)	-0.07 (0.08)		0.17 (0.11)	-0.03 (0.09)
Regional FE	Yes	Yes	Yes	Yes	Yes	Yes
Homeland Geographical Characteristics	Yes	No	Yes	Yes	No	Yes
Urheimat Geographical Characteristics	No	Yes	Yes	No	Yes	Yes
Adjusted- $R^2$	0.40	0.34	0.52	0.39	0.39	0.57
Observations	146	146	146	126	126	126
Language Families	36	36	36	28	28	28

Notes: This table explores the relative contributions of ecological diversity in the contemporary homeland vs. the Urheimat to the presence of politeness distinctions in a daughter language. Heteroskedasticity robust standard error estimates clustered at the language family level are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table C14: Geographic Origins of Jurisdictional Hierarchy and Politeness Distinctions (Intensive Measure)

	Mechanism			
	Jurisdictional Hierarchy		Politeness	
	(1)	(2)	(3)	(4)
Ecological Diversity	0.23*** (0.04)	0.12*** (0.03)		
Average Caloric Yield (All Crops, pre-1500)	0.17*** (0.03)	0.23*** (0.03)		
Jurisdictional Hierarchy Beyond Local Community			0.38*** (0.05)	0.33*** (0.05)
All Geographic Controls	No	Yes	No	Yes
Regional FE	No	Yes	No	Yes
Adjusted- $R^2$	0.07	0.32	0.35	0.54
Observations	1154	1154	139	139

Notes: This table establishes the positive statistically and economically significant association between the geographical determinants of statehood, as measured by jurisdictional hierarchy beyond the local level, and politeness distinctions in a language. The first two columns provide the evidence on the association between ecological diversity and statehood, and columns (3) and (4) show the association between statehood and the emergence of politeness distinctions. The table shows the estimated coefficients in an OLS regression as the dependent variable in columns (1) and (2) is not binary. Heteroskedasticity robust standard error estimates are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

Table C15: Hierarchy and Politeness

	Hierarchy Index					
	All			Old World		
	(1)	(2)	(3)	(4)	(5)	(6)
Politeness Distinctions	0.48*** (0.15)	0.37** (0.14)	0.37** (0.16)	0.55*** (0.16)	0.56*** (0.16)	0.56*** (0.10)
Ecological Diversity			0.18* (0.09)			0.07 (0.09)
Regional FE	No	Yes	Yes	No	Yes	Yes
Main Geographical Controls	No	No	Yes	No	No	Yes
Adjusted- $R^2$	0.22	0.43	0.49	0.28	0.47	0.60
Observations	53	53	53	50	50	50

Notes: This table establishes the statistically and economically positive association between of politeness distinctions and preferences for hierarchy in society. The analysis accounts for the geographical origins of politeness distinctions and other geographical characteristics of the contemporary homeland of the language. Heteroskedasticity robust standard error estimates clustered at the language family level are reported in parentheses; \*\*\* denotes statistical significance at the 1% level, \*\* at the 5% level, and \* at the 10% level, all for two-sided hypothesis tests.

## D Variable Definitions, Sources and Summary Statistics

### D.1 Variable Definition and Sources

- **Absolute latitude:** The absolute value of the latitude of a homeland’s approximate geodesic centroid. Author’s computations.
- **Mean Elevation:** The mean elevation of a homeland in km above sea level, calculated using geospatial elevation data taken from GLOBE Task Team and others (1999). Author’s computations.
- **Terrain Ruggedness:** The mean change in elevation across cells in a homeland in km, calculated following the methodology of Riley et al. (1999), using geospatial elevation data taken from GLOBE Task Team and others (1999). Author’s computations.
- **Caloric Suitability:** Pre-1500CE Caloric suitability is the potential caloric output in a region as reported in Galor and Özak (2016).
- **Coast length:** Length, in thousands of km, of a country’s coastline. Author’s computations.
- **Ecological Diversity:** Herfindahl index of share’s of a country’s area in various ecologies. Author’s computations following the method of Fenske (2014) and Depetris-Chauvin and Özak (2016).
- **Volatility (temperature and precipitation):** Volatility of temperature and precipitation constructed using v3.2 of the Climatic Research Unit (CRU) database following the method of Durante (2010).
- **Diversification (temperature and precipitation):** Spatial Correlation of temperature and precipitation shocks constructed using v3.2 of the Climatic Research Unit (CRU) database following the method of Durante (2010).

