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The Deep Historical Roots of Macroeconomic Volatility*

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Abstract

We present cross-country evidence that a country's macroeconomic volatility, measured either by the standard deviation of output growth or the occurrence of trend-growth breaks, is significantly affected by the country's historical variables. In particular, countries with longer histories of state-level political institutions experience less macroeconomic volatility in post-war periods. Robustness checks reveal that the effect of this historical variable on volatility remains significant and substantial after controlling for a host of structural variables investigated in previous studies. We also find that the state history variable is more important in countries with a higher level of macroeconomic volatility.

JEL codes: O10, O33, O43

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1. Introduction

Macroeconomic volatility varies significantly across nations. And much effort has been devoted to study the reasons behind and whether there are rooms for policies to improve the situation. In this paper, we ask the following questions: do historical variables affect macroeconomic volatility today? If so, which variables are most important?

Clearly, these research questions can be interpreted as natural extensions of some growing literatures. For instance, in the recent growth literature, the search for the fundamental factors of economic prosperity has traced its roots to variables of pre-historic times, dating back to more than 10,000 B.C.E. This line of research has produced empirical evidence that current cross-country income differences are related to several key historical variables: the biogeographic conditions that determined the timing of the Neolithic Revolution (Diamond, 1997; Hibbs and Olsson, 2004; Olsson and Hibbs, 2005), the history of state-level political institutions (Bockstette, Chanda and Putterman, 2002; Putterman and Weil, 2010), the history of agriculture (Putterman and Weil, 2010), the history of technology adoption (Comin, Easterly and Gong, 2010), genetic distance from the frontier (Spolaore and Wacziarg, 2009), and genetic diversity of the population (Ashraf and Galor, 2013).[1] These seminal studies have not only provided stimulating insights, but have also made available rich datasets of historical variables that have stimulated further research in this direction. Our studies take advantage of these datasets and study the question related to macroeconomic volatility rather than long run growth.

This paper is also inspired by the literature which focuses on the fundamental factors of macroeconomic volatility, especially in developing countries. Those studies show that distortionary or discretionary policies that cause high macroeconomic volatility and economic

[1] See Engerman and Sokoloff (2008), Spolaore and Wacziarg (2013), among others, for a summary of this growing body of literature. Nunn (2009) provides a survey of the literature on the importance of history to economic development.

crises are themselves the "symptoms" of weak institutional quality, unfavorable geography or less democratic political systems. Among others, Rodrik (1999) argues that divided societies and weak conflict management at the institutional level amplify external shocks, causing volatile growth and crises. Acemoglu, Johnson, Roberson and Thaicharoen (2003) (henceforth AJRT, 2003) show that countries that inherited more "extractive" institutions from their former European colonizers are more likely to experience high volatility and economic crises during post-war periods. Fatás and Mihov (2003) find that institutional environments that impose few constraints on governance via checks and balances experience greater discretion in fiscal policy, which causes macroeconomic instability. Malik and Temple (2009) provide evidence that remote countries with poor market access are more likely to have undiversified exports and to experience greater volatility in output growth. There is also substantial evidence that less democratic countries experience more macroeconomic volatility. For instance, Mobarak (2005) finds that countries with Muslim-majority populations are less democratic, which increases volatility. Our work is closely related to research on the fundamental factors shaping macroeconomic volatility. However, we look much more deeply into history to determine whether and how human evolution in the last 10,000 years continues to influence macroeconomic volatility today.

This paper makes the following contribution to the literature. We show that countries with longer histories of state-level political institutions experience less macroeconomic volatility in post-war periods.[2] The effect of this historical variable is manifested not only in high-frequency volatility, measured by the standard deviation of annual output growth, but in medium-term volatility, measured by the occurrence of trend-growth breaks. In addition,

[2] A country's history of state-level political institutions is measured by the extent to which the country was controlled by a government above tribal level from 1 to 1950 C.E. This historical variable is adjusted for the proportion of the territory of the modern country ruled by the government during this period, and also for whether its government was foreign or locally based. See Section 2 for a detailed description of this historical variable. See also Acemoglu et al. (2013) for a related analysis of "weak states."

robustness checks reveal that the effect of this historical variable on volatility remains significant and substantial after controlling for a host of structural variables investigated in previous studies. Moreover, adding current income to the list of regressors does not eliminate the significant effect of this historical variable on volatility, suggesting that state history affects current macroeconomic volatility through independent channels, rather than through the growth channel alone.

Why does the history of state-level political institutions have such a strong influence on macroeconomic volatility and its proximate factors today? Diamond (1997) argues that people living in countries with long histories of nationhood are more likely to have a sense of common identity and a common language. A common language also reinforces national identity. Clots-Figueras and Masella (2013) show that teaching Catalan in Catalonian schools instils greater loyalty to the Catalan identity, and affects political preferences and attitudes toward the organization of the state. Sharing an identity and a language fosters trust and social interaction, which are important components of social capital (Temple, 1998). Knack and Keefer (1997) find that social capital, as measured by trust and civic norms, is higher in countries that are less polarized in terms of ethnicity and class. Putterman and Weil (2010) show that trust, control, respect, obedience and thriftiness are all positively affected by state history. In addition, a unified state with a common national identity and language is less likely to experience the devastating effects of civil war and other forms of political instability (Easterly and Levine, 1997). Bockstette, Chanda and Putterman (2002) argue that through learning by doing, public administration is more effective in long-standing states. Also, long-standing states may develop better bureaucratic discipline and hierarchical control. Hence, countries with longer histories of nationhood are likely to be more stable because they may have higher social capital, fewer civil wars and other forms of political instability, more effective administration, and greater bureaucratic discipline and hierarchical control.

Recent studies also point out that state antiquity plays an important role in the development of financial institutions of modern states that helps lower macroeconomic volatility of these states. For instance, a longer history of state-level political institutions contributes to state capacity in collecting tax revenue and enforcing contracts, and hence affects the level of financial development. A study by Ang (2013a) finds that state antiquity provides the basis for explaining the fundamental sources of variations in financial development between countries today. Besley and Persson (2009, 2010) argue that legal and fiscal state capacity are built upon past investments in common interest public goods such as fighting external wars, political stability, and inclusive political institutions, all of which may be positively linked to state antiquity. Dincecco and Prado (2012) confirm that war casualties sustained in pre-modern wars affect the long-term development of a country's fiscal institutions which in turn affects the country's economic performance and labour productivity today. La Porta et al. (1997) emphasize on legal traditions in affecting the development of financial institutions. They argue that British common law provides better protection of private property rights compared to that of French civil law, and hence enjoys higher levels of financial development. An important message being shared by all these studies is that a longer history of state-level political institutions may enhance the state's fiscal and legal capacity, leading to higher levels of financial development and better economic performances including greater economic stability.

The remainder of this paper is divided into four sections. Section 2 presents the definitions and constructions of the two measures of macroeconomic volatility and the historical variables used in the regressions. Section 3 presents empirical evidence for linking historical variables to macroeconomic volatility. In particular, we show in Section 3 that the history of state-level political institutions has an important role in explaining macroeconomic volatility today, especially in more volatile countries. Section 4 conducts robustness checks to see how sensitive are our baseline results to using alternative periods of state history, controlling for the volatility of state history, using instrumental variable estimation to control for potential endogeneity bias, controlling for more confounding variables, and using state history that has not been adjusted for world population migration since 1500 C.E.. In the last section, we summarize our findings and conclude the paper.

2. Data Description

This section describes the main variables used in this study, with particular attention given to two measures of macroeconomic volatility and four historical variables. A detailed description of the other variables used in the regressions is provided in Appendix A.

2.1 Macroeconomic Volatility—Output Volatility and Occurrence of Trend-Growth Breaks

The vast majority of researchers examining macroeconomic volatility use the standard deviation of output growth as a measure of macroeconomic volatility (Klomp and Haan, 2009). Output volatility is measured by calculating the standard deviation of the annual growth rates of real gross domestic product (GDP) per capita between 1960 and 2011. The annual growth rates of real GDP are log differences of annual GDP per capita in constant local currency. The standard deviation of annual output growth captures the total variation in output growth due to business-cycle fluctuations, crises, and changes in trends; not just the variation arising from uncertainty or unpredictability. It is worth noting that output variation incurs some costs even when the variation is fully anticipated, especially when individuals have limited opportunities for consumption smoothing.

