The Origins of Financial Development: How the TseTse Fly Continues to Influence Modern Finance

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Abstract

We assess how the TseTse fly, a unique feature of African ecology that transmitted a parasite lethal to livestock and had enduring effects on human subsistence strategies, continues to influence modern financial systems. After showing that the suitability index of TseTse fly helps account for overall financial development, household access to credit, and firm access to finance, we evaluate three potential mechanisms linking the TseTse fly to modern finance—ethnic fragmentation, precolonial centralization, and trade. We discover that the TseTse fly is strongly, positively related to ethnic fragmentation and negatively related to precolonial centralization. We find limited evidence on the trade channel.

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I. Introduction

A growing body of literature examines the historical determinants of financial development, given the first order impact of finance on growth[1]. While many of these studies have concerned the legacy of the colonial powers[2] (La Porta, et al. 1998, 1999, 2000; Acemoglu, Johnson and Robinson, 2001), an emerging strand of literature finds the historical slave trade in Africa explains a nontrivial part of cross-country variations in financial markets (Pierce and Snyder, 2017a). Levine, Lin and Xie (2017) further emphasize that the breakdown of social cohesion is a major channel linking the slave trade and financial development across Africa. In this paper, we extend the research scope to an important and unique feature of African ecology by documenting a new historical determinant of social cohesion—the TseTse fly—and its impact on financial systems.

Prior research has emphasized the role of the TseTse fly—which transmits a parasite harmful to humans and lethal to livestock—on African development. Nash (1969) and Diamond (1997) note that by restraining the use of domesticated animals as a source of draft power, and precluding the adoption of technologies complementary to draft power, the TseTse may have hindered the ability of Africans to generate an agricultural surplus and transport goods overland easily. Alsan (2015) shows that ethnic groups in the TseTse infested areas were less likely to form politically centralized states and therefore are less developed today, given the importance of precolonial centralization on modern economic development (Fenske 2013; Gennaioli and Rainer 2007; Michalopoulos and Papaioannou 2013, 2014). Researchers, however, have not yet explored the potential role of finance in linking the TseTse fly to economic development today. Our paper (1) assesses the relation between the TseTse fly and modern financial development and (2) dissects the mechanisms linking the TseTse fly and the operation of financial systems.

To link the TseTse fly to modern financial development, we empirically evaluate three mechanisms: ethnic fragmentation, precolonial centralization, and trade. First, as emphasized by Alsan (2015), ethnic groups were more likely to rely on hunting and gathering in the TseTse-infested areas and more likely to break into small bands to avoid conflict over resources. This subsistence

[1] See, for example, King and Levine (1993), Jayaratne and Strahan (1996), Levine and Zervos (1998), Rajan and Zingales (1998), and the literature reviews by Levine (2005a) and Popov (2018).

[2] For example, La Porta, et al. (1997, 1998, 2008) stress that cross-country differences in legal origin help explain differences in modern financial development. Acemoglu, Johnson and Robinson (2001) and Engerman and Sokoloff (1997) emphasize the roles of natural endowments in shaping modern financial markets (Beck, Demirgüç-Kunt, and Levine 2003). Guiso, Sapienza, and Zingales (2004) and Karlan (2005) find that historically determined differences in social trust promotes financial development.

strategy in turn solidified and perpetuated narrow ethnic identities through limiting inter-ethnicity mixing and development of similar culture. When food was scarce and/or population rose within the band, they tended to further split into subgroups. This resulted in ethnic fractionalization that in turn stymied the development of institutions associated with property rights protection and contract enforcement (Easterly and Levine, 1997), formed weak social cohesion that tends to have deleterious effects on the development of institutions conducive to inter-clan transactions (Alesina and Spolaore, 1997; Levine, Lin and Xie, 2017) and created unfamiliar counterparties and intertemporal exchange that impede financial development (Alesina and La Ferrara, 2000). To assess this mechanism, we examine whether the TseTse fly is positively associated with ethnic fragmentation today. Second, foraging (i.e., hunting and gathering) societies do not establish permanent settlements; rather, they function as isolated bands without authority above the local level (Alsan, 2015). Herbst (2000) also stresses that low population density and high transportation costs caused by the TseTse fly are two major impediments to state-building in Africa. As shown by Gennaioli and Rainer (2007) and Michalopoulos and Papaioannou (2013, 2014) that precolonial political centralization is positively correlated with modern development, we thus explore the connection between the TseTse fly and precolonial political centralization. Third, by transmitting a parasite lethal to livestock, the TseTse has been hypothesized to have hindered the ability of Africans to transport goods overland easily (McPhee, 1926; Nash, 1969). In turn, the high transportation costs and homogeneous food source (e.g., food from hunting and gathering) may lead to less trade in the TseTse infested areas. Fehr, Gächter, and Kirchsteiger (1997) show that reciprocal trading causes a substantial increase in the quality of contract enforcement, which is a key factor in the functioning of financial markets. We thus assess the relationship between the TseTse fly and trade.

To conduct our study, we assemble data on the TseTse fly from 44 African countries and other potential determinants of financial development. Alsan (2015) provides data on the TseTse suitability index (*TSI*) for each African ethnic group. In particular, the *TSI* is the standardized value (Z-score) of the fly's steady-state population derived from insect growth modelling, gridded climate data, and geospatial data for the geographic location of each ethnicity. The exact functional forms linking the TseTse fly birth and death rates to climate (e.g., temperature and humidity) are derived from controlled laboratory experimentation on the fly (Bursell, 1960; Rajagopal and Bursell, 1965; Mellanby, 1937). We use the country average value of this index to conduct our analyses. In the

analyses, we control for other historical determinants of financial development that have been identified by prior research. For example, La Porta et al. (1998) find that a country's legal origin, as defined by its European colonizer, explains current investor protection laws and hence financial development in general. Acemoglu, Johnson, and Robinson (2001) show that a country's natural resource endowments shaped the political institutions imposed by European colonizers, which have had enduring effects on modern financial systems. Beck, Demirgüç-Kunt, and Levine (2003) and Stulz and Williamson (2003) document the impact of cultural differences, including religion, on finance. More recently, Pierce and Snyder (2017a) and Levine, Lin and Xie (2017) assess the influence of the African slave trade between 1400 and 1900 on the functioning of modern financial systems. We therefore control for legal origin, natural resource endowments, cultural, slave exports and other national traits in assessing the relation between the TseTse fly and the operation financial systems today.

Our empirical analyses are divided into two parts: examining the relation between the TseTse fly and modern financial development and exploring theoretically-motivated channels through which the TseTse fly might shape the operation of modern financial systems. We begin by assessing the connection between the TseTse fly and three sets of measures of modern financial development— country-level overall financial development, household access to finance, and firm access to credit. To measure overall financial development at the national level, we use standard measures of overall bank development that have been used to assess the impact of finance on growth, such as bank credit to the private sector as a share of Gross Domestic Product (GDP) from the Global Financial Development Database (2017). Second, we use household finance data from World Bank's *Financial Inclusion Database* to construct measures of household access to credit, such as whether the household has ever received a loan or obtained a credit card from a financial institution. Third, we use firm-level data from the World Bank's *Enterprise Survey* to construct measures of firm access to credit.

We find that the TseTse suitability index (*TSI*) is strongly, negatively associated with overall financial development, household access to finance, and firm access to credit. The results hold when controlling for other historical determinants of financial development, the level and growth rate of GDP per capita, and an assortment of other country characteristics. When examining household or firm access to credit, the results are robust to controlling for household and firm traits respectively, such as the income, education, gender, and age of the person and the firm's size,

growth, age, etc. For the firm-level analyses, we find that the TseTse suitability index has a negative relationship with firm access to credit. The economic magnitudes of our estimates, at both household and firm levels, exceed the impact of slave trade documented in Levine, Lin and Xie (2017) by a large margin. We also examine whether the negative association between firm financing constraints today and the TseTse fly differs across industries in a theoretically consistent manner. Specifically, if the TseTse fly influenced social cohesion in ways that continue to hinder the efficient financing of firms, then the relationship between the TseTse fly and obtaining external credit should be especially pronounced among firms in industries that depend heavily, for technological reasons, on external finance. We follow the approaches in Pierce and Snyder (2017a) and Rajan and Zingales (1998) to perform the tests and the results confirm our predictions.

The second part of our analyses assesses three potential mechanisms linking the TseTse fly to modern financial development—ethnic fragmentation, precolonial centralization and trade. To examine the ethnic fragmentation channel, we use (a) the natural logarithm of the number of languages spoken in each country constructed by Michalopoulos (2012); (b) the probability that two randomly selected individuals in a country will not speak the same language from Easterly and Levine (1997), and (c) two measures of linguistic diversity from Desmet, Ortuño-Ortín, and Wacziarg (2011). To examine the precolonial centralization mechanism, we use two indicators constructed from the variable "jurisdictional hierarchy beyond the local authority" in the *Ethnographic Atlas* (Murdock 1967), which is widely used in the literature (Gennaioli and Rainer, 2006, 2007; Michalopoulos and Papaioannou, 2013; Alsan, 2015). To test the trade channel, we use two contract enforcement measurements from the World Bank's Doing Business Data (Djankov, McLiesh, and Shleifer, 2007; Djankov et al., 2008; Djankov et al., 2003) by assuming trade as a contract enforcement device. Holding all other factors constant, if a country had more trading activities in history, it may have developed better institutions for contract enforcement and vice versa. The data on cross-country trade in precolonial Africa is not available (Fenske, 2014).

We discover that the TseTse fly is strongly related to the ethnic fragmentation and precolonial political centralization mechanisms but not robustly related to the trade mechanism. On the ethnic fragmentation mechanism, we find that the TseTse fly is strongly, positively associated with ethnic fragmentation and this finding is robust to controlling for the same factors discussed above and when the dependent variable is either one of the four measures. The estimated effects are large. If we consider a conceptual experiment of moving a country, say Ghana, from the

75th percentile of the cross-country distribution of the TseTse fly index to the 25th percentile, the estimated ethnic fragmentation measured by the number of languages with at least 1,000 speakers would rise by more than 400%, from 69 to 335.

We also find strong support for the precolonial political centralization mechanism, evident by a large, negative, and statistically significant relation between the TseTse fly and precolonial political centralization. The estimated coefficients suggest that the economic impact of the TseTse fly on precolonial centralization is nontrivial. If Ghana had been moved from the 75th percentile to the 25th percentile of the distribution of the TseTse suitability index, the estimated precolonial political hierarchy of an average ethnic group in Ghana would change from chiefdom to large state, confirming the economic significance of the impact.

We find limited support for the view that the TseTse fly influences financial development through trade. Specifically, the negative association between the TseTse suitability index and the effectiveness of contract enforcement today are not robust to the inclusion of contemporary macroeconomic factors such as inflation. This is consistent with the view that the TseTse fly exerts influence on modern economic development, which in turn has spill-over effects on the quality of contract enforcement today.

The main threat to the validity of the analyses is that the TseTse suitability index constructed by Alsan (2015) may be capturing the latent negative effects of the tropics spuriously. In addition to controlling for a rich set of geographic and climate variables, four additional steps are taken. First, instead of the TseTse suitability index, the intrinsic growth rate of the fly (the birth minus the death rate) from Alsan (2015), is used directly. The alternative TSI produces almost identical results to our main regression models. Second, following Alsan (2015), the formulas for the TSI are perturbed in a quantitatively slight but physiologically important way. If the TSI is precisely picking up the effects of the TseTse fly, this "perturbed" index with slight change in the temperature input (one standard deviation) should not have the same correlations with financial development indicators. The results confirm our predictions. Third, we note that Alsan (2015) shows that agricultural suitability and TseTse suitability are strongly, positively correlated. So if anything, the TSI reflects the positive latent factors of climate, not those that are detrimental to livestock and human settlement. Fourth, Alsan (2015) constructs the TSI index for ethnic groups in the tropics outside of Africa. If the TseTse suitability index is only capturing effects of tropical climate factors, the index should have similar predictive powers in the tropical areas outside of Africa. In contrast,

Alsan (2015) finds that the TSI does not have the same predictive power in those areas outside of Africa. We are not able to directly conduct the test in this study, because our data does not report information on respondent's ethnic identity, although some of our financial development measures are based on individuals and firms. We caution the readers that it is difficult to completely rule out the possibility that the TSI is capturing some latent aspect of the tropics, but the evidence presented here is consistent with the idea that the TseTse suitability index within Africa is mainly capturing the effect of the TseTse fly.

To the best of our knowledge, this paper is the first to reveal the relationship between the animal ecology and finance. While economists, historians and biologists have long debated the attribute of TseTse fly to Africa's underdevelopment (McPhee, 1926; Nash, 1969; Herbst, 2000; Chaves, Engerman and Robinson, 2013), empirical evidence has been scarce until Alsan (2015) shows that current economic performance is affected by the TseTse through the channel of precolonial political centralization. We further provide original evidence linking the TseTse fly to modern financial development, which is consistent with an enduring effect of the TseTse fly on modern financial markets through ethnic fragmentation and precolonial centralization mechanisms.

This paper relates to the literature that examines the origins of modern financial development. La Porta, et al. (1997, 1998, 2008) emphasize that cross-country variations in legal origin help explain differences in modern financial development. Acemoglu, Johnson and Robinson (2001) and Engerman and Sokoloff (1997) stress the roles of natural endowments in shaping financial markets today (Beck, Demirgüç-Kunt, and Levine 2003). Guiso, Sapienza, and Zingales (2004) and Karlan (2005) show that historically determined differences in social trust shape modern financial development. In D'Acunto, Prokopczuk, and Weber (2017), Pierce and Snyder (2017a) and Levine, Lin and Xie (2017), the researchers examine the effects of traumatic shocks, namely the historical anti-Semitism in Germany and the slave trade during 1400-1900 in Africa, on the functioning of present-day financial markets. Our contribution to this literature is to propose a determinant of financial development that has both historical and ecological elements, the historical TseTse fly in Africa, and thus to provide unique evidence on the origins of financial development.

The paper also builds on a stream of research that uses historical natural experiments to shed light on present-day outcomes (Spolaore and Wacziarg, 2013; Nunn, 2014; Klüppel, Pierce, and Snyder, 2017). Pascali (2016) exploits the expulsion of the Jews from the southern Italian cities under the rule of the Spanish Crown in 1541 and shows that more developed banking in the past

increases external credits available to firms and the density of current bank branch. D'Acunto (2017) shows that historical variation in basic education across European regions helps explain the present-day regional differences in wealth and innovation. In a recent study, Pierce and Snyder (2017b) show that the slave trade in Africa during 1400-1900 is a fundamental determinant of present-day ownership structure and labour productivity. We exploit a natural experiment that has rarely been studied previously, but has important implications for modern finance, the variation of land suitability for the TseTse fly in African countries.

