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The First Great Divergence and the Evolution of Cross-Country Income Inequality during the Last Millennium: the Role of Institutions and Culture[1]

Jakob Madsen and Eric Yan

Abstract

Using a millennium of data for 12 countries in the East and in the West this paper tests the extent to which the three most influential hypotheses on growth and development can shed light on why some economies developed earlier than others and which factors were fundamental for the Great Divergence. These hypotheses are the contracting institutions, property right institutions, and culture. It is tested whether these theories influence growth through science and technology or human capital or channels that are independent of these two channels. It is found that culture, contracting institutions and property right institutions have all been relevant for growth and development.

JEL classification: O1, P16
Key words: the Great Divergence, culture, institutions

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Jakob Madsen and Eric Yan Department of Economics Monash University

1. Introduction

The causes of the Great Divergence remain a mystery and several growth theories have recently been proposed to explain it. Many theories are based on the models of Hansen and Prescott (2002) and Lucas (2002), in which technological progress eventually renders the manufacturing sector sufficiently profitable for the economy to take off. Unified theory of economic growth is another influential line of thought, which provides a three-stage interpretation of long-run economic growth in the Western world (Galor and Weil, 2000; Galor, 2011). The first stage is the Malthusian growth regime, which lasted up until around the year 1800 in the Western world. This was followed by the post-Malthusian growth regime with low but positive per capita growth rates. The final stage is the modern growth regime, which the Western world entered in the 20th century. At the more fundamental level, the most influential hypotheses of the Great Divergence have been the institutional hypothesis of North and Thomas (1973), which has been developed further by Williamson (1985) and Acemoglu (2005), and tested empirically by Acemoglu *et al*. (2001) and Acemoglu and Johnson (2005) and the cultural/religious hypothesis of Weber (2002), Landes (1998), Morkyr (2005), Doepke and Zilibotti (2008) and Becker and Woessmann (2009).

Using a millennium of data for 12 countries this paper examines the influence of culture, property rights and contracting institutions on growth and development in the East, the Middle East and the West since the year 950 through the channels of human capital and science and technology (S&T). Three different income indicators are used to ensure robustness of the results, namely scaled urbanization, Maddison's (1995, 2003) data, and the income data used by Acemoglu *et al*. (2005b). The cultural hypothesis suggests that economic development is associated with values such as time preferences, and work ethics and some other social values that are supportive for economic development because they affect people's attitude towards knowledge, independent thinking, work and savings.

The institutional hypothesis relates to property rights and legal enforcement of contracts. Acemoglu and Johnson (2005) distinguish between two types of institutions, namely contracting institutions and property rights institutions. Property rights institutions refer to the legal protection of private parties from expropriation of private property by governments and elites (Jones, 1981, DeLong and Shleifer, 1993, Olson, 2000). Contracting institutions, by contrast, refers to the efficiency of organizations in the enforcement of contracts between private parties. These models are advocated by Williamson (1985, chapter 3), Grossman and Hart (1986), Hart (1995), and Grossman and Helpman (2002, 2004, 2005). Failure to enforce the contracts leads to economic inefficiencies. It is noticeable that the efficiency of contracting institutions, in terms of Williamson (1998), can be

fostered by political centralization resulting from vertical integration of economic organizations. The spatial scale of politics, according to Rosenthal and Wong (2011, ix of preface), is crucial for differentiating the historical development paths of China and Europe.

The contribution of the paper is two-fold. First, it constructs data on contracting institutions, culture, per capita income, S&T, human capital and property rights institutions for 12 countries over thousand years and tests the approximate and the more fundamental causes of growth and the Great Divergence. Quantitative measures are used for productivity, S&T and human capital, while qualitative indicators are used for the cultural and institutional variables. A scoring system is adopted in the construction of the qualitative indicators. The long time-span enables us to identify large changes in the slow moving forces behind changes in institutions and culture.

The following 12 countries, which are central to world economic history and development, are included in the sample: China, India, France, the UK, the Netherlands, Germany, Italy, Portugal, Spain, Japan, Russia, and Turkey. The country sample is dictated by the importance of each country in the world economy during the millennium up to the 19th century and data availability. Mongolia, which also played some role for economic development in the East, is not included in the sample because some key data are not available for this country. The starting period of circa 950 is also dictated by data availability, however, it appears that events that were important for the Great Divergence, started to unfold around 1250 AD – the conditions in these countries appear to have been fairly stable during the period 950-1250 and may also have been so during the dark ages. The analysis ends in 1850 and, as such, does not focus on the transition from the post-Malthusian growth regime to the modern growth regime at the turn of the 20th century or later because the economies were governed by a quite different growth regime in the 20th century than earlier. The data construction and scoring methods are detailed in Section 4.