### D.2 Summary Statistics

Table D1: Summary Statistics of the Existence of Periphrastic Future Tense by Region

Region	Observations	Mean	Std. Dev.
Sub-Saharan Africa	66	0.53	0.503
Middle East and North Africa	8	0.5	0.53
Europe and Central Asia	56	0.48	0.50
South Asia	21	0.19	0.40
East Asia and Pacific	71	0.55	0.50
North America	22	0.41	0.50
Latin America	31	0.55	0.50
Total	275	0.49	0.50

Table D2: Summary Statistics of the Existence of Sex-Based Grammatical Gender Systems by Region

Region	Observations	Mean	Std. Dev.
Sub-Saharan Africa	27	0.63	0.49
Middle East and North Africa	7	0.71	0.49
Europe and Central Asia	40	0.48	0.51
South Asia	16	0.63	0.50
East Asia and Pacific	70	0.27	0.45
North America	25	0.08	0.28
Latin America	32	0.28	0.46
Total	227	0.37	0.48

Table D3: Summary Statistics of the Existence of Politeness Distinctions by Region

Region	Observations	Mean	Std. Dev.
Sub-Saharan Africa	36	0.14	0.35
Middle East and North Africa	4	0.25	0.50
Europe and Central Asia	34	0.71	0.46
South Asia	19	0.63	0.50
East Asia and Pacific	59	0.32	0.47
North America	18	0.00	0.00
Latin America	28	0.18	0.39
Total	207	0.34	0.48

Table D4: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Absolute Latitude	0.096	1.025	-1.302	2.613	275
Elevation	0.027	1.026	-0.92	4.827	275
Ruggedness	-0.014	0.979	-0.877	6.162	275
Coast Length	0.024	1.154	-0.302	11.692	275
Precipitation	-0.078	0.928	-1.3	4.4	275
Precipitation (std)	-0.02	0.911	-0.667	8.314	275
Precipitation Volatility	-0.064	0.926	-1.531	4.665	275
Precipitation Spatial Correlation	0.064	0.939	-2.133	0.810	275
Temperature (Daily Mean)	-0.054	0.977	-2.996	1.176	275
Temperature (Daily Mean) (std)	-0.017	0.929	-0.877	4.876	275
Temperature Volatility	0.079	0.991	-1.641	3.504	275
Temperature Spatial Correlation	0.068	0.939	-2.161	0.683	275

Table D5: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Intensity of Agriculture	8.890	3.061	2	12	264