This study also speaks to the literature on the link between historical foundations of culture and the functioning of financial markets. Guiso, Sapienza, and Zingales (2004), Karlan (2005), McMillan and Woodruff (1999), and Karlan, Rosenblat, and Szeidl (2009) have shown a strong correlation between trust and financial contracting. Levine, Lin and Xie (2017) also demonstrated the breakdown of trust is a major channel through which the slave trade influences modern finance in Africa. We stress the role of social cohesion in finance and provide evidence that social cohesion is one of the main mechanisms linking the TseTse fly to the operation of financial markets today.

This paper is also related to an emerging literature that examines the origins of ethnic diversity. Given the importance of ethnic diversity on economic development (Easterly and Levine, 1997; Alesina et al., 2003, Banerjee and Somanathan, 2007), many researchers seek to understand the origins of ethnic fragmentation (Michalopoulos, 2012; Ahlerup and Olsson, 2012; Barth, 1969; Mace and Pagel, 1995; Nettle, 1998, 1999; Harmon, 1996; Moore et al., 2002). Michalopoulos (2012) shows variations in agricultural suitability and land elevation predict ethnic diversity. Ahlerup and Olsson (2012) use data on the duration of human settlements since prehistoric times to show that countries where modern humans settled earlier sustain higher ethnic diversity today. We provide unique evidence linking an ecology factor to ethnic diversity by showing that areas that were historically more suitable to the TseTse fly are more ethnically diversified today.

II. Institutional Background

The TseTse fly is a prehistoric species[3] and unique to Africa (Alsan, 2015). Geo-climate factors, such as climate change, continental drift and glacier advances, are believed to have caused this isolation (Lambrecht, 1964). The fly feeds strictly on vertebrate blood and has acted as a

[3] The TseTse fly is believed to have originated about 100 million years ago (Krafsur, 2009).

specialized vector for transmission of Animal *Trypanosomiasis*, a parasite lethal to domesticated livestock. The parasite is capable of rapid antigenic variation—the change of proteins on its surface so that a host cannot detect the infectious agent—that blocks the animal's immune response (Alsan, 2015). Together with this Animal *Trypanosomiasis*, the TseTse fly has been described by colonial Commissioner H.H. Johnston (1894) as the "greatest curse" nature laid upon Africa. This section discusses its influences on subsistence strategies and the subsequent consequences on institutions in Africa.

A. The TseTse Fly and African Subsistence Strategies

Livestock played an important role in agricultural production before mechanization (Allen, 1999; Alsan, 2015). They directly increased yields by providing manure for fertilizers and serving as a source of draft power. Overton and Campbell (1992) emphasize that the agricultural revolutions in England were closely associated with rising livestock density. Domesticated animals also prompted the adoption of agricultural technologies, such as the plow and harness, which further improved agricultural productivity.

Given the importance of domesticated animals on agriculture, researchers find that the TseTse fly, which transmits *Trypanosomiasis* lethal to livestock, has had important effects on subsistence strategies within Africa. Alsan (2015) finds that in places infected by the TseTse fly, local populations were less likely to own large domesticated animals, conduct intensive agriculture activities, and adopt the plow. Archaeological evidence also emphasizes that the diffusion of domesticated livestock in Africa was heavily hindered by the TseTse fly (Diamond, 1997; Ingold, 1987; Gifford-Gonzalez, 2000). These evidence, taken together with the fact that wildlife were more immune to *Trypanosomiasis* than domesticated animals, suggest that hunting and gathering were more likely to persist as the subsistence strategies as opposed to more advanced food production strategies that relied on animal husbandry in the TseTse fly-infected areas.

B. The TseTse Fly and Ethnic Fragmentation

In addition to the role in subsistence strategies, the TseTse fly may have also influenced ethnic fragmentation in the fly-infected areas. Since populations in the fly-infected areas were more likely to adopt hunting and gathering as their subsistence strategies, they tended to break into small bands to avoid conflict over resources and to reduce the probability of pathogen transmission of sleeping sickness caused by the fly (Alsan, 2015). This subsistence strategy may have consequently

solidified and perpetuated narrow ethnic identities through limiting inter-ethnicity mixing and hindering culture-synchronization. What's more, when food was scarce and/or population rose within the band, local population may further split into sub-bands. This in turn may have resulted in further ethnic fractionalization in local areas.

C. The TseTse Fly and Precolonial Political Centralization

As noted by Alsan (2015), there are three ways that the TseTse fly could have influenced precolonial political centralization. First, since the TseTse fly encouraged the persistence of hunting and gathering, it may have resulted in low population density, a key impediment to state-building and centralization (Herbst, 2000). Since foraging (i.e., hunting and gathering) can only support a limited number of individuals per hectare of land[4], it substantially limited population density in the fly-infected areas. Second, the TseTse fly may have increased transportation costs in Africa, another key impediment to political centralization (Herbst, 2000). Prior to mechanization, transportation including carrying goods and sending messages was heavily dependent on large domesticated animals. Therefore a lack of such animals due to the fly would have raised the transportation costs. Lastly, by encouraging foraging, the TseTse fly could have discouraged intensive farming that is conducive to state-building. As discussed in detail in Alsan (2015), intensive farming could have provided several benefits to the formation of precolonial centralization including permanent settlement, a high population density, a potential tax base, and occupational specialization.

III. Data

In this section, we describe the key data used in our estimation of the link between the TseTse fly and financial development in modern Africa and the potential mechanisms linking the TseTse fly to the functioning of current financial systems. Table A1 in the Online Appendix provides detailed definition of all variables, and Table 1 provides summary statistics.

A. The TseTse Fly Measure

We use the TseTse fly measure constructed by Alsan (2015). Specifically, the TseTse suitability index (*TSI*) is the standardized value (Z-score) of the fly's steady-state population derived

[4] Shifting agriculture can support a maximum of 10 individuals per square kilometre (Mazoyer and Roudart 2006) while intensively farming with domesticated animal-powered techniques, i.e., the plow and fertilizers, can sustain a maximum of 55 individuals per square kilometre (Mazoyer and Roudart 2006).

from insect growth modelling, gridded climate data, and geospatial data for each ethnicity. The exact functional forms linking the TseTse fly birth and death rates to climate (e.g., temperature and humidity) are derived from controlled laboratory experimentation on the fly. The climate data Alsan (2015) uses to construct this measure is from the National Oceanic and Atmospheric Administration's twentieth century reanalysis version 2 (20CRv2). The daily data of air temperature and relative humidity, which are key requirements for the fly's viability, from the earliest data-available year 1871 in this database is used in her study. Alsan (2015) shows African long-run temperature over 1500-1900 changes little using paleoclimate data from Mann et al. (2008), which eases the concern that the index might not reflect the TseTse population in precolonial Africa. Alsan (2015) finds that agricultural suitability and TseTse suitability are strongly, positively correlated. So if anything, the TSI reflects the positive latent factors of climate, not those that are detrimental to livestock and human settlement. To falsify that the TseTse suitability index only captures effects of tropical climate factors, Alsan (2015) shows that the TSI does not have the same predictive power in those areas outside of Africa. In this study, we use the mean TSI value for each country in Africa for empirical analysis since the original measure is at the ethnic group level.

As shown in Table 1, *TSI* ranges from -2.34 to 1.46, with higher number indicating more suitability of the TseTse fly. Although there are 44 countries in Alsan (2015)'s sample, we exclude Somalia and Zimbabwe due to a lack of financial development data. The median ratio of *TSI* index is -0.16. There is considerable cross-country variations, with Equatorial Guinea being the most suitable land for TseTse fly and South Africa the least. Figure 1 depicts the *TSI* index for each of the 42 countries in our sample, with darker colour representing higher values.

We also use TSI_intrinsic and TSI_perturbed as alternative TseTse fly measures. Both measures are from Alsan (2015). Particularly, TSI_intrinsic is the intrinsic growth rate of the fly (the birth minus the death rate) and TSI_perturbed is generated by manipulating the laboratory data gathered to generate the TSI and shifting the temperature entries one standard deviation to the left of the true observations. As shown in Table 1, TSI_intrinsic ranges from 0.09 in South Africa to 0.67 in Equatorial Guinea, with mean of 0.41 and standard deviation of 0.14. TSI_perturbed ranges from -2.35 in Mali and 1.70 in Liberia. The mean and standard deviation of this measure are -0.04 and 0.88, respectively.

B. Financial Development Indicators

We use various country-, household-, or firm-based indicators for financial development in the estimate of their link to TseTse fly.

At the country level, we use two bank-based cross-country indicators of overall financial development because banking system accounts for a large bulk of African financial institutions, and six enterprise-based indicators from the Global Financial Development Database (2017) (Čihák et al., 2013). *Ln Private credit to GDP*, a bank-based measure, equals the total credit issued by domestic money banks (commercial banks and other deposit-taking financial institutions) to the private sector as a share of gross domestic product (GDP) averaged over the 2006-2014 period. It measures the extent to which a country's savings are channelled to private sector through financial institutions. We use the natural logarithm form of this measure in the analyses since the density function of the log-transformed measure resembles a normal distribution more than the untransformed. As shown in Table 1, *Ln Private credit to GDP* ranges from 2.7 to 4.97, indicating that the untransformed ratio of private credit to GDP ranges from 5.2% in Chad to 80.85% in Morocco. The sample mean is 1.12 (25.84% for the untransformed) and the standard deviation is 0.76 (16.29% for the untransformed). Levine, Lin and Xie (2017) also uses this financial development indicator. *Ln Financial system deposit to GDP* equals the demand, time and saving deposits in deposit money banks and other financial institutions as a share of GDP averaged over the 2006-2014 period. Similarly, we use the natural logarithm form of this measure. If institutions that conducive to financial development are well developed (e.g., less ethnic fragmentation and more centralized political system), people will have more confidence and thus deposit more in the financial system.

To measure the degree to which firms can get access to formal credit from the financial system, we use six country-level enterprise-based measures from World Bank's *Enterprise Survey*: *Percent of firms with a bank loan/line of credit*, *Percent of firms using banks to finance investments*, *Proportion of investments financed internally*, *Proportion of investments financed by banks, Percent of firms using banks to finance working capital*, and *Proportion of working capital financed by banks*. For example, *Percent of firms with a bank loan/line of credit* equals the percentage of firms in the formal sector with a line of credit or a loan from a financial institution. It ranges 2.7% in Guinea-Bissau and 61.10% in Burundi. The median and standard deviation is 21.50% and 14.84%. Table A1 provides detailed definitions for the indicators.

At the household level, we use three indicators of household access to finance from the World Bank's *Financial Inclusion Database 2014*. *Account at a financial institution* equals one if the respondent has opened an account at a financial institution, and zero otherwise. The average across survey respondents within countries varies considerably. For example, over 84% of respondents had opened an account at financial institutions in Mauritius, while less than 0.1% survey participants had opened an account in Niger, Guinea, Madagascar, and Somalia. *Borrow from financial institutions* equals one if the respondent borrowed from a formal financial institution during 12 months before the 2014 survey and zero otherwise. *Credit card* equals one if the respondent reports having a credit card and zero otherwise. Both measures vary widely across countries. In Uganda, more than 17.5% respondents had borrowed from a formal financial institution, while in Guinea, Niger and Cameroon this ratio is below 0.1%. Similarly, in Mauritius, more than 17% survey participants had a credit card, whereas only less than 0.01% had a credit card in Madagascar, Sudan, and Ethiopia.

At the firm level, we use four measures to gauge the extent to which firms get access to finance from the financial system and offer and receive trade credit from other firms. Our data source at the firm level is from the World Bank's *Enterprise Survey,* which provides about 38,000 firm-year observations from 44 African countries over the period from 2006 through 2017. It also provides information on a wide range of firm characteristics including the number of employees, firm's establishment year, industry, sales growth, the percentage of its direct exports to other countries, private/government ownership, and CEO's experience. This allows us to alleviate omitted variable concern in examining the link between the TseTse fly and firm's access to finance. Specifically, the financial development indicators at the firm level are as follows. *Working capital financed from banks* equals the proportion of working capital in a firm that is financed by borrowing from banks. *Investment financed from banks* equals the proportion of a firm's long-term investment (i.e., purchases of fixed assets) that is financed by borrowing from banks. *Trade payable* equals the share of total annual purchases of material inputs or services that are paid for after delivery. It measures the degree to which a firm obtains trade credit from its suppliers. *Trade receivable* equals the proportion of a firm's total sales that are paid for after delivery. This measure captures the extent to which a firm provides trade credit to its customers.

C. Mechanism Indicators

We assess ethnic fragmentation, precolonial political centralization and trade as three potential channels through which historical TseTse fly continues to influence financial development in Africa.

First, we use four cross-country measures of ethnic diversity. *Ln Number of languages*, constructed by Michalopoulos (2012), equals the natural logarithm of the number of languages with at least 1000 speakers within a country. Michalopoulos (2012) uses the languages data from the World Language Mapping System (WLMS) (2006) and derives the number of languages spoken within each country. This measure ranges from zero to 6.13, indicating that the number of languages spoken in a country ranges from one (in Rwanda, Swaziland, and Burundi) to 459 (in Nigeria). *Ethnic fragmentation*, from Easterly and Levine (1997), equals the probability that two randomly selected individuals in a country will not speak the same language. It is derived from Soviet data, Atlas Narodov Mira (1964), collected in the early 1960s and first brought to attention by Mauro (1995). *ELF7* and *ELF9* are two measures of linguistic diversity from Desmet, Ortuño-Ortín, and Wacziarg (2011). These authors use information on language trees from the Ethnologue dataset to produce estimates of ethnolinguistic fractionalization at different levels of linguistic aggregation depending on how finely or coarsely language groups are defined. These measures have the advantage of giving a time-dimension of our analyses because a finer level of aggregation indicates a more recent language split between groups. Since the TseTse fly measure is constructed using 1871 climate data, we use the two finest levels of aggregation, namely level 7 (*ELF7*) and 9 (*ELF9*), in the analyses. *ELF7* ranges from zero to 0.90, with higher value indicating more ethnic fragmentation. Similarly, *ELF9* ranges from zero to 0.95 with a mean of 0.57 and a standard deviation of 0.30.