Although the standard deviation of output growth captures (relatively) high-frequency shocks, some researchers argue that this measure is not ideal when a country's economic growth is characterized by frequent episodes of accelerated growth and growth breaks, which is the case for many developing countries. For instance, Pritchett (2000) describes the different patterns of growth of developing countries as hills among plateaus, mountains, and plains. Jones and Olken (2008) find that most countries experience growth miracles and failures over substantial periods, and that productivity plays a significant role in accounting for patterns of start-stop growth. Hence, we also consider the relationship between historical variables and medium-run trend-growth volatility measured by the occurrence of trend-growth breaks, which is a dummy variable that takes the value of 1 if a country experiences at least one structural break (trend-growth break) during the sample period, and 0 otherwise. The data on structural breaks are taken from Jones and Olken (2008), who use a method developed by Bai and Perron (1998, 2003) to identify 73 structural breaks in 48 of 125 countries with at least 20 years of Penn World Table data.

2.2 History of State-Level Political Institutions

The history of state-level political institutions is the "State Antiquity Index Version 3.1" obtained from Putterman (2004), which measures the existence of any form of central state from 1 to 1950 C.E. in the history of a modern country. The index adjusts for the scope of a state's geographical control between 1 and 1950 C.E., and whether the state was indigenous or controlled by an outside power during that period. The index is constructed using the following formula:

$$statehis = \frac{\sum_{t=0}^{39}(1.05)^{-t}\, s_{i,t}}{\sum_{t=0}^{39} 50 * (1.05)^{-t}}$$

where s_{it} is the state-history variable for country *i* in the 50-year period *t*. For each of the 39 50-year periods, a country receives 1 point if it has a government above the tribal level (and 0 points otherwise), 1 point if its government is locally based (0.5 points if the country is controlled by an outside power, and 0.75 points if local and foreign powers share its governance), and 1 point if the government controls more than 50 percent of the territory of the modern country (0.75 points if 25-50 percent of the country's territory is under government control, 0.5 points if 10-25 percent is under government control, and 0.3 points if less than 10 percent is under government control). The three scores are then multiplied by each other, and the result is multiplied by 50 to give s_{it}. Take, for example, a country with a foreign government above the tribal level that ruled 30 percent of the territory of the modern country. This country has an s_{it} value of 18.75 (1 x 0.5 x 0.75 x 50) for the 50-year period *t*.

As older data are less reliable, s_{it} is thus discounted by additional 5 percent for each 50-year period before 1901-1950 C.E. For example, an s_{it} value of 18.75 for the 50-year period from 1801 to 1850 is discounted by $(1.05)^{-2}$ to give 17.01. Finally, dividing the discounted sum of the state-history variables, s_{it}, by the maximum achievable value gives the state-history index, which varies between 0 and 1.

The state-history index measures a country's history of state-level political institutions between 1 and 1950 C.E. However, some countries have experienced massive population migration since 1500 C.E. as a result of European colonization. Consequently, to measure the state history of the ancestors of the current population of a country, as opposed to the state history of the country, we use the World Migration Matrix (WMM) to adjust the state-history index for population migration since 1500 C.E. More specifically, we multiply the state-history index by the WMM, which is constructed by Putterman and Weil (2010). The WMM gives the share of the population in every country in 2000 C.E. descended from people in different source countries in 1500 C.E. The adjustment is made because the history of a country's current population has a greater effect than the history of the country on the country's economic outcomes. Most countries have experienced little population migration, and thus show little difference between the two variables. In some cases, however, the history of a country's current population and the history of that country are substantially different, due to extensive population migration. It is also worth noting that the main empirical results of this paper are unchanged even without adjusting the historical variables for population migration, as shown in the robustness check in section 4.

2.3 History of Agriculture

Drawing on a variety of sources, Putterman and Trainor (2006) assemble data on the transition from hunting and gathering to agriculture. The variable gives the number of years (in thousands) prior to 2000 since a significant number of people in an area within the country's present borders met most of their food needs by cultivating crops. Similar to the history of state-level political institutions, this variable is adjusted for population migration using the WMM.

2.4 History of Technology Adoption

We use technology-adoption indices constructed by Comin, Easterly and Gong (2010) to measure the level of technology adoption in the agricultural, transportation, communications, industry, and military sectors of a maximum of 135 countries in 1000 B.C.E, 1 C.E. and 1500 C.E.[9] The agricultural technology adoption index measures the extent to which agriculture had been adopted by a given country in the given year. The transportation technology adoption index indicates whether human, animals or vehicles were used for transportation. The communications technology adoption index reflects the presence of non-written records and true writing. The existence of pottery is used to measure the country's adoption of

[9] There are studies which employ post-war technological progress to explain the post-war macroeconomic volatility, such as Leung et al. (2006), Tang et al. (2008). However, there may be a reverse causation (RC) issue. Thus, using variables on the history of technology adoption to explain the post-war macroeconomic volatility may mitigate the RC problem.

industrial technology, and the existence of metalwork and bronze instruments is regarded as an indicator of the adoption of military technology. Each of the overall technology adoption indices denotes the country's average adoption level across these sectors, and is expressed in interval form, as [0,1]. Comin, Easterly and Gong (2010) use Peregrine's (2003) study as the main source of data for 1000 B.C.E. and 1 C.E. As Comin, Easterly and Gong (2010) use more than 170 source materials to construct the data for 1500 C.E., the technology-adoption index for 1500 C.E. has a more detailed classification for each type of technology. For example, transportation technology is classified by the presence of ships of different capabilities, the wheel, the magnetic compass and horse-powered vehicles. Similar to the other historical variables, the technology-adoption indices are adjusted for population migration using the WMM.

2.5 Genetic Distance

Genetic distance or F_{st} distance is also known as the "co-ancestor coefficient", which we obtained from Spolaore and Wacziarg (2009). It measures genetic differences based on indices of heterozygosity, which measure the probability that two alleles at a given locus selected at random from two populations will be different. If the allele distributions are identical across the two populations, F_{st} takes a value of 0; if the allele distributions differ, F_{st} is positive. A higher value of F_{st} represents a larger genetic difference. It is assumed that the diffusion of technology may be more efficient in genetically similar countries. We also assume that England was the most technologically advanced country in 1500 C.E., and thus our genetic distance variables refers to genetic difference between England and each of the other countries in the dataset.[10] Similar to the other historical variables, this variable is adjusted for population migration using the WMM.

3. Linking Historical Variables to Macroeconomic Volatility

3.1 Descriptive Evidence

Figure 1 provides a scatterplot of the history of state-level political institutions and output volatility. The diagram depicts a negative relationship between the two variables, which does not appear to be caused by the few outliers in the plot. The line of best fit indicates that countries with longer histories of state-level political institutions tend to experience less output volatility. The heteroskadastically robust t-statistic for state history is -3.50 in a bivariate regression of output volatility, which is statistically significant at the 0.1-percent level. Six former command economies (Armenia, Azerbaijan, Bosnia and Herzegovina, Georgia, Serbia, and Tajikistan) show relatively high output volatility (above 0.1) and have long histories of state-level political institutions (above 0.5). Most developed, high-income countries lie in the lower right-hand corner of the diagram, reflecting their low output volatility (below 0.05) and their relatively long histories of state-level political institutions (above 0.6).

[Insert Figure 1 about here]

Figure 2 shows the relationship between the history of state-level political institutions and the frequency of growth breaks for three groups of countries. The first group of countries is defined by a state-history index greater than 0.75. The countries in the second group have state-history indices in the intermediate range, between 0.25 and 0.75. The countries in the

[10] Scholars are increasingly linking genetic differences with cultural conditions and political behavior, as well as with the diffusion of technology. In the very long run, cultural formation may also be shaped by genetic differences. Therefore, the potential effects of genetic differences on political behavior should not be neglected. See Fowler and Schreiber (2008), among others, for a review of that literature.

third group have state-history indices lower than 0.25. The average state-history indices for the first, second and third groups of countries are 0.85, 0.53, and 0.15, respectively. As shown in Figure 2, the average numbers of trend-growth breaks for the first, second and third groups are 0.5, 0.63, and 0.91, respectively. The countries with the longest state histories have roughly half the average number of trend-growth breaks exhibited by the countries with the shortest state histories (0.5 versus 0.91). Figure 2 thus illustrates the relationship that countries with longer histories of state-level political institutions experience less medium-run trend-growth volatility.

[Insert Figure 2 about here]

3.2 Econometric Evidence

Figures 1 and 2 illustrate a negative relationship between the history of state-level political institutions and macroeconomic volatility. However, the observed relationship may result from other, deeper determinants of macroeconomic volatility, such as geography. Macroeconomic volatility may also be affected by other historical variables related to the history of state-level political institutions. In this section, we address these possibilities by determining whether the relationship between state history and macroeconomic volatility is sensitive to the introduction of other control and historical variables to the regressions.