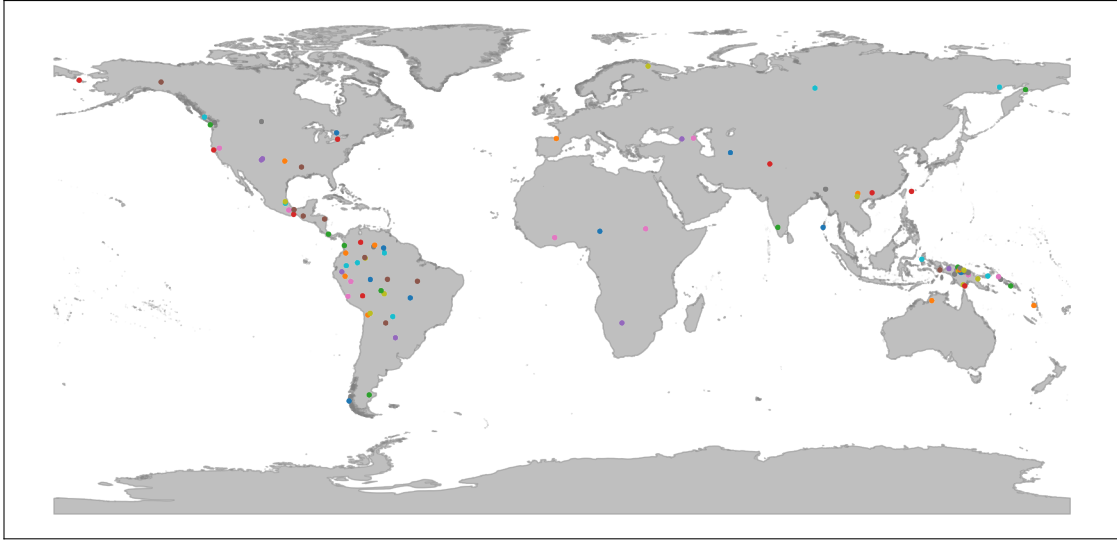


Figure E1: Location of Urheimats for 147 Language Families in Ethnologue

## E Identifying the Location of Urheimats of Language Families

The location of language’s Urheimat (i.e., the geographical region where the language family emerged) is identified based on the frontier methodology proposed by linguists (Wichmann et al., 2010), according to which the geographical area that maximized linguistic diversity within a language family corresponds to the Urheimat.<sup>52</sup>

In particular, using data on the linguistic diversity of 4169 languages from version 12 of the ASJP (Wichmann et al., 2009), Wichmann et al. (2010) identify the Urheimat of 82 language families based on the comparison of the level of linguistic diversity of each language within each language family. Following their methodology the analysis identifies the location of Urheimats for 147 language families based on the updated version 18 of the ASJP (Wichmann et al., 2018). Figure E1 depicts the location of these Urheimats, while Figures E2 and E3 depict the extent of the Indo-European and Niger-Congo language families and the location of their Urheimats.

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<sup>52</sup>This method builds upon a similar methodology employed by geneticists to determine the location in which domestication of crops was originated.