Second, we examine precolonial political centralization using two cross-country indicators. Alsan (2015) shows that in TseTse-infested areas, ethnic groups were less likely to form politically centralized society because the TseTse fly had exerted influence on low population density and high transportation costs in those areas, which are believed to be two major impediments to state-building and extension of authority in Africa (Herbst, 2000). An extensive literature shows precolonial centralization exerts first-order influence on financial development (Gennaioli and Rainer 2007; Michalopoulos and Papaioannou 2013, 2014, 2015). In particular, *Precolonial jurisdictional hierarchy* is a cross-ethnicity measured coded so that it equals zero for groups lacking any

form of centralized state, one for petty chiefdoms, two for large paramount chiefdoms/petty states, and three or four for large states. We use the country average of this measure for our analyses. It is constructed from the variable "jurisdictional hierarchy beyond the local authority" in the *Ethnographic Atlas* (Murdock 1967), which is widely used in the literature (Gennaioli and Rainer, 2006, 2007; Michalopoulos and Papaioannou, 2013, Alsan, 2015). As reported in Table 1, it ranges from 1.14 in Gabon and four in Tunisia, Burundi and Swaziland. The median and standard deviation are 2.38 and 0.64, respectively. *Precolonial political centralization* is an additional measure that equals one if the *Precolonial jurisdictional hierarchy* variable equals two, three, and four, and zero otherwise.

Third, we use two indicators from World Bank's *Doing Business Data* to examine the trade mechanism. Herbst (2000) and Alsan (2015) find that the TseTse fly has exerted considerable influence on high transportation costs in the infested areas because the fly transmits parasites lethal to domesticated animals. The high transportation costs and homogeneous food source (e.g., food from hunting and gathering) may lead to less trade in the TseTse infested areas. However, data on cross-country trade in precolonial Africa is scarce (Fenske, 2014). The only data related with precolonial trade is the distance from each country to the pre-600 CE and 1800 CE trade networks (Brice and Kennedy, 2001; Michalopoulos, Naghavi and Prarolo, 2014). Yet, data on pre-600 CE trade network only covers small parts of Egypt and Sudan, while data on 1800 CE network only covers the non-tropical areas in North Africa. These data are therefore not suitable for our analyses. We thus use two contract enforcement measurements by assuming trade facilitates contract enforcement. Holding all other factors constant, if a country had more trading activities in history, it may have developed better institutions for contract enforcement and vice versa. Fehr, Gächter, and Kirchsteiger (1997) show that reciprocal trading causes a substantial increase in the quality of contract enforcement. Specifically, the two measures are as follows.

Enforcing contracts distance to frontier (DTF) is the simple average of the distance to frontier scores for each of the three enforcing contract component indicators: days to resolve a commercial dispute through the courts; attorney, court and enforcement costs as a percentage of claim value, and quality of judicial process index. Days to resolve a commercial dispute measures how long it typically takes to resolve a commercial dispute. Contract enforcement cost measures the direct costs (e.g., legal and other fees) of resolving a commercial dispute. Quality of judicial processes index

measures whether each economy has adopted a series of good practices in its court system. It ranges from 26.26 to 62.34, with higher value indicating better contract enforcement institutions.

Enforcing contracts rank is the ranking of economies worldwide on the ease of enforcing contracts. It is calculated by sorting their enforcing contracts distance to frontier scores. It ranges from 57 for Morocco to 186 for Angola.

D. Other Country, Firm, and Household Traits

A large strand of literature documents that several historically determined country traits shape modern financial institutions. In examining the independent link between the precolonial TseTse fly and the operation of modern financial systems across Africa, we control for these key national traits.

First, *Slave exports*, constructed by Nunn (2008), equals to the natural logarithm of the total number of slaves exported from each country between 1400 and 1900 in the four slave trades normalized by land area. As emphasized by Lovejoy (2000), Nunn and Wantchekon (2011), Levine, Lin, and Xie (2017) and Pierce and Snyder (2017), enslavement in Africa created a culture of distrust that persists till today and distrust consequently harms the functioning of financial systems by impeding both transactions among unfamiliar counterparties and intertemporal exchange.

Second, *French legal origin* equals one if a country implants laws from the French civil law traditions and zero if a country has English common law origin because all countries in our sample belong to either French or English legal families. La Porta et al. (1997, 1998) show that the quality of investor protection varies greatly across countries with different legal origins and these variations continue to shape the functioning of modern financial systems.

Third, *Settler mortality* equals annualized death rates faced by former European settlers in European colonies in the early 19th century. It is developed by Acemoglu, Johnson, and Robinson (2001) who argue that Europeans tend to adopt institutions that protect property rights, enforce contracts and provide checks against government in places where environment is favourable for settlement and tend to adopt extractive institutions in places where disease and climate are not suitable for Europeans to settle. To quantify cross-country differences in the degree to which Europeans found the environment more or less familiar and hospitable, we also supplement *Settler mortality* with *Absolute latitude*, which equals the logarithm of the absolute distance between each country and the equator. We have data on *Settler mortality* for 32 out of 44 countries in our sample.

Fourth, La Porta et al. (1999), Beck, Demirgüç-Kunt, and Levine (2003), Stulz and Williamson (2003), and Levine, Lin and Xie (2017) emphasize the effects of religious differences in shaping modern financial institutions. We therefore control for each country's religious composition. In particular, *Catholic*, *Muslim*, and *Other religions* equal the percentage of population that are Catholic, Muslim and other religions including Protestant in 1980, respectively. Several researchers also stress that longer periods of independence from colonial rules allowed countries to develop institutions that conducive to financial development (Easterly and Levine, 2003; Beck, et al. 2003). We therefore control for *Year of independence*, which equals the first year a country obtained its independence.

We also control for historical climate conditions to isolate the effect of TseTse fly on modern financial system. Particularly, *Min of monthly average rainfall* is the lowest monthly rainfall, measured in millimetres, in the driest month of the year. *Max of monthly average humidity* is the average of the maximum afternoon humidity, measured in percent, during the hottest month of the year. The data are from meteorological data taken over a 30-year period and reported in Parker (1997). *Average temperature 1961-1990* is the average temperature during 1961-1900 in Celsius for a country. This measure is widely used in Michalopoulos and Papaioannou (2013) and Michalopoulos (2012), among others.

Michalopoulos (2012) shows that variation in regional land quality and elevation is a fundamental determinant of contemporary ethnic diversity and therefore has important implications for modern economic and financial institutions. We therefore control for each country's variation in land quality and elevation. Specifically, *SD of agriculture suitability index* is the standard deviation of land suitability for agriculture, which is the average land quality for cultivation within each country. The index is the product of two components capturing the climatic and soil suitability for farming. *SD of elevation* is the standard deviation of elevation within each country. Both measures are derived by Michalopoulos (2012).

We also control for both historical prosperity in our main analyses and contemporaneous macroeconomic conditions in some sensitivity analyses. We include Nunn's (2008) calculation of logged population density in 1400 (*Population density in 1400*)—a reasonable measure of pre-existing economic prosperity in Africa (Acemoglu et al. 2002). From the World Development Indicators (WDI, 2016), we control for *GDP per capita*, which equals the natural logarithm of gross domestic product divided by total population; *GDP per capita growth*, which equals the annual growth rate of

GDP per capita; and *Inflation*, which equals the annual growth rate of the GDP deflator since Boyd, Levine and Smith (2001) show that inflation harms the operation of financial systems. All three of the Macroeconomic controls are computed as the average over the 2006 – 2014 period. These indicators are also used in Levine, Lin and Xie (2017).

In the country-level analyses, we further control for geography effects that might potentially confound our results. As stressed by a number of researchers, natural endowment such as geography has considerable impact on modern economic and financial institutions (Easterly and Levine, 2003; 2016; Engerman and Sokoloff, 1997). Particularly, *Longitude* is a country's longitude; *Country area* equals a country's physical area, *Distance from coast* is the natural logarithm of the distance from the centroid of a country to the nearest coast. *Migratory distance from Addis Ababa* is the natural logarithm of the distance from Addis Ababa, Ethiopia, from the centroid of a country. All these indicators are from Michalopoulos (2012).

In the household-level analyses, we control for an assortment of individual characteristics, including *Gender*, an indicator that equals one if the respondent is female and zero otherwise, *Age*, which equals respondent's age, *Income*, an indicator of income quintiles, *Education*, an indicator of respondent education levels. These variables are from *Financial Inclusion Database 2014*.

In the firm-level analyses, we control for the following firm specific characteristics. *Firm size* is an indicator of firm's number of employees divided into tertiles; *Firm age* equals the first year that a firm starts operation; *Government* (*Private* and *Foreign*) is the share of company owned by government (private and foreign parties), *Exports* is the share of sales exported outside of the country; *Sales growth* is the median value of firms' sales growth within an industry in each year; *Business group* is a dummy variable that equals one if the firm is part of a larger company and zero otherwise; *CEO experience* equals the number of years of experience that a firm's CEO has.

When testing the relationship between TseTse fly and firm's decision to apply for a loan at a financial institution, we use eight binary indicators derived from World Bank's *Enterprise Survey*: *Apply for any loan last year*, *No need for a loan*, *Complex application procedures*, *High collateral requirements*, *Unfavourable interest rate*, *Insufficient size*, *Would not approve*, and *Others*. Particularly, *Apply for any loan last year* is an indicator that equals one if the firm has applied a loan or a line of credit at a financial institution, and zero otherwise. *No need for a loan*, *Complex application procedures*, *High collateral requirements*, *Unfavourable interest rate*, *Insufficient size*, *Would not approve*, and *Others* are indicators of

various reasons that a firm did not apply for a loan. Table A1 in the Online Appendix provides detailed definitions for the indicators.

IV. TseTse Fly and Modern Financial Development

In this section, we assess the relationship between the TseTse fly and modern financial institutions across Africa. We conduct our analyses based on three different levels of financial development indicators. The country-level analyses focus on overall financial development, while the firm-level and household-level emphasize firm's and household's access to finance.

A concern is that the underlying physiological relationship between climate and TseTse survival is manipulated via demographic modelling to achieve a steady state. To allay this concern, we use two approaches. Firstly, a more straightforward TseTse suitability index is used. Instead of the TSI, the intrinsic growth rate of the fly (the birth minus the death rate) from Alsan (2015), is used directly. The alternative TSI produces almost identical results to our main regression models and are tabulated in Table A9-A16 in the Online Appendix. Secondly, following Alsan (2015)[5], the formulas for the TSI are perturbed in a quantitatively slight but physiologically important way. If the TSI is precisely capturing the effects of the TseTse fly, this "perturbed" index with slight change in the temperature input (one standard deviation) should not have the same correlations with financial development indicators. The results confirm our predictions. The "perturbed" index eliminates any significant correlations between the TSI and the main outcomes of interest, as shown in Table A17-A22 in the Online Appendix.

Finally, we use a control function approach and saturate the regressions with many climate regressors (among others) to reduce these concerns. We present results without any control variable, when conditioning on a wide array of country traits and when further including contemporaneous indicators of economic conditions in the country. The results—both in terms of statistical significance and the estimated coefficient on the TseTse fly—vary little when changing the conditioning information set, further suggesting that the TSI capturing the TseTse effects mainly.

[5] Alsan (2015) further conducts sensitivity analysis of the values of a key parameter, ψ, which used in calculating steady state TseTse population. As the parameter ψ in the equation for the steady state TseTse fly population is varied over the feasible range as identified by May et. al., (1974), the results remain almost identical.

A. Overall Financial Development

We begin with cross-country, ordinary least squares (OLS) regressions to assess the relationship between the TseTse fly and overall financial development today. Specifically, we use the following regression specification:

$$FDI_c = \alpha + \beta TSI_c + \boldsymbol{\Gamma} X_c' + \varepsilon_c \quad (1)$$

where the dependent variable, FDI_c, is one of the country-level (c) indicators of financial development: *Ln Private credit to GDP* or *Ln Financial system deposit to GDP*. The key explanatory variable is TSI_c from country *c*. Other explanatory variables, X_c', control for an assortment of country characteristics and $\boldsymbol{\Gamma}$ represents the vector of coefficients on these variables. In most specifications, we control for *Slave exports*, *French legal origin*, *Latitude*, *Independence*, *Settler mortality*, *Log(Population in 1400)*, *cultural controls*, *Longitude*, *SD of agriculture suitability index*, *SD of elevation*, *Min of monthly average rainfall*, *Max of monthly average humidity*, *Average temperature 1961-1990*, *Country area*, *Distance from coast*, and *Migratory distance from Addis Ababa*. In several specifications, we add control variables for *GDP per capita*, *GDP per capita growth* and *Inflation*. Our coefficient of interest is β, which measures the relationship between TseTse fly and modern financial development. Robust p-values that allow heteroskedasticity are reported in parentheses. We summaries our results in Figure 2.

As reported in Table 2, the TseTse fly measured by TSI_c is strongly, negatively associated with financial development today when either using *Ln Private credit to GDP* or *Ln Financial system deposit to GDP*. For example, consider the *Ln Private credit to GDP* regressions. TSI_c enters all regressions negatively and significantly at one percent level and the estimated coefficients are economically large. If Ghana, which is roughly at the 75th percentile of the cross-country distribution of the TseTse suitability index with a value of 0.46, were to move to the 25th percentile (-0.79), the coefficient estimates from column (2) imply that *Ln Private credit to GDP* would surge 130%, from the current value of 2.59 to 3.37. This indicates that private credit as a share of GDP in Ghana would increase from 13.38% to 29.08%, an effect even larger than the slave trade documented in Levine, Lin and Xie (2017). Furthermore, the results are robust without any control variables in column (1), when controlling for plausibly exogenous country traits such as *Slave exports*, *French legal origin*, *Latitude*, *Independence*, *Settler mortality*, *Log(Population in 1400)*, *cultural controls*, *Longitude*, *SD of agriculture suitability index*, *SD of elevation*, *Min of monthly average rainfall*, *Max of monthly average*

humidity, *Average temperature 1961-1990*, *Country area*, *Distance from coast*, and *Migratory distance from Addis Ababa* in column (2), and when further conditioning on *GDP per capita*, *GDP per capita growth* and *Inflation* in column (3).