Formally, we consider the following econometric model:

(1) $$y_i = \theta_1 + \theta_2 \cdot history_i + \theta_3 \cdot \boldsymbol{W}_i + \mu_i$$

where the dependent variable y_i denotes one of the two measures of macroeconomic volatility for country *i*; $history_i$ is a historical variable; and $\boldsymbol{W_i}$ is a vector of the control variables. The residual, μ_i, is assumed to be iid. The parameter of special interest is θ_2, which provides an estimate of the relationship between a given historical variable and macroeconomic volatility. Clearly, as macroeconomic volatility in a post-war period cannot affect historical variables prior to that period, reverse causality is unlikely to affect the results of Equation (1). However, if certain structural factors are not included in the regression, they may be argued to be responsible for the observed results. Therefore, the potential misspecification issue must be fully addressed in Equation (1). Following the recent literature in the area, several structural factors are added to Equation (1) to control for their effects on macroeconomic volatility.

[Insert Table 1 about here]

Table 1 reports the results of the ordinary least squares (OLS) regression of Equation (1) when macroeconomic volatility is measured by the standard deviation of output growth. Columns 1-6 of Panel A report the results of setting $history_i$ as each of the six historical variables on the right-hand side of Equation (1). These variables are the history of state-level political institutions (column 1), the history of agriculture (column 2), the technology-adoption indices for 1000 B.C.E. (column 3), 1 C.E. (column 4) and 1500 C.E. (column 5), and genetic distance (column 6). Also included in the regressions are absolute latitude, arable-land area (in log form), and dummy variables for tropical regions, landlocked areas, islands, and continents of Africa, Asia and Europe (omitting America and Oceania). We use these geographic variables because climate, humidity, soil conditions, disease environment and market access may directly and/or indirectly affect human motivation, enterprise, agricultural productivity, institutions and trade, which have been shown to be important determinants of growth and volatility.[12]

[12] The literature on the effects of geography on economic performance is prolific. It can be divided into two main groups. Some researchers argue that factors such as tropical or landlocked geography directly inhibit growth and development through poor soil quality, a high prevalence of crop pests and parasites, a lack of coal deposits, an infectious-germ ecology, high transport costs, and the inhibition of motivation to work (see, for example, Bloom et al., 1998). Other authors find strong evidence that these geographical factors (tropics, germs and crops) only indirectly affect country income, through institutional factors (see, for example, Engerman and

Panel A of Table 1 shows that the history of state-level political institutions is the only historical variable with a statistically significant effect on the standard deviation of output growth in post-war periods. The estimate of -0.049 for the state-history variable shown in column 1 has a t-statistic (in absolute values) of 2.93, which is statistically significant at the 1-percent level. This finding indicates that output volatility is reduced by roughly 0.5 percent when the state-history index is increased by 0.1 points. The estimate is also economically large, because the presence of state history explains almost all of the cross-country average output volatility (the average standard deviation for output growth is 5.38 percent across all of the countries in the sample). The value of R^2 in column 1 is 17 percent, which is substantially larger than the values of other R^2 in Panel A, suggesting that the history of state-level political institutions has much larger explanatory power of output volatility than other historical variables. Also, Panel A, Table 1, shows that being an island country is estimated to reduce output volatility significantly in Column 1, 4, 5 and 6. Moreover, African and Asian countries consistently show higher output volatility compared to the rest of the world.

Panel B of Table 1 displays the results of adding another historical variable to the regression when the regression already includes the history of state-level political institutions and the baseline control variables. Column 1 of Panel B, Table 1 shows that the estimate for state history increases from -0.049 to -0.057 and remains statistically significant at the 1-percent level when both state history and agricultural history are included in the regression. The effect of agricultural history is estimated at 3.16e-06, with a t-statistic of 1.86, indicating that output volatility increases by around 0.32 percent for every 1,000 years of agricultural history. However, it is worth noting that the correlation between state history and agricultural history is moderately high (with a correlation coefficient of 0.68), which makes it fairly

Sokoloff, 1997; Acemoglu, Johnson and Roberson, 2002; Easterly and Levine, 2003). Island countries have also been found to have better institutions than countries with land borders (Fors, 2014).

difficult to separate the effects of these two historical variables. Similarly, the results in columns 2, 3, 4 and 5 of Panel B, Table 1 show that the estimate for the history of state-level political institutions remains roughly the same and is statistically significant regardless of whether other historical variables are added to the regression. However, the other historical variables are of little statistical significance, suggesting that state history is the most important historical variable explaining output volatility in post-war periods.

If all of the historical variables are considered to be closely related, and collectively to reflect a country's historical development, combining the historical variables to produce a single variable is justified (Ang, 2013b).[13] Column 6 of Panel B, Table 1 shows the results of using the first principal component (FPC) of all of the historical variables to explain output volatility in post-war periods.[14] The result shows that the estimate for the first principal component of all the historical variables is negative and statistically significant at the 5-percent level. This finding supports the claim that countries with long histories of development experience lower output volatility today.

[Insert Table 2 about here]

The OLS results provided in Table 1 show that on average a strong negative relationship is observed between state history and output volatility. These results, however, do not tell us whether the effect of state history on output volatility is more important for certain countries than the others. Thus, we ask not only the question, 'does state history matters for output volatility?', but also ask the other question, 'for which group of countries state history matters most?' To address this question, we run a quantile regression (QR) (Koenker, 2005). The results are reported in Table 2 and indicate that the strength of the

[13] The correlation coefficients of the six historical variables are presented in Table B.1, Appendix B. The results show that the six historical variables are all significantly correlated at the 1-percent level.

[14] Table B.2 in Appendix B reports the explanatory power of each principal component of the historical variables. The first principal component accounts for 67 percent of the variation in the historical variables.

relationship between state history and output volatility increases from the bottom to the top of the conditional distribution. At the 0.05 quantile, the relationship is estimated as -0.025, which is statistically significant but less than the OLS estimate of -0.049. From the 0.25 quantile to the 0.50 quantile and thence to the 0.75 quantile, the estimated relationship increases from -0.027 to -0.029 to -0.057, all of which are statistically significant at the conventional levels. The estimated relationship at the 0.75 quantile is almost twice that estimated at the 0.25 quantile. These results reveal that state history matters most for countries with relatively high volatility. The results also imply that it may be difficult for low-income developing countries to reduce their output volatility if much of their volatility is the result of being an inexperienced state.

[Insert Table 3 about here]

The results reported in Table 1 and 2 are generated from OLS and QR in which the standard deviation of output growth is used as the dependent variable. We now seek to confirm that the principal finding is not caused either by our use of the standard deviation of output growth to measure macroeconomic volatility, or by the OLS methodology. Table 3 reports the results of our probit regression of Equation (1) when macroeconomic volatility is measured in terms of the occurrence of trend-growth breaks. Column 1 of Panel A, Table 3 shows that the estimated marginal effect of state history on the occurrence of trend-growth breaks is -0.559, with a t-statistic of 1.82, which is statistically significant at the 10-percent level. This finding suggests that countries with short or no histories of state-level political institutions are roughly 56 percent more likely to experience at least one major trend-growth break than countries with long histories of state-level political institutions. Columns 2 and 4 of Panel A, Table 3 show, respectively, that agricultural history and the technology-adoption index in 1 C.E. have a statistically significant negative effect on the likelihood of experiencing a trend-growth break. In particular, the technology-adoption index in 1 C.E. has the most statistically significant marginal effect: it is estimated at -0.497, with a t-statistic of 4.04. This estimate indicates that a country with full technological adoption in 1 C.E. (technology-adoption index of 1) is roughly 50 percent less likely to experience a trend-growth break today than countries in which little or no technology had been adopted in 1 C.E.

Panel B of Table 3 reports the results of adding another historical variable to a probit regression that already includes the technology-adoption index for 1 C.E. and the baseline control variables. The estimated marginal effect of the technology-adoption index in 1 C.E. remains highly statistically significant across columns 1 to 5 of Panel B, Table 3, whereas the estimated marginal effects of the other historical variables are not statistically significant. These results suggest that the technology-adoption index in 1 C.E. is the most important historical variable affecting the occurrence of trend-growth breaks in a post-war period.

Thus far, we have described the introduction of separate historical variables to the regression of the occurrence of trend-growth breaks. In practice, however, the historical variables are correlated. In the appendix, we show that the first principal component of the six historical variables explains about two thirds of the variation in all of the historical variables. In column 6 of Panel B, Table 3, we thus present the results of the regression when all of the six historical variables are replaced by the FPC. The estimated marginal effect of the FPC is -0.145, with a t-statistic of 2.89, which is statistically significant at the 1-percent level. This estimate suggests that countries with longer histories of development are less likely to experience trend-growth breaks.