Indo-European Languages: Homelands and Urheimat

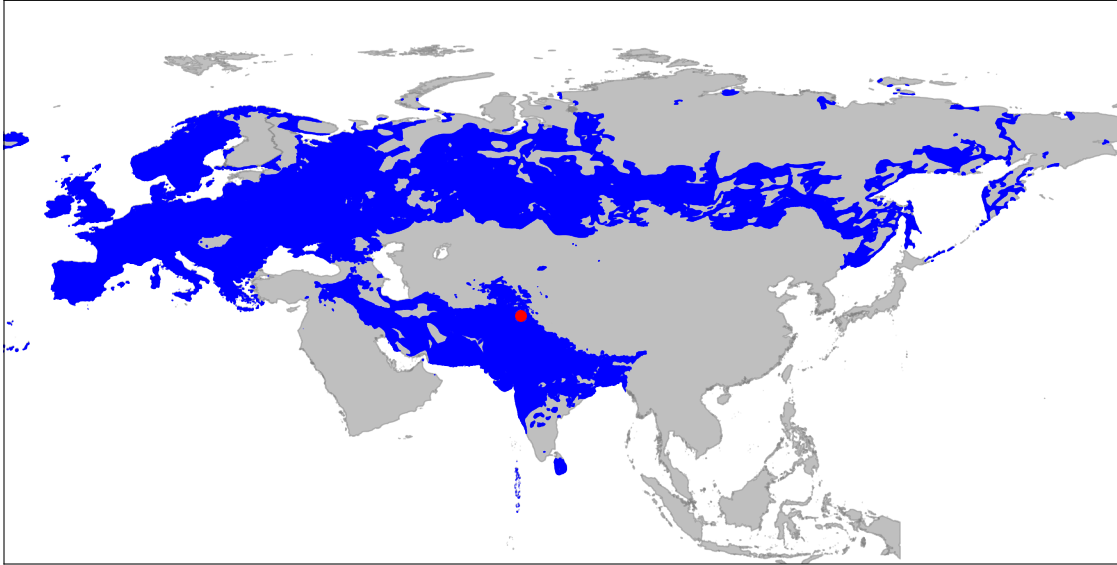


Figure E2: Indo-European Language Family: Homelands and Urheimat

Niger-Congo Language Family: Homelands and Urheimat

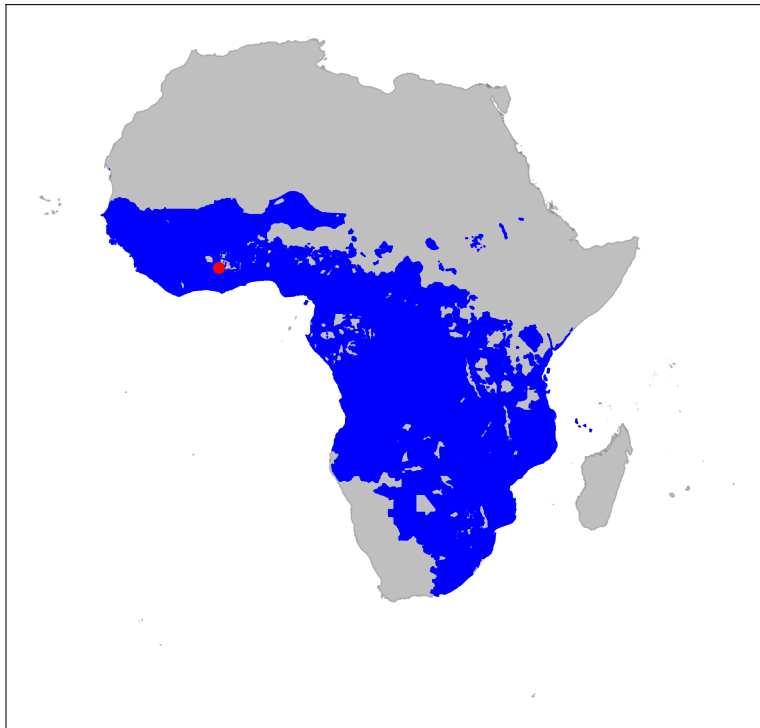


Figure E3: Niger-Congo Language Family: Homelands and Urheimat

## F The Timing of the Appearance of Ancient Plows



Figure F1: Ancient Egyptian arid. Burial chamber of Sennedjem (ca. 1200 BCE).