In Table 3, we present results on other financial development indicators at the national level. We use the same model specification as model (1). $\boldsymbol{FDI_c}$ is either *Percent of firms with a bank loan/line of credit*, *Percent of firms using banks to finance investments*, *Proportion of investments financed internally*, *Proportion of investments financed by banks, Percent of firms using banks to finance working capital*, or *Proportion of working capital financed by banks*. Each cell in Table 3 represents a separate regression and the coefficient on *TSI* is reported. Robust p-values that allow heteroskedasticity are shown in parentheses. Out of 36 regressions reported in the table, *TSI* enters 32 significantly with expected sign at least at the 10 percent level and the estimated coefficients are economically non-trivial. Consider *Percent of firms with a bank loan/line of credit* regressions, for example. In column (6) when conditioning on our full set of controlling variables, the coefficient of *TSI* is -22.86 at the five percent significance level. This implies that if Ghana, which is roughly at the 75th percentile of the distribution of the TSI index, were to move to the 25th percentile (-0.79), the coefficient estimates from column (6) would indicate that the percentage of firms with a bank loan would increase by 28.58% (=1.25*22.86%), where the median value of *Percent of firms with a bank loan/line of credit* is 22.86%. Furthermore, the results are robust without any control variables in column (1), when controlling for plausibly exogenous country characteristics (*Slave exports*, *French legal origin,* and *Settler mortality*) in column (4), and when conditioning of the full set of control variables in column (6). Therefore, the negative association between the TseTse fly and overall financial development is not a simple manifestation of the impact of the slave trades on these other country traits[6].

B. Household Access to Finance

We next examine the link between TseTse suitability index and the degree to which household access finance today. We use the following linear regression:

$$HFDI_{i,c} = \alpha + \beta TSI_c + \boldsymbol{\Gamma} X_c' + \Lambda X_i' + \varepsilon_i \qquad (2)$$

[6] Our results remain consistent when we add a control variable for malaria. The results are tabulated in Table A23-A29 in the Online Appendix. Malaria refers to the malaria ecology index developed by Kiszewski et al. (2004). Livingstone (1857) mentions the TseTse 67 times in his work, Missionary Travels and Researches in South Africa; by contrast, malaria is mentioned 6 times.

where the dependent variable, $HFDI_{i,c}$, is one of the three indicators that measure the extent to which household *i* in country *c* has access to financial institutions and credit: *Account at a financial institution*, *Credit card* or *Borrow from a financial institution*. We use OLS regressions because they produce quantitatively similar results to a probit model, but easier to interpret (Angrist and Pischke, 2008), although the dependent variables are binary. Our results are robust when use probit regressions and tabulated in Table A2 in Online Appendix.

With respect to the explanatory variables, the country-level variables—TSI_c and X_c'—are the same as those used in the estimation of equation (1) but equation (2) also includes household-level controls, where X_i' are the individual-level control variables, and Π represents the vector of coefficients on these individual-level controls. For X_i', we include the respondent's *education*, *income*, *gender*, *age* and *age-squared*. Our coefficient of interest is β, which measures the relationship between the TseTse fly and household access to financial market and credit. We report heteroskedasticity consistent p-values, where the standard errors are clustered at the country level.

The results in Table 4 indicate that the TseTse suitability index is negatively associated with household access to credit across Africa. *TSI* enters negatively and significantly in all of the regressions. This holds when the dependent variable is either *Account at a financial institution*, *Credit card* or *Borrow from a financial institution*. In terms of the economic size of the coefficients, consider *Borrow from a financial institution* regressions. If we were to move Ghana, which is roughly at the 75th percentile of the cross-country distribution of the *TSI* with a value of 0.46, to the 25th percentile (-0.79), the coefficient estimates from column (6) would imply that the probability that an average person in Ghana would have received a loan from a formal financial institution would increase by almost 8.8% (=0.07*1.25), which amounts to 73% of sample mean. In Levine, Lin and Xie (2017), if a country were to move from the 75th percentile of the cross-country distribution of *Slave exports* (6.66) to the 25th percentile (-1.47), the probability that an average person in that country would have received a loan from a formal financial institution would rise by almost 4 percentage points, which accounts for about 50% of their sample mean. We therefore stress that the effects of the TseTse fly on modern financial institution is no less, if not stronger, than those of the slave trade during the half a millennium from 1400 until 1900. When we restrict the sample to the households

with top 40% income, which are more likely to have demand for financial service, the results remain consistent[7].

C. Firm Access to Finance

We next assess the relationship between the TseTse fly and firm access to finance from formal financial institutions and from each other through trade credit. We begin with the following regression equation:

$$F_{f,c} = \alpha + \beta TSI_c + \boldsymbol{\Gamma} X_c' + \boldsymbol{\Phi} X_f' + \boldsymbol{\Psi} + \varepsilon_f \quad (3)$$

where the dependent variable, $F_{f,c}$, is either *Working capital financed from banks*, *Investment financed from banks*, *Trade payable*, or *Trade receivable* for firm *i* in country *c*. The key explanatory variable is $\boldsymbol{TSI_c}$ from country *c*. X_c' controls for an assortment of country characteristics, including *Slave exports*, *French legal origin*, *Latitude*, *Independence*, *Settler mortality*, *Log(Population in 1400)*, *cultural controls*, *Longitude*, *SD of agriculture suitability index*, *SD of elevation*, *Min of monthly average rainfall*, *Max of monthly average humidity*, *Average temperature 1961-1990*, *Country area*, *Distance from coast*, and *Migratory distance from Addis Ababa* and $\boldsymbol{\Gamma}$ represents the vector of coefficients on these variables. The regressions also control for firm-specific characteristics, X_f', *Firm size, Firm age, Government, Private*, *Foreign*, *Exports, Sales growth, Business group* and *CEO experience*, with their corresponding coefficient vector $\boldsymbol{\Phi}$. In addition, we include industry and year fixed effects, as denoted by $\boldsymbol{\Psi}$, to account for time-invariant factors within the same industry (at the three-digit International Standard Industrial Classification (ISIC) level), and common time-varying factors. We report heteroskedasticity robust p-values, where the standard errors are clustered at the country level[8].

As reported in Table 5, we find that firms tend to receive much less financing from banks today in countries that are more suitable to TseTse fly. As shown in Panel A of Table 5 columns (1) and (3) or (2) and (4), whether excluding or including controls for macroeconomic factors, *TSI* enters negatively and significantly at one percent level when dependent variable is either *Working*

[7] Our results remain either unchanged or even stronger when we use Levine, Lin and Xie (2017)'s full set of control variables. We tabulate these results in Table A3 in Online Appendix.
[8] We also multi-cluster standard errors at both industry and country levels, using code developed by Cameron, Gelbach, and Miller (2011). The coefficients on TSI either change little or become stronger. We tabulate these results in Table A4 in the Online Appendix.

capital financed from banks or *Investment financed from banks*. The estimated coefficients are economically large[9]. Consider, for example, the coefficients reported in Panel A column (2) and (4) where the full set of control variables are included. They indicate that if Ghana (0.46), which is roughly at the 75th percentile of the distribution of the TSI index, were to move to the 25th percentile (-0.79), the percentage of working capital and fixed investment financed from banks for an average firm in Ghana would rise by 9.9% (=7.92*1.25) and 14.19% (=11.35*1.25), which both exceed the sample mean by a large margin (5.98% and 10.72% respectively). Furthermore, we find that the TseTse suitability index is negatively associated with the degree to which a firm provides trade credit to (*Trade receivable*) and receives trade credit from (*Trade payable*) other firms in columns (5) – (8).

An alternative interpretation for these results is that it could be a demand side rather than a supply side effect. Perhaps, cross-country variations in the environment for TseTse fly influence the nature of production in economies and firms' demand of bank credit. To alleviate this concern, we conduct similar test as in Pierce and Snyder (2017). If indeed our results are driven by this demand side effects, we should observe a negative relationship between the TseTse suitability index and firms reporting that they do not need bank finance because they have sufficient internal funds. We use the following regression to conduct this test:

$$R_{f,c} = \alpha + \beta TSI_c + \boldsymbol{\Gamma} X_c' + \boldsymbol{\Phi} X_f' + \boldsymbol{\Psi} + \varepsilon_f \quad (4)$$

where the dependent variable, $R_{f,c}$, is one of the binary indicators of the reasons that a firm *f* in country *c* didn't apply for a bank loan: *Apply for any loan last year*, *No need for a loan, Complex application procedures, Unfavourable interest rate, High collateral requirements, Insufficient size, Would not approve* or *Others*. All other variables in equation (4) are the same from equation (3). As shown in Table 6, we do not find any significant coefficients between the *TSI* and any of these indicators. The alternative interpretation is therefore not plausible.

Furthermore, we find that the TseTse suitability index is negatively associated with the degree to which a firm provides trade credit to (*Trade receivable*) and receives trade credit from (*Trade payable*) other firms. Consistent with the earlier findings, the regressions in columns (5) – (8) Table

[9] When we apply the set of control variables used in Levine, Line and Xie (2017), our results remain qualitatively unchanged. The results are tabulated in Table A5 in the Online Appendix.

5 Panel A show that the *TSI* index enters negatively and significantly in all the Trade receivable and Trade payable regressions.

D. Firm Access to Finance: Differentiating by Industry

We next explore whether the associations between TseTse fly and (a) firm access to formal credit and (b) firm access to and provision of trade credit vary across industries in a theoretically predictable manner. In particular, if TseTse fly has had enduring, deleterious effects on the financial system in a manner that impedes firms from obtaining external finance, then the relationship between TseTse fly and firm financing should be especially pronounced in industries that depend, for technological reasons, on external credit.

We use the approach invented by Rajan and Zingales (1998) and further developed in African settings by Pierce and Snyder (2017)[10] to examine the relationship between finance and TseTse fly across different sectors. In this approach, we first identify sector-level effects on specific financial channels in the most frictionless financial market in sub-Saharan Africa, South Africa, which had the lowest score of the TSI index. We do so by regressing the firm-level access-to-finance variables on the full set of firm-level control variables and the industry indicators at the three-digit ISIC level. The model is as following:

$$F_f = \alpha + \boldsymbol{\Phi} X_f' + \boldsymbol{\Omega} X_s' + \varepsilon_f \quad (5)$$

where the dependent variable, F_f, is either *Working capital financed from banks*, *Investment financed* from *banks*, *Trade payable*, or *Trade receivable* for firm *i* in South Africa. X_f' represents a set of firm-specific characteristics including *Firm size*, *Firm age*, *Government*, *Private*, *Foreign*, *Exports*, *Sales growth*, *Business group* and *CEO experience*, with their corresponding coefficient vector $\boldsymbol{\Phi}$. X_s' is a set of industry dummy variables and $\boldsymbol{\Omega}$ is a vector that contains their respective coefficients. The observations and adjusted R-squares are reported in Table A6 in the Online Appendix. Of the four variables used in

[10] We note that Pierce and Snyder (2017) show that South Africa has the lowest reported level of access to finance as a business obstacle in the World Bank *Enterprise Survey*. Furthermore, its size provides sufficient observations in the World Bank *Enterprise Survey* data to estimate sector-specific effects on access to finance. They also stress that the United States, as used in Rajan and Zingales (1998), cannot be used here because the World Bank *Enterprise Survey* does not cover the US. Furthermore, sector-specific trade credit in South Africa is more likely to be similar to other African countries than would sectors from the US.

earlier regressions, *Trade receivable* is most significantly explained by industry factors, with more than double the adjusted R-squared of *Working capital financed from banks* and *Investment financed*. For example, while industry indicators explain only 5% of the variation in *Working capital financed from banks*, it explains approximately 22.20% of the variation in *Trade receivable*. *Trade receivable* therefore provides the best variation across sectors within a country, we use it to estimate industry-specific effects of the TseTse fly across Africa.

We use the following regression specification to assess the relationship between firm financing and the slave trade while differentiating by industry:

$$F_{f,c} = \alpha + \beta TSI_c * \Omega_f + \boldsymbol{\Gamma} X_c' + \boldsymbol{\Phi} X_f' + \boldsymbol{\Upsilon} + \varepsilon_f \quad (6)$$

where the dependent variable, $F_{f,c}$, is either *Working capital financed from banks*, *Investment financed* from *banks*, *Trade payable*, or *Trade receivable* for firm *f* in country *c*. The key explanatory variable is the interaction term, $TSI_c * \Omega_f$, where Ω_f is either the industrial coefficients from model (5) or a binary indicator that equals one if the industry coefficient is above the median value and zero otherwise, indicating the nature of firm *f*'s industry. The country-level and firm-level explanatory variables (X_c' and X_f', respectively) are the same as in equation (3). In these interaction term analyses, we also include several fixed effects, as represented by Υ. In particular, we control for country, industry, and year fixed effects. As a result, the *TSI* drops as a regressor and the country-level controls only include the time-varying Macroeconomic controls: GDP per capita, GDP per capita growth, and Inflation. Similarly, Ω_f drops from the regression when including industry fixed effects. We report heteroskedasticity robust p-values in the parentheses, with standard errors clustered at the country level[11]. Results are summarised in Figure 3 and reported in Panel B Table 5.

As reported in Panel B of Table 5, the relationships between TseTse fly and the firm financing indicators vary across industries in a manner that is fully consistent with the theoretical prediction articulated above. In particular, the *TSI*Dependence on sales credit_dummy* (and *TSI*Dependence on sales credit* reported in Table A7 in the Online Appendix) enters negatively and significantly in all regressions at least at five percent level, indicating that the relationship between

[11] We also report results using multi-clustered standard errors at both industry and country levels in Table A8 in the Online Appendix.

TseTse fly and firm access finance is especially strong in industries that naturally depend heavily on external credit. The estimated economic magnitudes are large. For example, consider the estimates from column (4) of Table 5 Panel B, in which the dependent variable is *Investment financed from banks*. If, for example, Ghana (0.46), which is roughly at the 75th percentile of the distribution of the TSI index, were to move to the 25th percentile (-0.79), the average percentage of fixed investment financed by banks for an industry that is more dependent on external credit (at the 75 percentile of the distribution of *Dependence on sales credit_dummy*) would rise by 4.35% (=1.25*1*3.48) higher than that of an industry with less dependence on external credit (at the 25 percentile of the distribution of *Dependence on sales credit_dummy*). This magnitude is considerable, given that the sample average of investment financed from banks equals 10.72%. Thus the relationship between the TseTse fly and the financing of firms today holds more strongly among firms in industries that rely heavily, for technological reasons, on external credit, which is consistent with the view that the TseTse fly had enduring, harmful effects on the operation of financial systems.

V. Mechanisms Linking TseTse Fly and Modern Finance

We now examine three mechanisms through which the historical TseTse fly might continue to influence modern financial systems across Africa.