In sum, the results presented in this section indicate that historical variables in the collective have a highly significant influence on macroeconomic volatility, measured as either the standard deviation of output growth or the occurrence of trend-growth breaks. Thus, countries with long histories of development are shown to experience more stable growth. When the six historical variables are considered separately, however, only the history of state-level political institutions is found to significantly affect both the standard deviation of output growth and the occurrence of trend-growth breaks. The technology-adoption index in 1 C.E. is found to have a highly significant effect on the occurrence of growth breaks (which captures medium-term shocks), but not on the standard deviation of output growth (which captures short-term shocks).

4. Further Robustness Checks

In this section, we further investigate the robustness of our baseline results by using alternative periods of state history, controlling for the volatility of state history, using instrumental variable estimation to control for potential endogeneity bias, excluding African countries from the regression, adding 15 climate and soil variables as controls, and controlling for European population, ethnic fractionalization, democratic institutions and current income. The purpose of these exercises is to check whether our principal finding is altered by varying the sample or the control variables. Reassuringly, our principal finding that state history is the most historical variable in explaining current macroeconomic volatility is largely unaffected by the sensitivity checks.

[Insert Table 4 about here]

Table 4 reports the regression results when the periods of state history are between 1 and 1950 C.E. (column 1), 1501 and 1950 C.E. (column 2), 1001 and 1500 C.E. (column 3), 501 and 1000 C.E. (column 4), and 1 and 500 C.E. (column 5). In Table 4, the *volatility of state history* is also added in the baseline regression. The volatility of state history is the standard deviation of state-history variable, s_{it}, for every 50-year periods from 1 to 1950 C.E. This variable attempts to distinguish countries which are consistently ruled by state-level institutions from other countries which might swing between state-level institutions and fragmented governments. Column 1 shows that the estimated coefficient of -0.046 for state history is slightly smaller in magnitude than the baseline result of -0.049, but is still statistically significant at the 1-percent level. Hence, controlling for the volatility of state history does not appear to alter our principal finding.

In Column 2, the result shows that if we use only the last 450 years (1501-1950 C.E.) of state history to explain macroeconomic volatility, the estimated coefficient increases to -0.056, which is also statistically significant at the 1-percent level. In Column 3 to 5, we examine the effect of the state history in different periods on the macroeconomic volatility, controlling for other factors. More specifically, the estimated coefficients of state history for the periods 1001-1500 C.E., 501-1000 C.E., and 1-500 C.E. are -0.015, -0.019, and -0.023 respectively. Although these estimates are smaller than that of the most recent historical period of 1501-1950 C.E., they are still statistically significant at the conventional levels. Thus, Column 1 to 5 of Table 4 demonstrate that state history of the most recent historical period of 1501-1950 C.E. exerts the largest effect on macroeconomic volatility today.

A question that needs to be addressed is potential endogeneity bias. Reverse causality is not the main issue for the history of state-level political institutions, but omitted-variable bias may be an issue because we are not able to control for country-specific factors using fixed effects. The direction of the bias, if any, depends on the correlations between the omitted variable and macroeconomic volatility and also between the omitted variable and state history. If, for example, the omitted variable is negatively correlated with both macroeconomic volatility and state history, then the OLS estimate would likely underestimate the reductive effect of state history on macroeconomic volatility. We attempt to overcome this potential bias by using instrumental variable estimation in Column 6, Table 4.

In Column 6, the endogenous variables are state history and the volatility of state history since 1 C.E. The instruments are population size at 1 C.E., urbanization index at 1000 B.C.E., agriculture history and adoption of military technology at 1000 B.C.E. To be an appropriate instrument, it has to meet the conditions of relevance and exogeneity. Surplus theories hypothesize that the availability of agricultural surplus supported increasing population and urbanization, which formed the basis for the emergence of social stratification and a hierarchical political structure for distributing the surplus.[15] Hence, population at 1 C.E. and urbanization at 1000 B.C.E. are likely to be positively correlated with state history. Also, following Ang (2015), we add agriculture history and adoption of military technology in the instrument set.

Results of the first-stage regressions are reported in Column 5 and 6, Panel B, Table 6. In Column 5, state history is significantly explained by population size at 1 C.E. at the 1-percent significance level, while *other instruments are not significant* at the conventional levels. In Column 6, the volatility of state history is only marginally explained by the history of agriculture. The (adjusted) R-squares indicate that the instrument set is capable of explaining 60% of the variation in state history and 27% of the variation in the volatility of state history. The Shea partial R-squares of 25% and 14% respectively for state history and the volatility of state history are relatively large to suggest that the instrument set is relevant in explaining the endogenous variables. The F-test for the joint significance of the instruments rejects the null hypothesis of no effect from the instrument set for the first-stage regressions (9.10 for state history and 5.3 for the volatility of state history). These diagnostic statistics of the first-stage regressions thus appear to suggest that the instruments are relevant.

Results of the second-stage regression are reported in Column 6, Panel A, Table 4. The reductive effect of state history on macroeconomic volatility is estimated at -0.084, which is statistically significant at the 5-percent significance level. Compared to the baseline result of -0.049, the IV result is substantially higher, indicating that the OLS estimate underestimates the reductive effect of state history due to omitted-variable bias. The Sargan-

[15] See, for example, Aspromourgos (1996) and Meek (1976) for surveys of surplus theories.

Hansen test is a test of over-identifying restrictions, i.e., whether the instruments explain macroeconomic volatility beyond their effects on state history and the volatility of state history. A rejection of the null suggests the instruments are invalid. The *P*-values of the Sargan-Hansen test reported in Table 4 is 0.775, which does not reject the null hypothesis and hence suggests the validity of our instrument set. It is reassuring to find that the OLS estimate underestimates the effect of state history, suggesting that even without correcting for potential endogeneity bias the reductive effect of state history on macroeconomic volatility is still highly significant and substantial in magnitude.

[Insert Table 5 about here]

Table 5 reports the regression results of further robustness checks. We begin with the "African factor." As can be seen from Figure 1, many African countries experience both high output volatility and relatively short history of state-level political institutions. We are then concerned that the estimated effect of state history is mainly caused by the difference between African countries and the rest of the world. Having included the dummy variable for Africa in the baseline regressions mitigates but not eliminates the concern. We thus exclude the African countries from the sample and report the regression results in Column 1, Table 5: the estimated effect of state history on output volatility increases from -0.049 to -0.067 and remains statistically significant at the one percent level in Panel A. In Panel B, the estimated marginal effect of state history on the occurrence of trend-growth breaks also increases from -0.559 to -0.665 and remains statistically significant at the 10 percent level. Moreover, the goodness-of-fit improves in both regressions (R^2 = 0.25). We can now be confident that the estimated effect of state history on macroeconomic volatility is not due to the inclusion of African countries in the sample.

The next concern is the extent of controls for geography. In the baseline regressions, we include absolute latitude and a tropical dummy to capture the potential effects of climates and soils on macroeconomic volatility and state history. Now, we ask whether a more detailed classification of climates and soils can better capture their effects. Column 2, Table 5, reports the regression results when we include four temperature, four humidity and seven soil zones from Parker (1997) in the baseline regressions: the results in Panel A show that the magnitude of the state history estimate is reduced to -0.037 from the baseline result of -0.049, but remains statistically significant at the 5 percent level. The F-test for the joint effect of the 15 additional climate and soil variables gives a P-value of 0.81, indicating that they are not jointly significant in explaining output volatility. In Panel B, the t-statistic of the estimated marginal effect of state history increases from 1.82 in the baseline result to 2.12 after the additional climate and soil variables are included in the regression. Again, the joint estimated effect of the additional climate and soil variables is not statistically significant (P-value = 0.24). In short, the estimated effects of state history on both output volatility and the occurrence of trend-growth breaks remain robust after including the 15 additional controls for climates and soils.

We then address the concern related to the “European factor.” Easterly and Levine (2012) show that the share of the European population in colonial times has a large and significant impact on income per capita today. They argue that European colonizers brought with them social values, ideologies and norms in addition to general education, scientific and technological knowledge, knowledge of access to international markets, and the human capital needed in building quality institutions. Clearly, this is also related to the literature on the role of human capital in long-run development, including Galor and Weil (2000), Glaeser et al. (2004), and Galor, Moav and Vollrath (2009), Hanushek and Woessmann (2012a, b, 2016), among others. As such, the share of the European population can be an important factor not only for long-run growth but also for macroeconomic volatility. Using Putterman and Weil’s (2010) World Migration Matrix, we construct a variable ‘European’ which is the share of the year 2000 population in every country that is descended from people in Belgium, France, Germany, Italy, the Netherlands, Portugal, Spain and the United Kingdom in the year 1500 C.E. Following Spolaore and Wacziarg (2013), we restrict our attention to a sample of countries with fewer than 30 percent of Europeans.