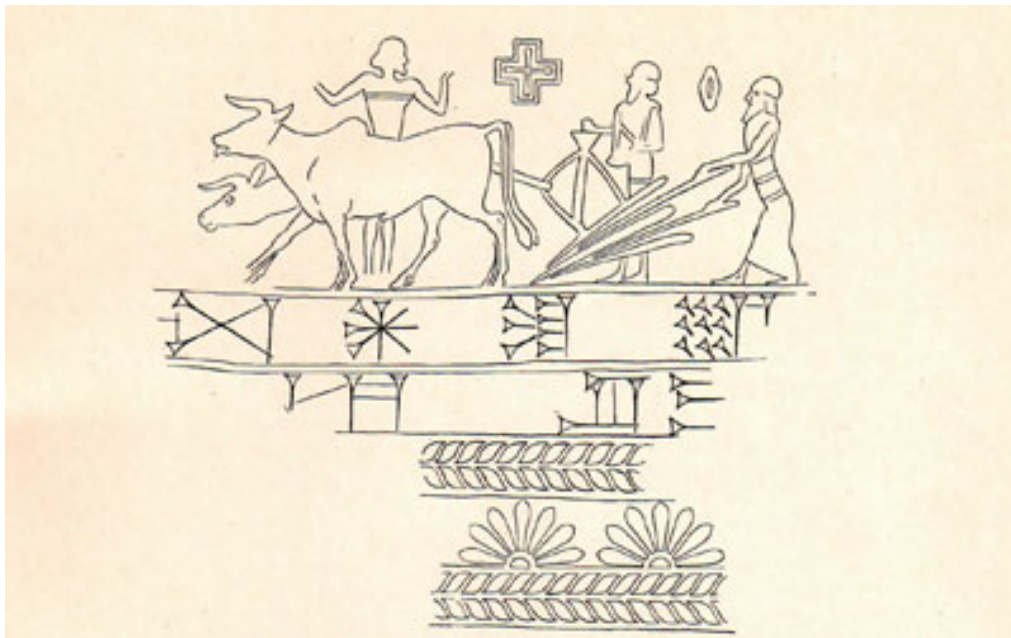


Figure F2: Gang of men plowing and sowing. Babylonian Seal Impression (1500 BCE)

The hypothesized coevolution of gender biases and sex-based grammatical gender based on their common geographical origin necessitates the appearance of the plow prior to the emergence of significant fraction of daughter languages within each language family. Indeed, paleo-linguistic and archeological evidence suggest that the plow appears prior to the formation of languages with a sex-





Figure F3: Gang of men plowing and sowing. Sumerian (ca.4500-2000BCE).



Figure F4: Picture of a field plowed along the Indus river (ca. 2000 BCE)

based grammatical gender. Evidence indicates that the plow has originated during the emergence of agriculture. In particular, evidence suggests that sporadic use of the plow is present as early as 10-13 thousands years ago in the fertile crescent, and in particular along the Tigris, Euphrates, Nile, as well as in Indus and Yangtze River valleys (Lal et al., 2007). Primitive prototypes of plows that were sufficiently demanding physically to provide a comparative advantage in their use for male (e.g, the *ard*) were more prevalent in the fertile crescent and in particular in Mesopotamia and along the Nile river 5000-8000 years ago (Lal et al., 2007; Lal, 2009). Moreover, nearly 4000 years ago, the plow was adopted by the Greeks, was further developed by the Indus Valley civilizations (i.e., the forefathers of the Dravidian language family), and by civilizations that resided along the Yangtze river (Lal, 2009). In addition, the plow was prevalent in both Northern Africa and Ethiopia, where the ancestors of the Afro-Asiatic language family resided, at least 2500 years ago (Blench, 2013).

Linguistic evidence suggests that early Indo-Europeans used the plow during the late Neolithic period, before their proto-language separated into its different daughter languages around 3000 BCE. In particular, German emerged around the 1st century BCE, English and Spanish in about the 5th century CE and Italian around the 14th century CE. The proto-language spoken around 4500 BCE consists of a word for the plow prior to the demic diffusion of the Indo-European languages to Asia and Europe (Piggott, 1983). Reconstructions of the proto-Indo-European language suggest that the verb, plow, was *ar(e)*, which is the root of *ear* (English), *erian* (Old English), *erja* (Old Norse), *arjan* (Gothic), *arare* (Latin), *arar* (Spanish), as well as *ard* (English) and *arado* (Spanish) (Pokorny, 1948). It should be noted that that

In contrast to temperate zones where plow positive crops were suitable for cultivation, tropical zones as well as the Americas have not adopted the earlier versions of the plow. Instead, in order to till the soil these areas adopted a hoe (i.e., a pointy stick used by hunter-gatherers) that was more suitable for their climatic environment. In these areas, the plow was introduced by Europeans during the colonial period.<sup>53</sup>

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<sup>53</sup>Figures F1-F3 depict ancient plow agriculture in Egypt, Babylon and Sumer around 2000BCE. Additionally, Figure F4 depicts a plowed field in the Indus Valley around 2000BCE. Literary evidence for the early adoption of the plow in these regions is “Debate between the pickaxe and the plough” (*The Sumerian Disputation/Debate*; 3rd millennium BCE), the Old and the New Testaments, and the Babylonian *Code of Hammurabi* (ca. 1750BCE) where references to the plow or plowing is present in laws 43, 44, 242, and 260.