A. Ethnic Fragmentation

We assess the link between the TseTse suitability index and country-level ethnic fragmentation using the following cross-country OLS regressions:

$$Ethnic\ Fragmentation_c = \alpha + \beta TSI_c + \boldsymbol{\Gamma} X_c' + \varepsilon_c \quad (7)$$

where the dependent variable, $Ethnic\ Fragmentation_c$, is one of four measures of ethnic fragmentation a country: *Ln Number of languages*, which equals the natural logarithm of the number of languages with at least 1000 speakers within a country, *Ethnic fragmentation*, equals the probability that two randomly selected individuals in a country will not speak the same language, *ELF7* and *ELF9*. As noted above, *ELF7* and *ELF9* are two measures of linguistic diversity from Desmet, Ortuño-Ortín, and Wacziarg (2011). These authors use information on language trees from the Ethnologue dataset to produce estimates of ethnolinguistic fractionalization at different levels of

linguistic aggregation depending on how finely or coarsely language groups are defined. The other explanatory variables, X_c', are the same as those used above.

As reported in Table 7, the TseTse suitability index is strongly, positively associated with ethnic fragmentation today. The *TSI* enters negatively and significantly in all regressions when the dependent variable is either *Ln Number of languages*, *Ethnic fragmentation*, *ELF7* and *ELF9*. The estimated coefficients are economically large. To illustrate the economic magnitudes, we use the same hypothetical example from above: If Ghana (0.46), which is roughly at the 75th percentile of the distribution of the TSI index, were to move to the 25th percentile (-0.79), the coefficient estimate on the *TSI* index (1.26) from column (3) would imply that *Ln Number of languages* would rise by 1.58 (=1.25*1.26). This is equivalent to a 4.85 times ($=e^{1.58}$) increase from 69 to roughly 335 language spoken in Ghana.

These findings are consistent with the view that one mechanism through which the TseTse fly continues to influence modern finance is its effects on ethnic fragmentation. This view emphasizes that ethnic groups in TseTse-infested areas were more likely to rely on hunting and gathering (i.e., foraging) and therefore divided into small bands. This consequently solidified and perpetuated narrow ethnic identities (Alsan, 2015) and created ethnically fragmented societies that (1) stymie the development of institutions associated with property rights protection and contract enforcement; (2) form weak social cohesion that tends to have deleterious effects on the development of institutions conducive to inter-clan transactions; and (3) create unfamiliar counterparties and intertemporal exchange that impede financial development. The positive association between TseTse fly and ethnic fragmentation confirms the latter as a mechanism linking TseTse fly and modern financial development across Africa.

B. Precolonial Political Centralization

We next examine the relationship between the TseTse fly and precolonial political centralization using the following regression equation:

$$Precolonial\ Political\ Centralization_c = \alpha + \beta TSI_c + \boldsymbol{\Gamma} X_c' + \varepsilon_c \qquad (8)$$

where the dependent variable, $Precolonial\ Political\ Centralization_c$, is one of two measures of precolonial political centralization in country c: *Precolonial jurisdictional hierarchy* or *Precolonial political*

centralization. The other explanatory variables, X_c', are the same as those used above. Our coefficient of interest is β, which measures the relationship between TseTse fly and precolonial centralization in financial institutions. We conduct the estimation using an OLS model with heteroskedasticity robust standard errors.

As shown in Table 8, the TseTse suitability index is strongly, negatively associated with precolonial political centralization. The *TSI* enters negatively and significantly in all regressions when the dependent variable is either *Precolonial jurisdictional hierarchy* or *Precolonial political centralization*. To illustrate the economic magnitudes, consider the estimates from column (6). If Ghana (0.46), which is roughly at the 75th percentile of the distribution of the TSI index, were to move to the 25th percentile (-0.79), *Precolonial jurisdictional hierarchy* would rise by 0.95 (=1.25*0.76), which would further imply that precolonial political hierarchy of an average ethnic group in Ghana would change from chiefdoms (2.05) to large states (=2.05+0.95).

These findings suggest precolonial political centralisation as a mechanism through which the TseTse fly continues to shape modern financial systems across Africa. Herbst (2000) and Alsan (2015) demonstrate that TseTse fly discouraged ethnic groups to form a centralized society that are essential for the development of economic and financial institutions. In turn, we discover that the TseTse fly is negatively associated with precolonial political centralization.

C. Trade

We next examine the relationship between the African TseTse fly and trade using the following OLS regression models:

$$Contract\ Enforcement_c = \alpha + \beta TSI_c + \boldsymbol{\Gamma} X_c' + \varepsilon_c \quad (9)$$

where the dependent variable, $Contract\ Enforcement_c$, is one of two measures of the quality of contract enforcement in country *c*: *Enforcing contracts distance to frontier (DTF)* or *Enforcing contracts rank*. The other explanatory variables, X_c', are the same as those used above. Our coefficient of interest is β, which measures the relationship between TseTse fly and the quality of contract enforcement. As discussed above, data on cross-country trade in precolonial Africa is scarce The only data related with precolonial trade, the distance from each country to the pre-600 CE and

1800 CE trade networks, only covers small parts of the non-tropical areas in North Africa. We thus use two contract enforcement measurements to test the trade channel.

As reported in Table 9, we do not find strong, robust connection between TseTse fly and contract enforcement. The *TSI* enters significantly and negatively in four out of six regressions. When conditioning on macroeconomic factors, however, the coefficient on the TseTse fly becomes insignificant, although maintains the expected sign. These results therefore should be interpreted with caution, because an alternative explanation could be that the TseTse fly exerts influence on modern economic development, which in turn has a spill-over effects on the quality of contract enforcement today.

VI. Conclusion

In this paper, we focus on the historical TseTse fly, which Alsan (2015) shows has had an enduring effect on African development through precolonial institutions and culture. We provide original evidence on the link between the TseTse fly and key institutions that hold back modern financial systems. The results shed light on the literature in search for the historical determinants of modern financial development and the influencing channels. With respect to the historical determinants, we show that the TseTse is negatively associated with firm access to credit, household access to credit and overall financial development. We further show that the negative association between the TseTse and firm access to credit varies in a theoretically predictable manner, as the association is especially pronounced among firms that depend heavily on external finance for technological reasons.

With respect to the influencing channels, we evaluate three potential mechanisms linking the historical TseTse fly to modern finance. A large body of evidence indicates that ethnic fragmentation that hinders the development of institutions that protect property rights and enforce contract, precolonial political centralization that facilitates public goods provision, and the quality of contract enforcement influence the operation of modern financial systems. We discover that the TseTse fly is strongly, positively related to ethnic fragmentation and negatively associated with precolonial political centralization but is not strongly related to trade and modern contract enforcement. These findings are consistent with the view that two mechanisms through which the historical TseTse fly continues to influence modern financial systems across Africa are ethnic fragmentation and precolonial political centralization.

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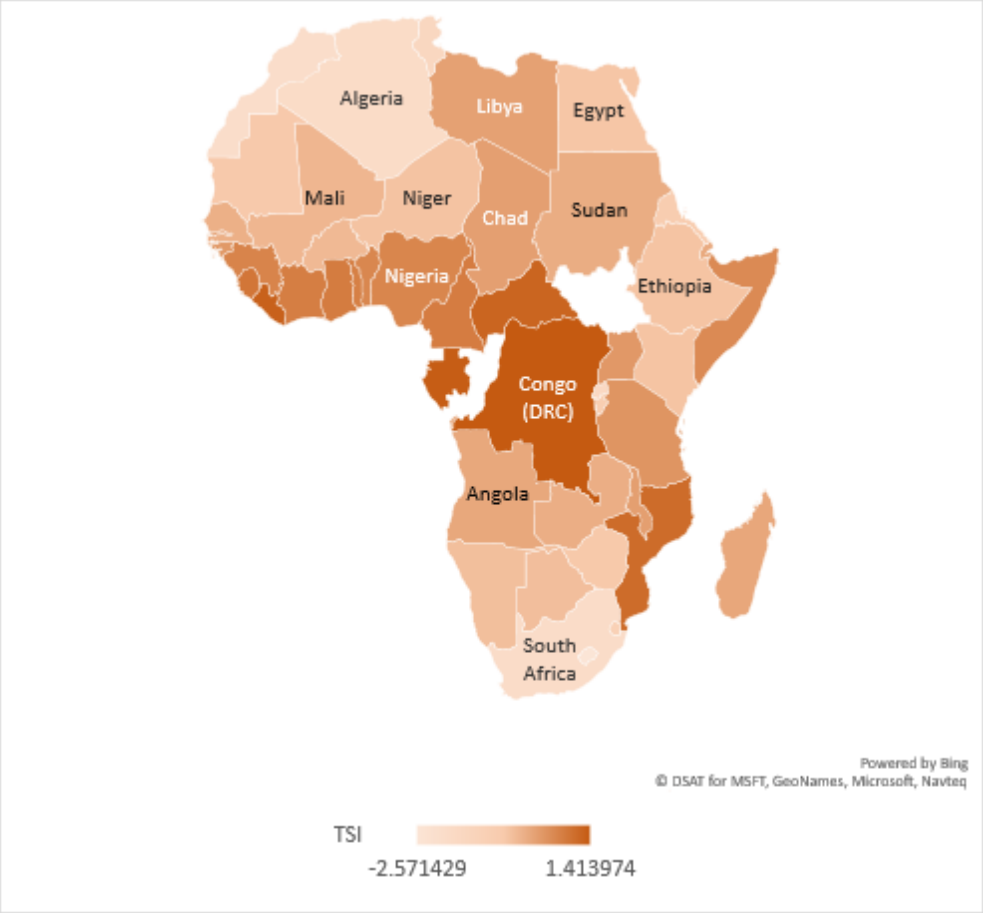
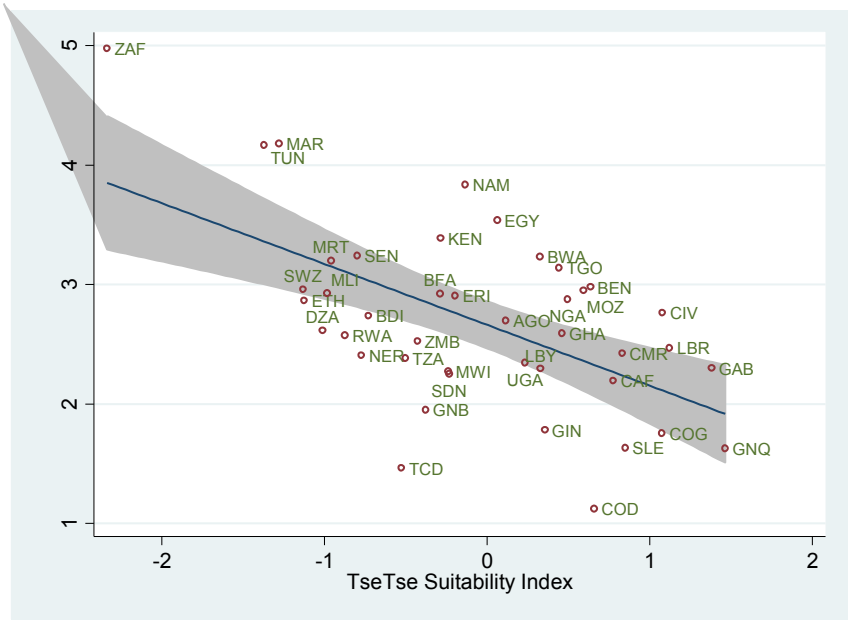
Figure 1 TseTse Suitability Index (TSI) in Africa



Note: Data are from Alsan (2015). Countries in white are not included in Alsan's dataset.

Figure 2: TseTse and Overall Financial Development

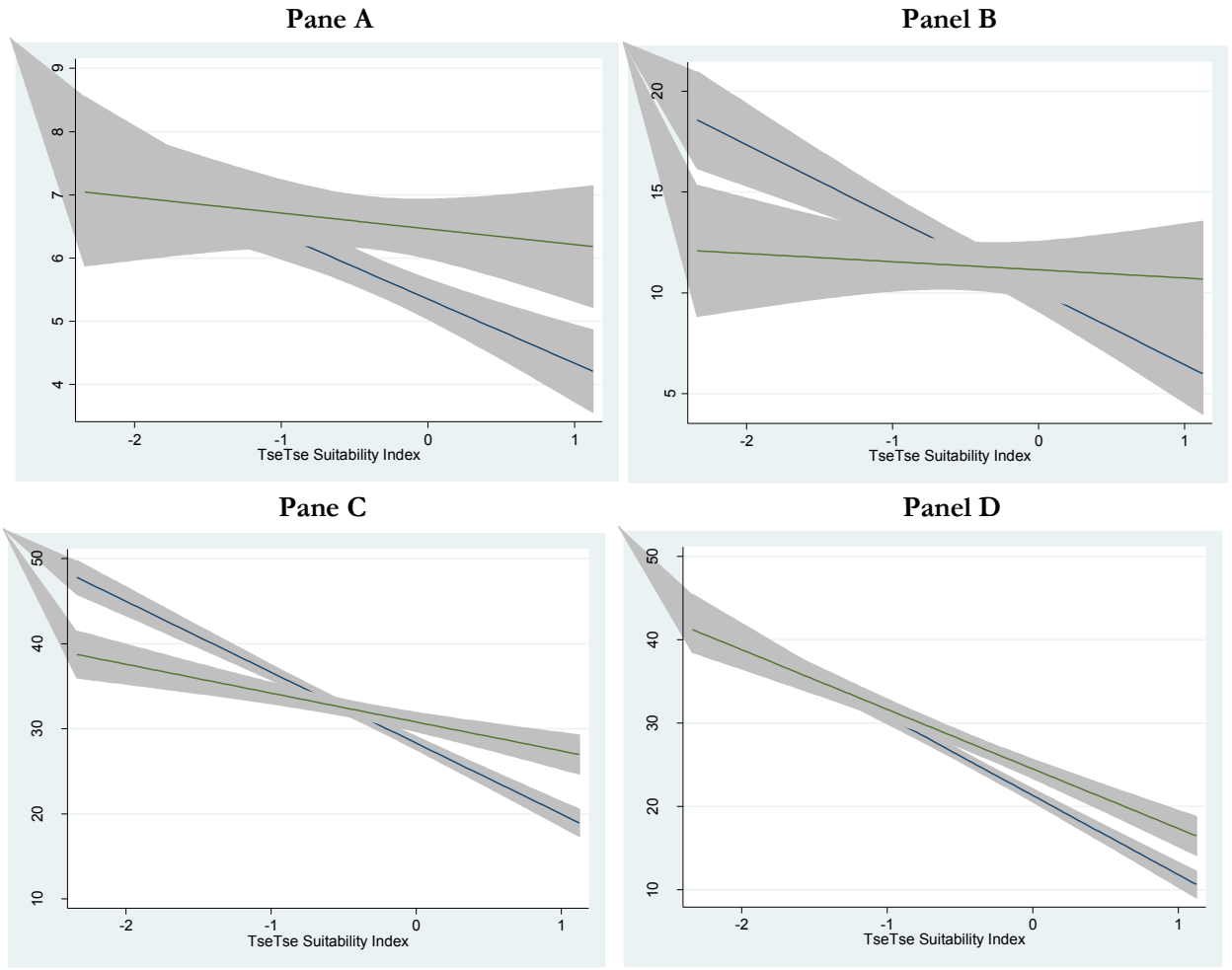
Panel A. TseTse and Private Credit to GDP



Panel B. TseTse and Financial System Deposit

Note: Data are from Alsan (2015) and Global Financial Development Database (2017). Small changes to positions of countries made to prevent overlap.