Column 3 of Panel A, Table 5, shows that the estimated effect of 'European' on output volatility is negative and statistically significant at the 10 percent level. Because the history of state-level political institutions has already been adjusted for population migration since 1500 C.E., the European variable represents the effects of European ancestry on output volatility over and above what has already been explained by the state history of European ancestry. The estimate indicates that countries with a larger share of current population descended from Europe experience less output volatility. More importantly, the estimate for state history remains unchanged from the baseline result and statistically significant at the 5 percent level even given the presence of 'European' in the regression.

Column 3 of Panel B, Table 5, shows that the estimated effect of 'European' on the occurrence of trend-growth breaks is negative, but statistically insignificant at conventional levels. In contrast, the estimated marginal effect of state history is -0.587 and is statistically significant at the 5 percent level. Hence, even though European is important for output volatility, it does not undermine the strength of the linkage between state history and macroeconomic volatility.

Rodrik (1999) shows that divided societies and weak institutions of conflict management amplify external shocks, causing volatile growth and crises. He adopts income inequality and ethnolinguistic fragmentation as indicators of divided societies. Inspired by his research, we use the variable 'ethnic fractionalization,' which is defined as the probability that two individuals selected at random from a country will be from different ethnic groups (Fearon, 2003). It is expected that greater ethnic fractionalization is associated with more divided countries, which hinders the ability of the authorities to manage external shocks (Alesina and La Ferrara, 2004; Yuki, 2015).

Column 4 of Table 5 reports the results when ethnic fractionalization is added to the baseline regressions. In Panel A, the estimated effect of ethnic fractionalization on output volatility is positive and statistically significant at the 10 percent level (0.019, t-statistic = 1.76). Greater ethnic fractionalization is thus associated with greater output volatility, which is consistent with our expectation. On the contrary, the estimated marginal effect of ethnic fractionalization on the occurrence of trend-growth breaks is negative and statistically significant at the 5 percent level (-0.573, t-statistic = 2.29) in Panel B, indicating that greater ethnic fractionalization is associated with a smaller chance of trend-growth breaks. Hence, the results for ethnic fractionalization are mixed as it increases the high-frequency output volatility, but reduces the occurrence of medium-run trend-growth breaks.[16] On the other hand, the estimates of state history, which *remain to be negative and statistically significant*, are robust to the addition of ethnic fractionalization in both panels.

We also consider the "democratic factor." Column 5, Table 5, checks whether the state history estimate would be affected when democracy is added to the baseline regressions. Previous studies find that democratic countries are less volatile (Rodrik, 2000; Mobarak, 2005, Cuberes and Jerzmanowski, 2009). Using Polity2 from the *POLITY IV PROJECT* (Marshall, Gurr and Jaggers, 2013) to measure democracy, we confirm the finding of previous studies that democracy has a significant stabilizing effect on both high-frequency output volatility (-0.002, t-statistic = 5.89) and medium-run trend-growth breaks (-0.023, t-

[16] We regard this result of ethnic fractionalization in reducing medium-run trend-growth volatility interesting, and it may highlight the potential dual roles of ethnic diversity on macroeconomic volatility. On the one hand, ethnic fractionalization increases social divides and conflicts, but, on the other, it may increase ideas and innovations. Ashraf and Galor (2013) demonstrate that human genetic diversity has a hump-shaped effect on the logged population density in 1500 C.E.

statistic = 1.64). More importantly, the magnitudes and statistical significances of the state history estimates in Column 5 of Panel A and B are roughly the same as their baseline results after controlling for the effect of democracy. Hence, the evidence suggests that state history and democracy both affect macroeconomic volatility significantly.

We also consider another robustness checks related to less developed countries, which is well known to be more volatile than developed ones (Lucas, 1988). Koren and Tenreyro (2007) show that as countries develop, they move their productive structure from more volatile to less volatile sectors. Therefore, if state history reduces macroeconomic volatility of a country primarily through enhancing its growth and development, then controlling for the stages of development in the regression should render the estimate for state history insignificant, but the estimate for development significant. If, however, state history operates primarily through routes other than development to affect macroeconomic volatility, the baseline estimate for state history should be unaffected by controlling for the stages of development. Clearly, state history can affect macroeconomic volatility through both routes, and in which case the magnitude of the state history estimate should be reduced but remain statistically significant.

Column 6 of Table 5 reports the results when log income per capita in 2002 is added to the baseline regressions to control for the stages of development. Results in Panel A show that the estimate of state history is substantially smaller in both magnitude and statistical significance (-0.027, t-statistic = 1.88) than the baseline result after controlling for development. However, it is still statistically significant at the 10 percent level in explaining output volatility. Moreover, the estimate for log income per capita in 2002 is highly significant (-0.011, t-statistic = 2.85). Taken together, these results appear to suggest that state history reduces output volatility of a country by both enhancing the country's development as well as by operating independently through other routes.

Results in Column 6 of Panel B, Table 5, indicate that controlling for development leaves the state history estimate unchanged from the baseline result in the regression of the occurrence of trend-growth breaks. The estimate for log income per capita in 2002, however, is non-significant. Hence, the evidence suggests that the stages of development appear to be important for high-frequency output volatility, but not so for the occurrence of medium-run trend-growth breaks.

In sum, regressions in Table 5 reports results from a set of regressions which include additional variables which are well-known to be related to macroeconomic volatility. It is reassuring to find that the baseline estimate of state history is largely unaffected by the inclusion of these addition controls. Furthermore, we confirm findings of previous studies that the share of European population, ethnic fractionalization, democratic institutions, and development all play a role in affecting macroeconomic volatility today.

[Insert Table 6 about here]

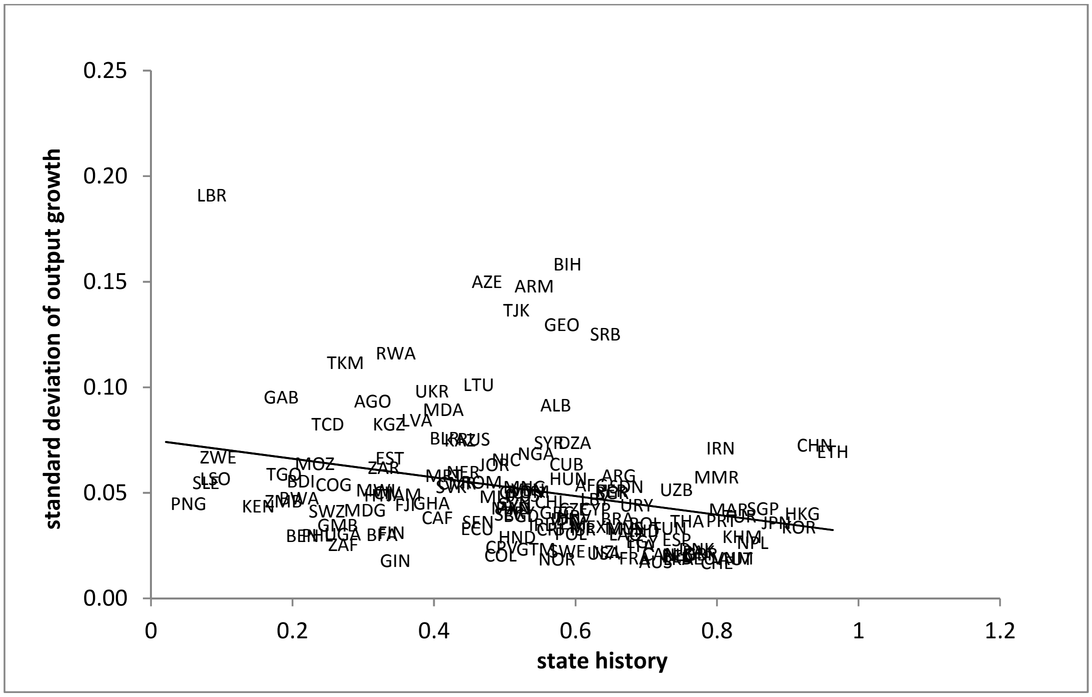
The historical variables used in the baseline regressions above have all been adjusted using the World Migration Matrix. We now come to investigate whether the principal finding would be altered by the use of historical variables which have not been adjusted for world population migration since 1500 C.E. Table 6 reports the regression results when each of the six historical variables that has not been adjusted for population migration is used in the regression to explain macroeconomic volatility. Panel A of Table 6 shows that the unadjusted state history is still *the only historical variable* out of all the other unadjusted historical variables that has a significant reductive effect on macroeconomic volatility. The estimate of -0.036 for the unadjusted state history is smaller than the baseline estimate of -0.049 for the adjusted state history, but is statistically significant at the 1-percent level. In the Panel B of Table 6, the significant reductive effect of unadjusted state history is shown to be unaffected by adding another unadjusted historical variable in the regression. In sum, results in Table 6 reaffirm the principal finding that state history is the most important historical variable accounting for current macroeconomic volatility even when it is not adjusted for world population migration since 1500 C.E.

5. Conclusions

This study is motivated by the recent finding that historical variables play a critical role in explaining current economic performance. While most existing studies focus on the effect of historical variables on the differences in income level or income inequality, we take a step further to examine whether and how historical variables affect macroeconomic volatility, measured either by high-frequency output volatility or by medium-run trend-growth breaks. The results of the study contribute to the ongoing debate regarding the fundamental determinants of macroeconomic volatility.

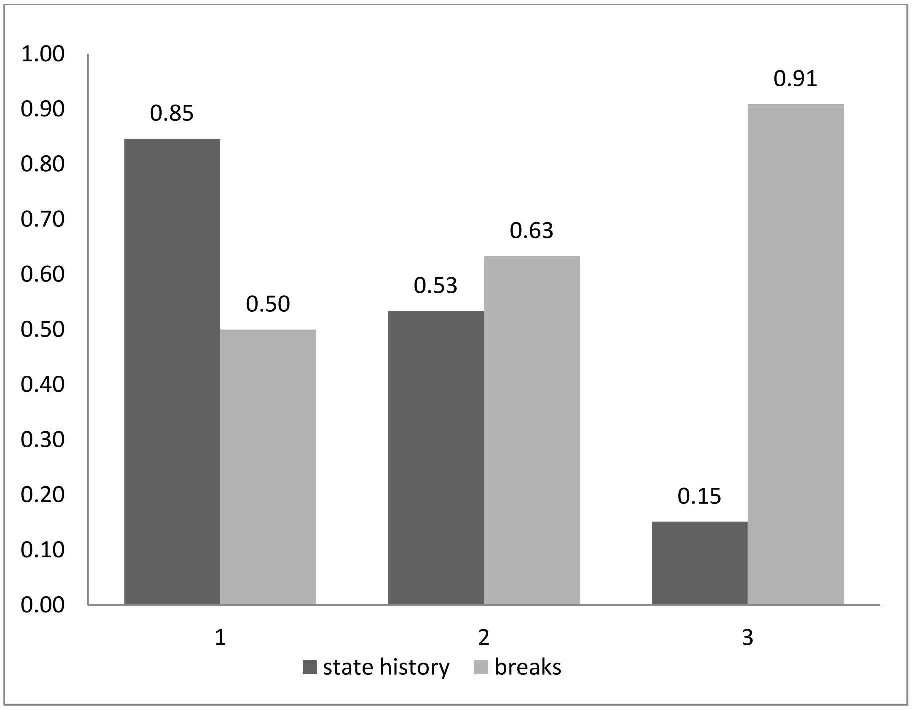
We also conduct a large number of robustness checks and find that among the six historical variables previously shown to be important determinants of income, only the history of state-level political institutions significantly affects both the high-frequency output volatility and the occurrence of medium-run trend-growth breaks. The other historical variables found to affect medium-run trend-growth breaks, but not high-frequency output volatility, are agricultural history and the adoption of technology in 1 C.E. Thus, the historical variables do not all provide equally important explanations of macroeconomic volatility, despite their important roles in determining differences in income, as shown in previous studies. We also find that the state history variable is more important in countries with a higher level of macroeconomic volatility. More recent history also tends to matter more. We leave it to the future research to investigate the mechanism behind all these findings.

<u>Figure 1: Scatterplot of State History and Output Volatility</u>



Notes: See Section 2 in text for discussions of state history and output volatility.

Figure 2: State History and Frequency of Trend-Growth Breaks



Notes: See Section 2 in text for discussions of state history and trend-growth breaks (breaks).

Table 1: Historical Variables and Volatility of Output Growth (OLS Regressions)

Dependent variable is the standard deviation of annual output growth (1960-2011)						
Panel A						
	1	2	3	4	5	6
State history	-0.049*** (2.93)					
Agri. history		5.13e-7 (0.29)				
Technology 1000BC			0.008 (0.88)			
Technology 1CE				-0.007 (0.92)		
Technology 1500CE					-0.011 (0.80)	
Genetic distance						4.74e-6 (0.77)
Absolute latitude	0.000 (0.64)	0.000 (0.96)	0.000 (0.65)	0.001* (1.77)	0.000 (0.19)	0.000 (0.85)
Tropics	0.001 (0.07)	0.007 (0.93)	0.007 (0.79)	0.004 (0.41)	-0.003 (0.27)	0.004 (0.43)
Log of arable land	-0.000 (0.23)	-0.002 (1.02)	-0.001 (0.57)	-0.003** (2.06)	-0.002 (1.37)	-0.002 (0.87)
Landlocked	0.001 (0.00)	0.002 (0.26)	0.005 (0.79)	-0.007 (1.05)	-0.008 (1.12)	0.000 (0.05)
Island	-0.010* (1.89)	-0.009 (1.65)	-0.004 (0.53)	-0.015*** (2.81)	-0.015** (2.35)	-0.009* (1.98)
Africa	0.004 (0.80)	0.014** (2.11)	0.013** (2.29)	0.016*** (2.81)	0.014** (2.16)	0.009 (1.29)
Asia	0.012** (2.13)	0.007 (1.28)	0.007 (1.19)	0.019*** (2.77)	0.013 (1.52)	0.006 (1.15)
Europe	0.000 (0.03)	-0.001 (0.08)	-0.001 (0.15)	-0.009 (1.10)	0.001 (0.11)	-0.000 (0.00)
Observations	117	117	102	122	114	117
R^2	0.17	0.07	0.07	0.14	0.10	0.08
Panel B						
	Agri. history	Technology 1000BC	Technology 1CE	Technology 1500CE	Genetic distance	FPC of history
State history	-0.057*** (3.24)	-0.052*** (3.15)	-0.045** (2.59)	-0.050** (2.61)	-0.054*** (2.67)	
Column variable	3.16e-06* (1.86)	0.014* (1.67)	-0.002 (0.25)	0.009 (0.80)	-4.73e-06 (0.60)	-0.004** (2.06)
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	117	98	113	105	117	113
R^2	0.19	0.21	0.18	0.19	0.18	0.12

Notes:
1. *** indicates significance at the 1-percent level, ** at the 5-percent level, and * at the 10-percent level.
2. Absolute values of heteroskasdastically robust t-statistics are in the parentheses. All regressions include an unreported constant.
3. Baseline controls include absolute latitude, logged arable land area, and dummies for tropics, landlocked, island, Africa, Asia and Europe. FPC is the first principal component of historical variables.
4. See Section 2 in text and Appendix A for discussions of the variables.

Table 2: State History and Volatility of Output Growth (Quantile Regressions)

Dependent variable is the standard deviation of annual output growth (1960-2011)					
	OLS	Quantile			
		0.05	0.25	0.50	0.75
State history	-0.049*** (2.93)	-0.025* (1.88)	-0.027*** (2.66)	-0.029** (1.82)	-0.057*** (2.64)
Absolute latitude	0.000 (0.64)	0.000 (0.60)	0.000 (0.16)	0.000 (0.91)	0.000 (0.31)
Tropics	0.001 (0.07)	0.001 (0.11)	0.004 (0.41)	0.004 (0.58)	0.005 (0.33)
Log of arable land	-0.000 (0.23)	-0.001 (0.66)	-0.000 (0.24)	0.000 (0.02)	0.003 (1.03)
Landlocked	0.001 (0.00)	0.008 (1.33)	0.001 (0.20)	0.001 (0.10)	-0.007 (0.65)
Island	-0.010* (1.89)	-0.001 (0.27)	0.001 (0.16)	-0.001 (0.21)	-0.013 (0.98)
Africa	0.004 (0.80)	-0.004 (0.55)	0.006 (1.05)	0.005 (0.98)	0.001 (0.09)
Asia	0.012** (2.13)	0.002 (0.49)	0.008 (1.59)	0.004 (0.72)	0.013 (1.63)
Europe	0.000 (0.03)	-0.013 (1.00)	-0.001 (0.10)	-0.014 (1.38)	0.002 (0.12)
Observations	117	117	117	117	117
R^2	0.17	0.10	0.13	0.10	0.10

Notes:
1. *** indicates significance at the 1-percent level, ** at the 5-percent level, and * at the 10-percent level.
2. Absolute values of heteroskasdastically robust t-statistics are in the parentheses for OLS, and bootstrapped for quantiles.
3. All regressions include an unreported constant.
4. See Section 2 in text and Appendix A for discussions of the variables.