Figure 3: TseTse and Access to Finance: Differentiating by Industry



Note: Data are from Alsan (2015) and World Bank Enterprise Surveys. Blue line represents firms located in industries that are more dependent on external finance, while green line represents firms located in industries that are less dependent on external credit. Small changes to positions of countries made to prevent overlap. X-axis represents the TseTse suitability index and Y-axis is firm's *Working capital financed from banks* in Panel A, firm's *Investment finance from banks* in Panel B, *Trade receivables* in Panel C and *Trade receivables* in Panel D.

Table 1: Summary Statistics

Variable	N	Mean	SD	Min	P25	P50	P75	Max
Country-level variables								
TSI	44	-0.08	0.84	-2.34	-0.79	-0.16	0.54	1.46
TSI_intrinsic	44	0.41	0.14	0.09	0.24	0.39	0.51	0.67
TSI_perturbed	44	-0.04	0.88	-2.35	-1.79	0.22	0.36	1.70
Ln Private credit to GDP	42	2.70	0.76	1.12	2.29	3.00	2.98	4.97
Ln Financial system deposit to GDP	43	3.09	0.58	1.65	2.76	3.00	3.45	4.39
% of firms with a bank loan/line of credit	40	22.86	14.84	2.70	10.30	21.50	29.25	61.10
% of firms using banks finance investments	40	18.96	11.82	0.70	9.65	16.25	25.65	55.10
% of investments financed internally	40	75.60	11.54	44.80	67.15	76.55	84.20	94.00
% of investments financed by banks	40	10.01	7.50	0.80	3.65	7.85	14.45	25.80
% of firms using banks finance work capital	40	22.38	14.42	1.10	11.60	19.90	30.70	57.90
% of working capital financed by banks	40	8.63	5.88	0.10	3.90	6.90	13.15	21.40
Ln Number of languages	44	3.15	1.40	0.00	2.25	3.40	4.09	6.13
Ethnic fragmentation	37	0.60	0.28	0.00	0.51	0.71	0.81	0.89
ELF7	45	0.46	0.33	0.00	0.12	0.51	0.76	0.90
ELF9	45	0.57	0.30	0.00	0.32	0.66	0.82	0.95
Precolonial political centralization	44	0.45	0.33	0.00	0.21	0.35	0.67	1.00
Precolonial jurisdictional hierarchy	43	2.38	0.64	1.14	2.00	2.29	2.64	4.00
Enforcing contracts DTF	44	47.59	9.71	26.26	40.97	48.28	55.62	62.34
Enforcing contracts rank	44	22.50	12.85	1.00	11.50	22.50	33.50	44.00
GDP per capita	44	7.09	1.10	5.45	6.20	6.86	7.92	9.83
GDP per capita growth	43	2.16	2.50	-8.16	1.08	2.27	3.38	7.68
Inflation	43	0.08	0.05	0.01	0.04	0.07	0.12	0.21
Slave exports	42	9.96	3.35	3.91	7.54	10.87	12.82	14.40
Settler mortality	32	5.48	1.07	2.74	5.04	5.63	6.09	7.99
French legal origin	42	0.62	0.49	0.00	0.00	1.00	1.00	1.00
Catholic	37	22.39	22.96	0.10	2.20	18.50	31.40	78.30
Muslim	37	33.81	36.47	0.00	0.90	16.20	69.00	99.40
Other religions	37	29.94	19.93	0.30	15.90	24.70	48.30	64.10
Absolute latitude	44	13.01	9.02	0.64	6.26	11.91	18.27	33.96
Longitude	42	14.36	17.23	-14.97	-1.21	16.22	29.89	45.93
Year of independence	43	1957	22.18	1855	1960	1960	1963	1993
Population density in 1400	42	0.37	1.17	-2.12	-0.47	0.43	1.21	3.04
SD of agriculture suitability index	44	0.17	0.09	0.02	0.11	0.16	0.22	0.38
SD of elevation	44	0.24	0.15	0.04	0.14	0.21	0.32	0.62
Min of monthly average rainfall	42	7.24	11.45	0.00	0.00	1.50	13.00	46.00
Max of monthly average humidity	42	71.60	12.31	35.00	67.00	72.50	79.00	95.00
Average temperature 1961-1990	44	24.16	2.94	18.22	21.60	24.62	26.80	28.74
Country area	44	1.10	1.28	-1.76	0.30	1.35	2.13	3.12
Distance from coast	44	0.47	0.32	0.07	0.17	0.42	0.73	1.14
Migratory distance from Addis Ababa	44	3.29	1.53	0.10	2.20	3.29	4.39	5.82

Household-level variables								
Account at a financial institution	34094	0.29	0.45	0	0	0	1	1
Credit card	33538	0.04	0.19	0	0	0	0	1
Borrow from financial institutions	33866	0.07	0.25	0	0	0	0	1
Education	34092	1.52	0.61	1	1	1	2	5
Gender	34094	1.49	0.50	1	1	1	2	2
Age	34064	34.65	15.14	15	23	30	43	99
Income	34094	3.24	1.43	1	2	3	5	5
Firm-level variables								
Working capital financed from banks	31414	5.98	14.12	0	0	0	0	50
Investment financed from banks	13032	10.72	26.72	0	0	0	0	100
Trade payable	27629	25.12	32.67	0	0	5	50	100
Trade receivable	31428	27.26	32.68	0	0	10	50	100
Firm size	33744	1.54	0.71	1	1	1	2	3
Firm age	32964	1996	11.21	1968	1991	1999	2004	2010
Sales growth	33724	0.20	0.23	-0.16	0.01	0.19	0.39	0.67
Government ownership	33138	0.78	6.56	0	0	0	0	100
Foreign ownership	33105	10.82	28.72	0	0	0	0	100
Private ownership	33137	83.73	34.41	0	100	100	100	100
Export	32886	3.06	9.63	0	0	0	0	40
Business group	32527	1.78	0.41	1	2	2	2	2
CEO experience	33010	14.94	9.47	3	7	13	20	35
Apply for any loan last year?	32659	0.19	0.39	0	0	0	0	1
No need for a loan	33752	0.37	0.48	0	0	0	1	1
Complex application procedures	33752	0.10	0.30	0	0	0	0	1
Unfavourable interest rate	33752	0.12	0.32	0	0	0	0	1
High collateral requirements	33752	0.08	0.27	0	0	0	0	1
Insufficient size	33752	0.01	0.12	0	0	0	0	1
Would not approve	33752	0.04	0.19	0	0	0	0	1
Others	33752	0.05	0.22	0	0	0	0	1
Industrial-level variables								
Dependence on sales credit	80	-16.55	41.80	-127.9	-91.49	-14.16	4.94	126.6
Dependence on sales credit dummy	80	0.50	0.50	0	0	0.5	1	1

Note: See Table A1 in the Online Appendix for detailed description of variables and the sources for each variable.

Table 2: TseTse and Country-level Financial Development

This table reports OLS regression results of overall financial development on the TseTse fly suitability index. The dependent variable is *Ln Private credit to GDP* in columns 1-3, and *Ln Financial system deposit to GDP* in columns 4-6, both of which are averaged across 2006-2014. The key explanatory variable, *TSI*, is from Alsan (2015) and equals the standardized value (Z-score) of the fly's steady-state population derived from insect growth modelling, gridded climate data, and geospatial data for each country. *Slave exports* is from Nunn (2008) and equals the natural logarithm of the total number of slaves exported from each country between 1400 and 1900 normalized by land area .*French legal origin* is an indicator that equals one if a country's commercial code has a French legal origin, and zero otherwise. *Latitude* equals the logarithm of the absolute distance between each country and the equator. *Independence* equals the first year a country obtained its independence. *Settler mortality* equals the annualized death rate of European soldiers in European colonies in the early 19th century. *Log (Population in 1400)* equals the logarithm of population density in 1400. *GDP per capita* equals the natural logarithm of gross domestic product per capita (current US dollars); *GDP per capita growth* is the average annual growth rate in gross domestic product per capita, both averaged over 2006-2014. *Culture controls* include percentage of population that follows (a) Catholic, (2) Muslim, and (3) Other religions including Protestant religion in 1980. *Inflation* equals the average annual inflation rate (GDP deflator) over 2006-2014. *Other geography controls* includes *SD of agriculture suitability index*, *SD of elevation*, *Longitude, Country area*, *Distance from coast*, and *Migratory distance from Addis Ababa*. Other climate controls includes *Min of monthly average rainfall*, *Max of monthly average humidity* and *Average temperature 1961-1990*. See the Table A1 in the Online Appendix for more detailed variable definitions and data sources. P-values calculated using heteroskedasticity robust standard errors are reported in parentheses. *, **, and *** indicate significance at 10%, 5%, and 1%.

	Dependent variable					
	Ln Private credit to GDP			*Ln Financial system deposit to GDP*		
	Mean: 2.70			Mean: 2.75		
	(1)	(2)	(3)	(4)	(5)	(6)
TSI	-0.51***	-1.04***	-1.18***	-0.24**	-0.56*	-0.98***
	[0.00]	[0.00]	[0.01]	[0.01]	[0.06]	[0.01]
Slave exports		-0.24**	-0.23**		-0.11	-0.10
		[0.02]	[0.05]		[0.22]	[0.21]
French legal origin		0.15	0.29		0.20	0.05
		[0.60]	[0.57]		[0.54]	[0.92]
Latitude		0.01	0.01		-0.01	-0.01
		[0.75]	[0.75]		[0.80]	[0.75]
Independence		0.01	0.01		0.00	0.01
		[0.34]	[0.29]		[0.73]	[0.27]
Settler mortality		0.05	0.09		-0.03	0.01
		[0.68]	[0.51]		[0.91]	[0.97]
Log (Population in 1400)		0.16	0.18		0.30	0.44**
		[0.30]	[0.38]		[0.16]	[0.04]
GDP per capita			0.08			0.12
			[0.61]			[0.48]
GDP per capita growth			-0.06			-0.15**
			[0.50]			[0.03]
Cultural controls	No	Yes	Yes	No	Yes	Yes
Other geography controls	No	Yes	Yes	No	Yes	Yes
Other climate controls	No	Yes	Yes	No	Yes	Yes
Inflation	No	No	Yes	No	No	Yes
Observations	42	29	29	40	29	29

R-squared	0.312	0.847	0.826	0.104	0.668	0.807
Unit of analysis	Country	Country	Country	Country	Country	Country
Standard errors	Robust	Robust	Robust	Robust	Robust	Robust
Specifications	OLS	OLS	OLS	OLS	OLS	OLS

Table 3: Further Evidence on TseTse and Country-level Financial Development

This table reports OLS regression results of overall financial development on the TseTse fly suitability index. Each cell represents a separate regression. We report the coefficient on the key explanatory variable, *TSI*, from each regression. The dependent variable is either *Percent of firms with a bank loan/line of credit*, *Percent of firms using banks to finance investments*, *Proportion of investments financed internally (%)*, *Proportion of investments financed by banks (%)*, *Percent of firms using banks to finance working capital*, and *Proportion of working capital financed by banks (%)*. The *TSI* is from Alsan (2015) and equals the standardized value (Z-score) of the fly's steady-state population derived from insect growth modelling, gridded climate data, and geospatial data for each country. *Slave exports* is from Nunn (2008) and equals the natural logarithm of the total number of slaves exported from each country between 1400 and 1900 normalized by land area .*French legal origin* is an indicator that equals one if a country's commercial code has a French legal origin, and zero otherwise. *Settler mortality* equals the annualized death rate of European soldiers in European colonies in the early 19th century. *Culture controls* include percentage of population that follows (a) Catholic, (2) Muslim, and (3) Other religions including Protestant religion in 1980. *Other controls* include *Latitude, Independence, Log (Population in 1400), SD of agriculture suitability index*, *SD of elevation*, *Longitude, Country area*, *Distance from coast*, *Migratory distance from Addis Ababa*, *Min of monthly average rainfall*, *Max of monthly average humidity* and *Average temperature 1961-1990*. *GDP per capita* equals the natural logarithm of gross domestic product per capita (current US dollars); *GDP per capita growth* is the average annual growth rate in gross domestic product per capita, both averaged over 2006-2014. *Inflation* equals the average annual inflation rate (GDP deflator) over 2006-2014. See the Table A1 in the Online Appendix for more detailed variable definitions and data sources. P-values calculated using heteroskedasticity robust standard errors are reported in parentheses. *, **, and *** indicate significance at 10%, 5%, and 1%.