Table 3: Historical Variables and Trend-Growth Breaks (Probit Regressions)

Dependent variable is a dummy variable indicating the presence of trend-growth breaks						
Panel A						
	1	2	3	4	5	6
State history	-0.559* (1.82)					
Agri. history		-7.94e-5* (1.77)				
Technology 1000BC			-0.075 (0.36)			
Technology 1CE				-0.497*** (4.04)		
Technology 1500CE					-0.088 (0.26)	
Genetic distance						1.82e-4 (1.38)
Absolute latitude	0.006 (0.70)	0.000 (0.05)	0.004 (0.44)	0.005 (0.65)	0.002 (0.24)	0.005 (0.56)
Tropics	0.238 (1.04)	0.083 (0.35)	0.238 (0.95)	0.159 (0.76)	0.163 (0.63)	0.174 (0.74)
Log of arable land	0.062** (2.12)	0.049* (1.68)	0.029 (0.83)	0.057** (2.24)	0.034 (1.16)	0.052* (1.89)
Landlocked	-0.054 (0.47)	-0.093 (0.78)	0.020 (0.15)	-0.027 (0.25)	-0.035 (0.27)	-0.109 (0.89)
Island	-0.057 (0.37)	-0.118 (0.71)	0.080 (0.31)	0.009 (0.06)	-0.011 (0.07)	-0.045 (0.30)
Africa	-0.046 (0.31)	-0.128 (0.72)	0.011 (0.08)	-0.077 (0.59)	0.007 (0.04)	-0.076 (0.44)
Asia	0.238* (1.66)	0.288* (1.92)	0.260 (1.54)	0.214* (1.66)	0.210 (1.34)	0.130 (0.89)
Europe	0.424** (2.30)	0.494*** (2.73)	0.411** (2.10)	0.477*** (2.89)	0.439** (2.39)	0.446** (2.41)
Observations	94	94	83	95	93	94
Pseudo R^2	0.13	0.13	0.09	0.20	0.09	0.12
Panel B						
	State history	Agri. history	Technology 1000BC	Technology 1500CE	Genetic distance	FPC of history
Technology 1CE	-0.433*** (3.27)	-0.458*** (3.31)	-0.584*** (3.17)	-0.634*** (4.34)	-0.521*** (3.39)	
Column variable	-0.306 (0.93)	-2.92e-5 (0.59)	0.303 (1.19)	0.430 (1.09)	-2.38e-5 (0.15)	-0.145*** (2.89)
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	91	91	81	89	91	91
Pseudo R^2	0.19	0.19	0.16	0.21	0.19	0.18

Notes:
1. *** indicates significance at the 1-percent level, ** at the 5-percent level, and * at the 10-percent level.
2. Absolute values of heteroskasdastically robust t-statistics are in the parentheses.
3. All regressions include an unreported constant.
4. Baseline controls include absolute latitude, logged arable land area, and dummies for tropics, landlocked, island, Africa, Asia and Europe. FPC is the first principal component of historical variables.
5. See Section 2 in text and Appendix A for discussions of the variables.

Table 4: Alternative Periods of State History and Volatility of Output Growth

Dependent variable is the standard deviation of annual output growth (1960-2011)						
Panel A						
	OLS (1-1950 CE) 1	OLS (1501-1950 CE) 2	OLS (1001-1500 CE) 3	OLS (501-1000 CE) 4	OLS (1-500 CE) 5	IV (1-1950 CE) 6
State history	-0.046*** (2.78)	-0.056*** (2.93)	-0.015* (1.87)	-0.019** (2.59)	-0.023** (2.39)	-0.084** (2.25)
Volatility of state history	-0.001* (1.68)	-0.000 (0.32)	-0.001* (1.84)	-0.001** (2.45)	-0.001*** (2.66)	-0.003** (2.10)
Absolute latitude	0.000 (1.25)	0.001 (1.45)	0.001 (1.56)	0.000 (1.40)	0.001 (1.54)	0.001*** (3.04)
Tropics	0.008 (0.92)	0.011 (1.35)	0.013* (1.76)	0.011 (1.57)	0.012 (1.65)	0.035*** (2.80)
Log of arable land	-0.001 (0.43)	-0.001 (0.43)	-0.002 (0.92)	-0.001 (0.80)	-0.001 (0.79)	0.002 (1.03)
Landlocked	0.002 (0.25)	0.002 (0.37)	0.003 (0.43)	0.003 (0.49)	0.002 (0.38)	0.006 (0.93)
Island	-0.011** (2.06)	-0.012** (2.19)	-0.012** (2.30)	-0.011** (2.19)	-0.013** (2.51)	-0.004 (0.45)
Africa	0.004 (0.72)	0.002 (0.37)	0.015** (2.26)	0.012** (2.06)	0.011** (2.01)	-0.003 (0.34)
Asia	0.013** (2.23)	0.010* (1.84)	0.017** (2.33)	0.016*** (2.62)	0.015** (2.48)	0.014* (1.95)
Europe	-0.001 (0.07)	-0.003 (0.37)	0.006 (0.64)	0.005 (0.50)	0.002 (0.27)	-0.011 (1.13)
Observations	113	113	113	113	113	85
R^2	0.20	0.21	0.13	0.15	0.15	0.07
Hansen-J test (p value)						0.775
Panel B: First-stage regressions						
					State history	Volatility of state history
Population at 1 CE					0.061*** (3.93)	0.787 (1.48)
Urbanization at 1000 BCE					-0.010 (0.35)	-0.879 (1.05)
Agriculture history					7.95e-6 (0.37)	-9.96e-4* (1.69)
Military tech at 1000 BCE					0.025 (0.23)	-2.970 (1.28)
Controls in the 2^{nd} stage					Yes	Yes
R^2 (Adj.)					0.589	0.270
Shea Partial R^2					0.247	0.135
F-test excl. instruments					9.10	5.28

Notes:

1. *** indicates significance at the 1-percent level, ** at the 5-percent level, and * at the 10-percent level.
2. Absolute values of heteroskasdastically robust t-statistics are in the parentheses. All regressions include an unreported constant.
3. See Section 2 in text and Appendix A for discussions of the variables.

Table 5: Further Robustness Checks

	Excluding Africa (1)	Controlling for climate and soil (2)	Controlling for European (3)	Controlling for ethnicity (4)	Controlling for democracy (5)	Controlling for income (6)
Panel A: Dependent variable is the standard deviation of annual output growth (OLS regressions)						
State history	-0.067*** (3.54)	-0.037** (2.07)	-0.043** (2.38)	-0.044*** (2.74)	-0.055*** (3.39)	-0.027* (1.88)
P-value for climate & soil		[0.81]				
European share of population			-0.073* (1.93)			
Ethnic fractionalization				0.019* (1.79)		
Democratic institutions					-0.002*** (5.89)	
Log income in 2002						-0.011*** (2.85)
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	80	117	89	116	116	111
R^2	0.25	0.36	0.15	0.19	0.29	0.26
Panel B: Dependent variable is a dummy variable indicating the presence of trend-growth breaks (Probit regressions)						
State history	-0.665* (1.72)	-0.582** (2.12)	-0.587** (2.02)	-0.710** (2.34)	-0.632** (2.05)	-0.578* (1.81)
P-value for climate & soil		[0.24]				
European share of population			-0.128 (0.17)			
Ethnic fractionalization				-0.573** (2.29)		
Democratic institutions					-0.023* (1.64)	
Log income in 2002						0.076 (1.02)
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	61	89	67	93	94	93
Pseudo R^2	0.25	0.23	0.19	0.17	0.15	0.13

Notes:

1. *** indicates significance at the 1-percent level, ** at the 5-percent level, and * at the 10-percent level.
2. Absolute values of heteroskasdastically robust t-statistics are in the parentheses.
3. All regressions include an unreported constant.
4. Baseline controls include absolute latitude, logged arable land area, and dummies for tropics, landlocked, island, Africa, Asia and Europe.
5. See Section 2 in text and Appendix A for discussions of the variables.

Table 6: Baseline Results (Without Adjusting for Population Migration)

Dependent variable is the standard deviation of annual output growth (1960-2011)						
Panel A						
	1	2	3	4	5	6
State history	-0.036*** (2.63)					
Agri. history		8.79e-07 (0.58)				
Technology 1000BC			0.011 (1.40)			
Technology 1CE				-0.007 (0.93)		
Technology 1500CE					-0.010 (0.53)	
Genetic distance						-1.06e-07 (0.02)
Absolute latitude	0.000 (0.99)	0.000 (1.09)	0.000 (0.60)	0.001* (1.69)	-4.98e-06 (0.01)	0.000 (0.81)
Tropics	0.008 (0.93)	0.009 (1.23)	0.008 (0.83)	0.004 (0.43)	-0.003 (0.32)	0.002 (0.20)
Log of arable land	-0.001 (0.67)	-0.002 (1.35)	-0.001 (0.69)	-0.003** (2.13)	-0.002 (1.23)	-0.004** (2.51)
Landlocked	0.002 (0.24)	0.003 (0.42)	0.005 (0.77)	-0.007 (1.00)	-0.010 (1.41)	-0.005 (0.74)
Island	-0.013** (2.40)	-0.008 (1.42)	-0.004 (0.53)	-0.016*** (2.86)	-0.013** (2.14)	-0.017*** (3.21)
Africa	0.015** (2.48)	0.013** (2.23)	0.010* (1.68)	0.019** (2.60)	0.020** (2.59)	0.016*** (2.73)
Asia	0.023*** (2.87)	0.007 (0.94)	0.004 (0.59)	0.023*** (2.83)	0.018** (2.05)	0.020*** (2.75)
Europe	0.010 (1.01)	-0.004 (0.37)	-0.005 (0.53)	-0.005 (0.47)	0.003 (0.20)	-0.002 (0.16)
Observations	113	113	103	123	111	128
R^2	0.15	0.09	0.08	0.14	0.11	0.13
Panel B						
	Agri. history	Technology 1000BC	Technology 1CE	Technology 1500CE	Genetic distance	FPC of history
State history	-0.042*** (2.93)	-0.043*** (3.12)	-0.030** (2.18)	-0.029* (1.90)	-0.041** (2.36)	
Column variable	2.79e-06* (1.79)	0.018** (2.48)	-0.005 (0.68)	0.007 (0.53)	-5.68e-06 (0.72)	-0.001 (0.43)
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	113	95	109	99	111	84
R^2	0.17	0.22	0.17	0.17	0.17	0.14

Notes:
1. *** indicates significance at the 1-percent level, ** at the 5-percent level, and * at the 10-percent level.
2. Absolute values of heteroskasdastically robust t-statistics are in the parentheses. All regressions include an unreported constant.
3. Baseline controls include absolute latitude, logged arable land area, and dummies for tropics, landlocked, island, Africa, Asia and Europe. FPC is the first principal component of historical variables.
4. See Section 2 in text and Appendix A for discussions of the variables.

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Appendix

The appendix is organized as follows:

- Appendix A provides more details on data definitions and sources.
- Appendix B provides the supplementary results behind the principal component analysis relating to historical variables and covariates of output volatility.
- Appendix C provides a list of countries included in the study.

<u>Appendix A: Data</u>

- Absolute latitude: absolute value of the latitude of the country (*THE WORLD FACTBOOK*, CIA).
- Arable land area: log of total arable land area in sq. km (*THE WORLD FACTBOOK*, CIA).
- Climate and soil: climate includes five measures of temperatures (average, minimum monthly high, maximum monthly high, minimum monthly low, and maximum monthly low, all in centigrade), and four measures of humidity (morning minimum, morning maximum, afternoon minimum and afternoon maximum, all in percent). Soil includes seven types of soil qualities (steppe [low latitude], desert [low latitude], steppe [middle latitude], desert [middle latitude], dry steppe wasteland, desert dry winter, and highland). (Parker, 1997).
- Colonial origins: are four dummy variables representing former colonies of the UK, France, Spain or others. It takes on the value of one if the country is a former colony of one of the above-mentioned countries, zero otherwise. (*THE WORLD FACTBOOK*, CIA).
- Democracy institutions: is the variable *Polity2* that is calculated by subtracting the autocratic score from the democratic score for each country. If a country has a "standardized authority score" (66, 77 or 88) for a particular year, it will be converted to "conventional polity scores". This variable has a range from -10 to 10, with 10 being the perfect score for democracy (*POLITY IV PROJECT*, Marshall, Gurr, and Jaggers, 2013).
- Ethnic fractionalization: is the probability that two individuals selected at random from a country will be from different ethnic groups (Fearon, 2003).
- European share of population: is the share of the year 2000 population in every country that is descended from people in Belgium, France, Germany, Italy, the Netherlands,

Portugal, Spain and the United Kingdom in the year 1500CE (Constructed using Putterman and Weil's (2010) World Migration Matrix).

- Income level: is the log of Purchasing Power Parity adjusted per capita GDP in 2002 (rgdpch, *Penn World Tables*, version 6.3).
- Island: is a dummy variable taking on the value of one if a country is an island, zero otherwise (*THE WORLD FACTBOOK*, CIA).
- Malaria prevalence: is the index of malaria prevalence in 1966 (Gallop et al., 200).
- Neo-Europes: is a dummy variable taking on the value of one if a country is Australia, Canada, New Zealand or the US, zero otherwise.
- Political stability: is the *Political Risk Index* from *International Country Risk Guide* for the year 2000, which is an index between zero and one, with one being perfectly politically stable.
- Protestant share: is the fraction of population protestant in 1960 (Barro, 1999)
- Tropics: a dummy variable taking on the value of one if the country is tropical and zero otherwise (Comin, Easterly and Gong, 2010).

Appendix B

Table B.1: Correlation Coefficients of Historical Variables

	State history	Agricultural history	Technology at 1,000BC	Technology at 1CE	Technology at 1,500CE	Genetic distance
State history	1.00					
Agricultural history	0.68***	1.00				
Technology at 1,000BC	0.41***	0.66***	1.00			
Technology at 1CE	0.60***	0.55***	0.64***	1.00		
Technology at 1,500CE	0.61***	0.69***	0.49***	0.59***	1.00	
Genetic distance	-0.55***	-0.67***	-0.53***	-0.59***	-0.74***	1.00

Note: *** indicates significance at the 1-percent level.

Table B.2: Explanatory Power of Each Principal Component of Historical Variables

PC	Percentage explained	Cumulative
1	0.67	0.67
2	0.11	0.78
3	0.08	0.86
4	0.07	0.93
5	0.04	0.97
6	0.03	1.00

Table B.3: Correlation Coefficients of Proximate Factors

	Political volatility	Discretionary fiscal policy	Financial development	FDI inflow
Political volatility	1.00			
Discretionary fiscal policy	-0.37***	1.00		
Financial development	0.46***	-0.51***	1.00	
FDI inflow	0.18	-0.12	0.14	1.00

Note: *** indicates significance at the 1-percent level.

Table B.4: Explanatory Power of Each Principal Component of Proximate Factors

PC	Percentage explained	Cumulative
1	0.49	0.49
2	0.24	0.73
3	0.16	0.88
4	0.12	1.00

Appendix C: A List of Countries

Country Name

Afghanistan
Albania
Algeria
Angola
Argentina
Armenia
Australia
Austria
Azerbaijan
Bangladesh
Belarus
Belgium
Benin
Bolivia
Bosnia & Herzegovina
Botswana
Brazil
Bulgaria
Burkina Faso
Burundi
Cambodia
Cameroon
Canada
Cape Verde
Central African Rep.
Chad
Chile
China
Colombia
Congo, Dem. Rep.
Congo, Rep.
Costa Rica
Cote d'Ivoire
Croatia
Cuba
Cyprus
Czech Republic
Denmark
Dominican Republic
Ecuador
Egypt, Arab Rep.
El Salvador
Estonia
Ethiopia
Fiji
Finland
France
Gabon
Gambia, The
Georgia
Germany
Ghana
Greece
Guatemala
Guinea
Guyana
Haiti
Honduras
Hong Kong
Hungary
India
Indonesia
Iran, Islamic Rep.
Ireland
Israel
Italy
Jamaica
Japan
Jordan
Kazakhstan
Kenya
Korea, Rep.
Kyrgyz Republic
Lao PDR
Latvia
Lesotho
Liberia
Libya
Lithuania
Macedonia, FYR
Madagascar
Malawi
Malaysia
Mali
Mauritania
Mauritius
Mexico
Moldova
Mongolia
Morocco
Mozambique
Myanmar
Nepal
Netherlands
New Zealand
Nicaragua
Niger
Nigeria
Norway
Pakistan
Panama
Papua New Guinea
Paraguay
Peru
Philippines
Poland
Portugal
Romania
Russian Federation
Rwanda
Senegal
Serbia
Sierra Leone
Singapore
Slovak Republic
Slovenia
South Africa
Spain
Sri Lanka
Sudan
Swaziland
Sweden
Switzerland
Syrian Arab Republic
Tajikistan
Thailand
Togo
Trinidad and Tobago
Tunisia
Turkey
Turkmenistan
Uganda
Ukraine
United Kingdom
United States
Uruguay
Uzbekistan
Venezuela, RB
Vietnam
Yemen, Rep.
Zambia
Zimbabwe