Dependent variable		Independent variable: TSI					
Name	Mean	(1)	(2)	(3)	(4)	(5)	(6)
Percent of firms with a bank loan/line of credit	22.86	-7.76***	-4.86**	-4.78**	-7.90***	-23.37***	-22.86**
		[0.00]	[0.02]	[0.02]	[0.00]	[0.00]	[0.04]
Percent of firms using banks to finance investments	18.96	-6.18***	-4.60**	-4.61*	-7.91**	-15.97**	-10.64
		[0.00]	[0.05]	[0.05]	[0.01]	[0.04]	[0.40]
Proportion of investments financed internally (%)	75.60	5.23**	2.87*	2.92	4.26**	9.76**	10.47
		[0.01]	[0.09]	[0.10]	[0.04]	[0.02]	[0.31]
Proportion of investments financed by banks (%)	10.01	-4.12***	-2.83**	-2.85**	-4.50***	-11.13***	-5.30
		[0.00]	[0.02]	[0.02]	[0.00]	[0.01]	[0.23]
Percent of firms using banks to finance working capital	22.38	-6.72***	-4.62*	-4.55*	-9.05***	-20.94***	-26.51**
		[0.01]	[0.07]	[0.07]	[0.00]	[0.00]	[0.01]
Proportion of working capital financed by banks (%)	8.63	-2.67**	-1.79*	-1.76*	-3.43***	-10.85***	-11.37***
		[0.01]	[0.08]	[0.07]	[0.00]	[0.00]	[0.00]
Slave exports	N/A	No	Yes	Yes	Yes	Yes	Yes
French legal origin	N/A	No	No	Yes	Yes	Yes	Yes
Settler mortality	N/A	No	No	No	Yes	Yes	Yes
Cultural controls	N/A	No	No	No	No	Yes	Yes

Other controls	N/A	No	No	No	No	Yes	Yes
GDP per capita; GDP per capita growth, Inflation	N/A	No	No	No	No	No	Yes

Table 4: TseTse and Household-level Financial Development

This table reports OLS regression results of overall financial development on the TseTse fly suitability index at individual-level. The dependent variables are *Account at a financial institution* in columns 1-2, *Credit card* in columns 3-4, and *Borrow from a financial institution* in column 5-6. The key explanatory variable, *TSI*, is from Alsan (2015) and equals the standardized value (Z-score) of the fly's steady-state population derived from insect growth modelling, gridded climate data, and geospatial data for each country. *Slave exports* is from Nunn (2008) and equals the natural logarithm of the total number of slaves exported from each country between 1400 and 1900 normalized by land area. *Individual controls* include a gender indicator, age, age squared, education, and five household income level fixed effects (the omit group: Income (richest 20%)). *French legal origin* is an indicator that equals one if a country's commercial code has a French legal origin, and zero otherwise. *Settler mortality* equals the annualized death rate of European soldiers in European colonies in the early 19th century. *Macroeconomic controls* include *GDP per capita*, *GDP per capita growth* and *Inflation. Culture controls* include percentage of population that follows (a) Catholic, (2) Muslim, and (3) Other religions including Protestant religion in 1980. *Geo & Climate controls* include *Latitude, Log (Population in 1400)*, *Independence, SD of agriculture suitability index*, *SD of elevation*, *Longitude, Country area*, *Distance from coast*, *Migratory distance from Addis Ababa*, *Min of monthly average rainfall*, *Max of monthly average humidity* and *Average temperature 1961-1990*. See the Table A1 in the Online Appendix for more detailed variable definitions and data sources. P-values calculated using heteroskedasticity robust standard errors clustered at country level are reported in parentheses. *, **, and *** indicate significance at 10%, 5%, and 1%.

	Dependent variable					
	Account at a financial institution		Credit card		Borrow from a financial institution	
	Mean: 0.55		Mean: 0.22		Mean: 0.12	
	(1)	(2)	(3)	(4)	(5)	(6)
	Overall sample	Income top 40%	Overall sample	Income top 40%	Overall sample	Income top 40%
TSI	-0.23***	-0.27***	-0.02*	-0.02*	-0.06***	-0.07***
	[0.00]	[0.00]	[0.06]	[0.07]	[0.00]	[0.00]
Slave exports	0.01	0.01	-0.01***	-0.02***	0.00	-0.00
	[0.51]	[0.23]	[0.00]	[0.00]	[0.72]	[0.99]
Education	0.18***	0.22***	0.03***	0.04***	0.03***	0.04***
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Income (second 20%)	0.01		0.00		0.01	
	[0.13]		[0.39]		[0.16]	
Income (middle 20%)	0.07***		0.00		0.02***	
	[0.00]		[0.44]		[0.00]	
Income (fourth 20%)	0.12***	-0.09***	0.02***	-0.02***	0.02***	-0.02***
	[0.00]	[0.00]	[0.01]	[0.00]	[0.00]	[0.00]
Income (richest 20%)	0.22***		0.04***		0.05***	

	[0.00]		[0.00]		[0.00]	
Gender	-0.05***	-0.07***	-0.00	-0.01	-0.01**	-0.01**
	[0.00]	[0.00]	[0.14]	[0.22]	[0.02]	[0.01]
Age	0.02***	0.03***	0.00***	0.00***	0.01***	0.01***
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Age squared	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
French legal origin	Yes	Yes	Yes	Yes	Yes	Yes
Settler mortality	Yes	Yes	Yes	Yes	Yes	Yes
Geo & Climate controls	Yes	Yes	Yes	Yes	Yes	Yes
Cultural controls	Yes	Yes	Yes	Yes	Yes	Yes
Macroeconomic controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	27073	12935	26735	12817	26953	12886
R-squared	0.266	0.272	0.055	0.073	0.046	0.056
Unit of analysis	Individual	Individual	Individual	Individual	Individual	Individual
Standard errors	Clustered	Clustered	Clustered	Clustered	Clustered	Clustered
Number of countries	27	27	27	27	27	27
Specifications	OLS	OLS	OLS	OLS	OLS	OLS

Table 5: TseTse and Firm-level Financial Development

This table reports the regression results of the impact of the TseTse fly suitability index on firm access to finance. Panel A presents the average effects, while Panel B shows the heterogeneous effects that differentiate industries by their dependence on external finance. The dependent variable is the amount of bank credit as a proportion of total working capital (*Working capital financed from banks*), the amount of bank credit for investment as a proportion of total investment (*Investment financed from banks*), the proportion of the value of total purchases of material inputs or services that are paid for after delivery (*Trade payable*), and the proportion of the value of total sales of goods or services that are paid for after delivery (*Trade receivable*). The key explanatory variable, *TSI*, is from Alsan (2015) and equals the standardized value (Z-score) of the fly's steady-state population derived from insect growth modelling, gridded climate data, and geospatial data for each country. External Financial dependence (*DEF_dummy*) measures the extent to which firms depend on external finance and is calculated at the three-digit ISIC level using South African data from World Bank's Enterprise Survey following the method in Pierce and Snyder (2017). Firm-level controls include *Firm size*, *Firm age*, *Sales growth, Government, Private, Foreign ownership, Exports, Business group* and *CEO experience*. Country-level controls include the full set of controls we used in previous analyses. We include Industry (at the three-digit ISIC level) and Year fixed effects throughout all the analyses, and Country fixed effects in Panel B. See the Table A1 in the Online Appendix for more detailed variable definitions and data sources. P-values calculated using heteroskedasticity robust standard errors clustered at country level are reported in parentheses. *, **, and *** indicate significance at 10%, 5%, and 1%.

Panel A: Average Effects

	Dependent variables							
	Working capital financed from banks		Investment financed from banks		Trade receivable		Trade payable	
	Mean: 5.98 %		Mean: 10.72 %		Mean: 25.12 %		Mean: 27.26 %	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
TSI	-4.56***	-7.92***	-9.89***	-11.35***	-6.44**	-9.94**	-7.30***	-7.60**
T(G-1)	[0.00]	[0.00]	[0.00]	[0.00]	[0.04]	[0.03]	[0.00]	[0.01]
Wild bootstrap	(0.005)	(0.005)	(0.005)	(0.01)	(0.010)	(0.065)	(0.205)	(0.005)
Wild bootstrap null=0	{}	{}	{}	{}	{}	{}	{}	{}
Slave exports	-0.04	-0.01	-1.59***	-1.39**	-6.35***	-5.70***	-2.32***	-1.96**
	[0.93]	[0.98]	[0.01]	[0.01]	[0.00]	[0.00]	[0.01]	[0.01]
Firm size	2.50***	2.51***	4.57***	4.56***	4.09***	4.13***	4.26***	4.26***
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Firm age	-0.03	-0.03	-0.01	-0.01	-0.13**	-0.13**	-0.00	-0.01
	[0.13]	[0.15]	[0.76]	[0.76]	[0.04]	[0.04]	[0.92]	[0.89]
Sales growth	1.32	0.99	-0.25	-0.26	3.39	2.55	5.71	6.29
	[0.49]	[0.61]	[0.93]	[0.93]	[0.27]	[0.42]	[0.17]	[0.14]
Government ownership	0.05	0.05	0.02	0.02	-0.03	-0.03	-0.12	-0.12

	[0.27]	[0.28]	[0.69]	[0.68]	[0.72]	[0.73]	[0.12]	[0.13]
Foreign ownership	0.00	0.00	-0.00	-0.00	-0.04	-0.04	-0.04	-0.03
	[0.82]	[0.89]	[0.91]	[0.90]	[0.53]	[0.52]	[0.56]	[0.58]
Private ownership	0.01	0.01	0.01	0.01	-0.05	-0.05	-0.05	-0.05
	[0.26]	[0.32]	[0.25]	[0.23]	[0.26]	[0.27]	[0.31]	[0.33]
Export	0.06*	0.06*	0.12***	0.12***	0.03	0.03	0.13**	0.14**
	[0.07]	[0.07]	[0.00]	[0.00]	[0.50]	[0.49]	[0.03]	[0.03]
Business group	-0.76*	-0.73*	0.62	0.62	-1.61	-1.45	0.48	0.47
	[0.05]	[0.07]	[0.47]	[0.48]	[0.15]	[0.20]	[0.67]	[0.67]
CEO experience	0.05**	0.04**	0.01	0.01	0.16***	0.16**	0.30***	0.30***
	[0.01]	[0.01]	[0.81]	[0.84]	[0.01]	[0.01]	[0.00]	[0.00]
French legal origin	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Settler mortality	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geography controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cultural controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Macroeconomic controls	No	Yes	No	Yes	No	Yes	No	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	23006	23006	9625	9625	20531	20531	23152	23152
R-squared	0.140	0.141	0.130	0.130	0.202	0.204	0.208	0.209
Unit of analysis	Firm	Firm	Firm	Firm	Firm	Firm	Firm	Firm
Standard errors	Clustered	Clustered	Clustered	Clustered	Clustered	Clustered	Clustered	Clustered
Number of countries	26	26	26	26	26	26	26	26
Specifications	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS

Panel B: Heterogeneous Effects

	Dependent variables							
	Working capital financed from banks		Investment financed from banks		Trade receivable		Trade payable	
	Mean: 5.98 %		Mean: 10.72 %		Mean: 25.12 %		Mean: 27.26 %	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
TSI*DEF_dummy	-0.87**	-0.87**	-3.48***	-3.48***	-2.40***	-2.40***	-4.73***	-4.73***
	[0.02]	[0.02]	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]
Firm size	2.53***	2.53***	5.35***	5.35***	5.74***	5.74***	5.20***	5.20***
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Firm age	-0.02	-0.02	0.03	0.03	-0.10*	-0.10*	-0.02	-0.02
	[0.25]	[0.25]	[0.55]	[0.55]	[0.08]	[0.08]	[0.74]	[0.74]
Sales growth	-1.67	-1.67	-2.71	-2.71	-4.90	-4.90	0.09	0.09
	[0.42]	[0.42]	[0.44]	[0.44]	[0.32]	[0.32]	[0.98]	[0.98]
Government ownership	0.05	0.05	0.02	0.02	-0.02	-0.02	-0.13	-0.13
	[0.30]	[0.30]	[0.76]	[0.76]	[0.84]	[0.84]	[0.11]	[0.11]
Foreign ownership	-0.00	-0.00	-0.01	-0.01	-0.00	-0.00	0.02	0.02
	[0.75]	[0.75]	[0.68]	[0.68]	[0.97]	[0.97]	[0.42]	[0.42]
Private ownership	0.00	0.00	0.02	0.02	-0.01	-0.01	-0.00	-0.00
	[0.66]	[0.66]	[0.35]	[0.35]	[0.69]	[0.69]	[0.95]	[0.95]
Export	0.07**	0.07**	0.12***	0.12***	0.05	0.05	0.10	0.10
	[0.01]	[0.01]	[0.00]	[0.00]	[0.43]	[0.43]	[0.18]	[0.18]
Business group	-0.58	-0.58	0.91	0.91	-2.18*	-2.18*	-0.17	-0.17
	[0.22]	[0.22]	[0.43]	[0.43]	[0.10]	[0.10]	[0.91]	[0.91]
CEO education	0.04*	0.04*	0.01	0.01	0.12	0.12	0.27***	0.27***
	[0.08]	[0.08]	[0.89]	[0.89]	[0.11]	[0.11]	[0.00]	[0.00]
Macroeconomic controls	No	Yes	No	Yes	No	Yes	No	Yes

Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12680	12680	5543	5543	11319	11319	12768	12768
R-squared	0.137	0.137	0.145	0.145	0.221	0.221	0.240	0.240
Unit of analysis	Firm	Firm	Firm	Firm	Firm	Firm	Firm	Firm
Standard errors	Clustered	Clustered	Clustered	Clustered	Clustered	Clustered	Clustered	Clustered
Number of countries	25	25	25	25	25	25	25	25
Specifications	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS

Table 6: TseTse and Reasons Didn't Apply for a Loan

This table reports OLS regression results of the reasons that a firm did not apply for a loan on the TseTse fly suitability index. Each cell represents a separate regression. We report the coefficient on the key explanatory variable, *TSI*, from each regression. The dependent variable is either *Apply for any loan last year*, *Reasons didn't apply: No need for a loan*, *Reasons didn't apply: Complex application procedures*, *Reasons didn't apply: Unfavourable interest rate*, *Reasons didn't apply: High collateral requirements*, *Reasons didn't apply: Insufficient size*, *Reasons didn't apply: Would not approve*, and *Reasons didn't apply: Others*. The *TSI* is from Alsan (2015) and equals the standardized value (Z-score) of the fly's steady-state population derived from insect growth modelling, gridded climate data, and geospatial data for each country. *Slave exports* is from Nunn (2008) and equals the natural logarithm of the total number of slaves exported from each country between 1400 and 1900 normalized by land area .*French legal origin* is an indicator that equals one if a country's commercial code has a French legal origin, and zero otherwise. *Settler mortality* equals the annualized death rate of European soldiers in European colonies in the early 19th century. *Culture controls* include percentage of population that follows (a) Catholic, (2) Muslim, and (3) Other religions including Protestant religion in 1980. *Geo & Climate controls* include *Latitude, Independence, Log (Population in 1400), SD of agriculture suitability index*, *SD of elevation*, *Longitude, Country area*, *Distance from coast*, *Migratory distance from Addis Ababa*, *Min of monthly average rainfall*, *Max of monthly average humidity* and *Average temperature 1961-1990*. *GDP per capita* equals the natural logarithm of gross domestic product per capita (current US dollars); *GDP per capita growth* is the average annual growth rate in gross domestic product per capita, both averaged over 2006-2014. *Inflation* equals the average annual inflation rate (GDP deflator) over 2006-2014. See the Table A1 in the Online Appendix for more detailed variable definitions and data sources. P-values calculated using heteroskedasticity robust standard errors clustered at country level are reported in parentheses. *, **, and *** indicate significance at 10%, 5%, and 1%.

Dependent variable		Independent Variable: TSI	
Name	Mean	(1)	(2)
Apply for any loan last year?	0.19	-0.14	-0.19
		[0.00]	[0.00]
Reasons didn't apply: No need for a loan	0.37	0.09	0.14
		[0.03]	[0.00]
Reasons didn't apply: Complex application procedures	0.10	0.09	0.19
		[0.00]	[0.00]
Reasons didn't apply: Unfavourable interest rate	0.12	-0.01	-0.09
		[0.60]	[0.00]
Reasons didn't apply: High collateral requirements	0.08	-0.04	-0.05
		[0.02]	[0.02]
Reasons didn't apply: Insufficient size	0.01	-0.00	0.00
		[0.25]	[0.50]
Reasons didn't apply: Would not approve	0.04	0.04	0.06
		[0.00]	[0.00]
Reasons didn't apply: Others	0.05	-0.04	-0.03
		[0.01]	[0.00]
Slave exports	N/A	Yes	Yes
French legal origin	N/A	Yes	Yes
Settler mortality	N/A	Yes	Yes
Geo & Climate controls	N/A	Yes	Yes
Cultural controls	N/A	Yes	Yes
GDP per capita; GDP per capita growth, Inflation	N/A	No	Yes

Table 7: TseTse and Ethnic Fragmentation

This table reports OLS regression results of ethnic fragmentation on the TseTse fly suitability index. The dependent variable is *Ln Number of languages* in columns 1-3, *Ethnic fragmentation* in columns 4-6, *ELF7* in columns 7-9 and *ELF9* in columns 10-12. *Ln Number of languages* is from Michalopoulos (2012) and equals the natural logarithm of the number of languages with at least 1000 speakers in each country. *Ethnic fragmentation* is from Easterly and Levine (1997) and equals the probability that two randomly selected individuals in a country will not speak the same language. *ELF7* and *ELF9* are two measures of linguistic diversity from Desmet, Ortuño-Ortín, and Wacziarg (2011). These authors use information on language trees from the Ethnologue dataset to produce estimates of ethnolinguistic fractionalization at different levels of linguistic aggregation depending on how finely or coarsely language groups are defined. The key explanatory variable, *TSI*, is from Alsan (2015) and equals the standardized value (Z-score) of the fly's steady-state population derived from insect growth modelling, gridded climate data, and geospatial data for each country. *Slave exports* is from Nunn (2008) and equals the natural logarithm of the total number of slaves exported from each country between 1400 and 1900 normalized by land area .*French legal origin* is an indicator that equals one if a country's commercial code has a French legal origin, and zero otherwise. *Latitude* equals the logarithm of the absolute distance between each country and the equator. *Independence* equals the first year a country obtained its independence. *Settler mortality* equals the annualized death rate of European soldiers in European colonies in the early 19th century. *Log (Population in 1400)* equals the logarithm of population density in 1400. *GDP per capita* equals the natural logarithm of gross domestic product per capita (current US dollars); *GDP per capita growth* is the average annual growth rate in gross domestic product per capita, both averaged over 2006-2014. *Culture controls* include percentage of population that follows (a) Catholic, (2) Muslim, and (3) Other religions including Protestant religion in 1980. *Inflation* equals the average annual inflation rate (GDP deflator) over 2006-2014. *Other geography controls* includes *SD of agriculture suitability index*, *SD of elevation*, *Longitude, Country area*, *Distance from coast*, and *Migratory distance from Addis Ababa*. Other climate controls includes *Min of monthly average rainfall*, *Max of monthly average humidity* and *Average temperature 1961-1990*. See the Table A1 in the Online Appendix for more detailed variable definitions and data sources. P-values calculated using heteroskedasticity robust standard errors are reported in parentheses. *, **, and *** indicate significance at 10%, 5%, and 1%.

	Dependent variable: Ethnic diversity											
	Ln Number of languages			Ethnic fragmentation			ELF7			ELF9		
	Mean: 3.15			Mean: 0.60			Mean: 0.46			Mean: 0.57		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
TSI	0.70***	1.11***	1.26**	0.12**	0.18***	0.25*	0.11*	0.13*	0.33**	0.15***	0.20***	0.33*
	[0.01]	[0.00]	[0.01]	[0.03]	[0.01]	[0.09]	[0.06]	[0.06]	[0.03]	[0.01]	[0.00]	[0.05]
Variation in Agricultural Suitability		8.97***	5.91**		1.08	1.55		1.28**	1.73**		1.39**	1.49
		[0.00]	[0.02]		[0.14]	[0.11]		[0.04]	[0.03]		[0.02]	[0.14]
Variation in Elevation		-0.30	-3.16		0.14	0.34		-0.73**	1.75		-0.30	1.95
		[0.80]	[0.45]		[0.70]	[0.77]		[0.05]	[0.20]		[0.36]	[0.13]
Slave exports			0.05			0.00			0.03			0.07
			[0.70]			[1.00]			[0.56]			[0.20]
French legal origin			0.24			-0.02			0.13			0.29*
			[0.68]			[0.90]			[0.28]			[0.07]

Latitude			-0.08*			-0.02*			-0.00			-0.01
			[0.09]			[0.07]			[0.88]			[0.64]
Independence			-0.00			-0.00			-0.01**			-0.01
			[0.88]			[0.74]			[0.01]			[0.20]
Settler mortality			-0.32			-0.01			-0.03			0.04
			[0.15]			[0.88]			[0.68]			[0.56]
Log(Population in 1400)			0.62*			-0.05			0.02			0.07
			[0.05]			[0.53]			[0.81]			[0.38]
Cultural controls	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes
Other geography controls	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes
Other climate controls	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes
Observations	44	44	29	37	37	29	42	42	29	42	42	29
R-squared	0.156	0.390	0.847	0.129	0.207	0.717	0.058	0.156	0.743	0.157	0.253	0.644
Unit of analysis	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country
Standard errors	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust
Specifications	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS

Table 8: TseTse and Precolonial Political Centralization

This table reports OLS regression results of precolonial political centralization on the TseTse fly suitability index. The dependent variable is *Precolonial political centralization* in columns 1-3, and *Precolonial jurisdictional hierarchy* in columns 4-6. *Precolonial jurisdictional hierarchy* is constructed from the variable "jurisdictional hierarchy beyond the local authority" in the Ethnographic Atlas (Murdock 1967) and is a cross-ethnicity measured coded so that it equals 0 for groups lacking any form of centralized state, 1 for petty chiefdoms, 2 for large paramount chiefdoms/petty states, and 3 or 4 for large states. The country average of this measure is used. *Precolonial political centralization* is an additional measure that equals 1 if the *Precolonial jurisdictional hierarchy* variable equals 2, 3, and 4, and 0 otherwise. The key explanatory variable, *TSI*, is from Alsan (2015) and equals the standardized value (Z-score) of the fly's steady-state population derived from insect growth modelling, gridded climate data, and geospatial data for each country. *Slave exports* is from Nunn (2008) and equals the natural logarithm of the total number of slaves exported from each country between 1400 and 1900 normalized by land area .*French legal origin* is an indicator that equals one if a country's commercial code has a French legal origin, and zero otherwise. *Latitude* equals the logarithm of the absolute distance between each country and the equator. *Independence* equals the first year a country obtained its independence. *Settler mortality* equals the annualized death rate of European soldiers in European colonies in the early 19th century. *Log (Population in 1400)* equals the logarithm of population density in 1400. *GDP per capita* equals the natural logarithm of gross domestic product per capita (current US dollars); *GDP per capita growth* is the average annual growth rate in gross domestic product per capita, both averaged over 2006-2014. *Culture controls* include percentage of population that follows (a) Catholic, (2) Muslim, and (3) Other religions including Protestant religion in 1980. *Inflation* equals the average annual inflation rate (GDP deflator) over 2006-2014. *Other geography controls* includes *SD of agriculture suitability index*, *SD of elevation*, *Longitude, Country area*, *Distance from coast*, and *Migratory distance from Addis Ababa*. Other climate controls includes *Min of monthly average rainfall*, *Max of monthly average humidity* and *Average temperature 1961-1990*. See the Table A1 in the Online Appendix for more detailed variable definitions and data sources. P-values calculated using heteroskedasticity robust standard errors are reported in parentheses. *, **, and *** indicate significance at 10%, 5%, and 1%.

	Dependent variable: Pre-colonial centralization					
	Precolonial political centralization Mean: 0.45			Precolonial jurisdictional hierarchy Mean: 2.38		
	(1)	(2)	(3)	(4)	(5)	(6)
TSI	-0.24***	-0.30***	-0.48***	-0.48***	-0.55***	-0.76***
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Variation in Agricultural Suitability		-1.19**	-3.00***		-1.91	-3.71***
		[0.02]	[0.00]		[0.11]	[0.01]
Variation in Elevation		0.00	-0.91		0.25	0.55
		[0.99]	[0.36]		[0.70]	[0.80]
Slave exports			-0.01			0.05
			[0.80]			[0.39]
French legal origin			-0.18			-0.02
			[0.16]			[0.93]
Latitude			0.03***			0.08**
			[0.01]			[0.01]
Independence			0.01***			0.01*
			[0.00]			[0.07]
Settler mortality			-0.02			0.11
			[0.70]			[0.17]
Log(Population in 1400)			0.01			0.07
			[0.77]			[0.59]

Cultural controls	No	No	Yes	No	No	Yes
Other geography controls	No	No	Yes	No	No	Yes
Other climate controls	No	No	Yes	No	No	Yes
Observations	44	44	29	43	43	29
R-squared	0.362	0.420	0.856	0.388	0.417	0.846
Unit of analysis	Country	Country	Country	Country	Country	Country
Standard errors	Robust	Robust	Robust	Robust	Robust	Robust
Specifications	OLS	OLS	OLS	OLS	OLS	OLS

Table 9: TseTse and Trade

This table reports OLS regression results of trade on the TseTse fly suitability index. The dependent variable is *Contract enforcement DTF* in columns 1-3, and *Contract enforcement rank* in columns 4-6. *Contract enforcement DTF* is the simple average of the distance to frontier scores for each of the three enforcing contract component indicators: days to resolve a commercial dispute through the courts; attorney, court and enforcement costs as a percentage of claim value, and quality of judicial process index. Days to resolve a commercial dispute measures how long it typically takes to resolve a commercial dispute. Contract enforcement cost measures the direct costs (e.g., legal and other fees) of resolving a commercial dispute. Quality of judicial processes index measures whether each economy has adopted a series of good practices in its court system. *Contract enforcement rank* is the ranking of economies worldwide on the ease of enforcing contracts. It is calculated by sorting their enforcing contracts distance to frontier scores. The key explanatory variable, *TSI*, is from Alsan (2015) and equals the standardized value (Z-score) of the fly's steady-state population derived from insect growth modelling, gridded climate data, and geospatial data for each country. *Slave exports* is from Nunn (2008) and equals the natural logarithm of the total number of slaves exported from each country between 1400 and 1900 normalized by land area .*French legal origin* is an indicator that equals one if a country's commercial code has a French legal origin, and zero otherwise. *Latitude* equals the logarithm of the absolute distance between each country and the equator. *Independence* equals the first year a country obtained its independence. *Settler mortality* equals the annualized death rate of European soldiers in European colonies in the early 19th century. *Log (Population in 1400)* equals the logarithm of population density in 1400. *GDP per capita* equals the natural logarithm of gross domestic product per capita (current US dollars); *GDP per capita growth* is the average annual growth rate in gross domestic product per capita, both averaged over 2006-2014. *Culture controls* include percentage of population that follows (a) Catholic, (2) Muslim, and (3) Other religions including Protestant religion in 1980. *Inflation* equals the average annual inflation rate (GDP deflator) over 2006-2014. *Other geography controls* includes *SD of agriculture suitability index*, *SD of elevation*, *Longitude, Country area*, *Distance from coast*, and *Migratory distance from Addis Ababa*. Other climate controls includes *Min of monthly average rainfall*, *Max of monthly average humidity* and *Average temperature 1961-1990*. See the Table A1 in the Online Appendix for more detailed variable definitions and data sources. P-values calculated using heteroskedasticity robust standard errors are reported in parentheses. *, **, and *** indicate significance at 10%, 5%, and 1%.

	Dependent variable					
	Contract enforcement DTF			Contract enforcement rank		
	Mean: 47.59			Mean: 22.50		
	(1)	(2)	(3)	(4)	(5)	(6)
TSI	-3.69**	-9.23*	-9.85	-4.82**	-13.99**	-14.11
	[0.03]	[0.06]	[0.28]	[0.04]	[0.02]	[0.21]
Slave exports		1.28	1.44		1.72	1.59
		[0.43]	[0.54]		[0.40]	[0.58]
French legal origin		-4.52	-6.24		-6.00	-9.70
		[0.29]	[0.56]		[0.29]	[0.45]
Latitude		-0.57	-0.60		-0.62	-0.62
		[0.42]	[0.46]		[0.43]	[0.47]
Independence		-0.00	-0.01		0.08	0.07
		[1.00]	[0.95]		[0.65]	[0.80]
Settler mortality		3.14	3.06		4.61	4.06
		[0.33]	[0.48]		[0.32]	[0.48]
Log(Population in 1400)		-4.34	-3.69		-6.00	-5.52
		[0.20]	[0.40]		[0.18]	[0.36]
GDP per capita			0.61			-1.03
			[0.86]			[0.78]
GDP per capita growth			-0.18			0.09

			[0.91]			[0.96]
Cultural controls	No	Yes	Yes	No	Yes	Yes
Other geography controls	No	Yes	Yes	No	Yes	Yes
Other climate controls	No	Yes	Yes	No	Yes	Yes
Inflation	No	No	Yes	No	No	Yes
Observations	44	29	29	44	29	29
R-squared	0.082	0.686	0.544	0.079	0.778	0.680
Unit of analysis	Country	Country	Country	Country	Country	Country
Standard errors	Robust	Robust	Robust	Robust	Robust	Robust
Specifications	OLS	OLS	OLS	OLS	OLS	OLS