Second, the paper examines the extent to which cultural, contracting institutions and property rights institutions can explain the income path and the Great Divergence through, or independently of, human capital and S&T, over the period from 950 to 1850. For that purpose the instrumental variable estimation method is used where institutions and cultural/religious forces are used as instruments for S&T and human capital, which are in turn used to explain productivity. The key here is that institutional and cultural forces could potentially create prosperity through human capital and S&T. However, whether institutions and culture influenced income independently of S&T and human capital is also tested. The empirical tests are presented in Section 5 and Section 6 concludes.

2. Three theories of early development and divergence

2.1 Culture

Culture is a key determinant of the values, preferences and beliefs of individuals and societies and is advocated to have been an important factor behind the Industrial Revolution by Weber (2002), Landes (1998), Mokyr (2005), and Doepke and Zilibotti (2008). Landes (1998) concludes that "if we learn anything from the history of economic development it is that culture makes all the difference" (1998, p. 516) and "what counts is work, thrift, honesty, patience, tenacity" (1998, p. 523). In the context of the Industrial Revolution and the Great Divergence between the West and the East there are two influential contributions: the Industrial Enlightenment by Mokyr (2005) and religious beliefs by Weber (2002) (first published in 1905).

For Mokyr (2005) the Industrial Enlightenment was the secret behind the Industrial Revolution by influencing innovative and intellectual activity. Although Mokyr acknowledges the importance of good institutions for take-off they are not a sufficient condition for sustained growth. "A desire for improvement and even the 'right' kind of institutions by themselves do not produce sustained growth unless society produces new useful knowledge and unless the growth of knowledge can be sustained over time. Useful knowledge grows because in each society there are people who are creative and original, and motivated by some combination of greed, ambition, curiosity, and altruism" Mokyr (2005, p. 60).

According to Mokyr (2005) the Industrial Enlightenment is a milestone in the improvement of organizational efficiency in human history. Before the Industrial Enlightenment unfolded, inventors did not have much clue about why and how new techniques worked: subsequent micro-inventions to support and improve on the macro-inventions were by and large absent. Since the age of Industrial Enlightenment, people started to think about why techniques worked. The consequent discoveries and research accounted for the enormous number of innovations in the age of Industrial Revolution (Mokyr, 2005). People's attitude towards knowledge is critical to the progress of human civilization and a positive attitude towards knowledge is shaped by secularism. The attitude, along with accumulation of human capital, forms a cultural climate evolving with time, facilitating both social learning and effective coordination. Mokyr (2005, p. 61) hypothesizes that with gradual improvement of organizational efficiency, the economy was able to transform pieces of knowledge into useful units for production; and, the force behind this was that there was a more and more open cultural climate that allowed for the pursuit of productivity improvements. The key here is that the European Enlightenment was associated with religious and political tolerance, human rights and freedom and natural law and justice (Mokyr, 2005). In these societies potential 'outrageous' ideas among eccentric innovators were tolerated without violent responses.

In *The Protestant Ethic and the Spirit of Capitalism*, first published in 1905, Weber (2002) puts forward the thesis that Protestantism, especially Calvinist ethics and ideas, influenced the development of capitalism by being supportive of the rational pursuit of economic gain. According to Weber (2002) protestant beliefs included hard work, thrift, saving and economic success, whereas Catholic and Muslim beliefs did not promote capitalism. Weber argued that there were many reasons to look for the origins of modern capitalism in the religious ideas of the Reformation during the 16th century. Comparing economic development in the East and West, Weber argued that Chinese patrimonialism (all power flows directly from the leader) and officialdom, and Chinese religion were the areas in which Chinese development differed most distinctively from the European route. According to Weber, Confucianism attempts to prescribe a way of life based on religious dogma that values self control with the goal of a cultural status position (Mackinnon, 2001). Therefore, Weber states that it was this difference in social attitudes and mentality in dominant religions that contributed to the development of capitalism in the West and the absence of it in China. However, even though Weber is famous from hypothesizing the relationship between economic development and religious orientation, his core argument was that the rise of rationality, following the Enlightenment, would undermine religious beliefs in the West (Mackinnon, 2001).

2.2 Contracting Institutions

Contracting institutions determine the type of contract that can be enforced between private agents. Good contracting institutions are associated with effective resource allocation, particularly transaction cost economizing (Williamson, 1985). Transaction costs, are in turn about structural efficiency such as financial development, trade, capitalistic development, and division of labor. Transaction cost economizing is based on effective contracting relationships that reduce institutional frictions and may, therefore, overcome the force of diminishing returns. Trade improves economic growth through market expansion and international specialization. Financial development reduces contracting costs, which facilitates contracting relationships. Capitalistic development leads to increasing reliance on impersonal labor market transactions. Trade improves economic growth through market expansion and international specialization (Grossman and Helpman, 2002, 2004, 2005, Antràs *et al*., 2006 and Grossman and Rossi-Hansberg, 2008). Financial development reduces contracting costs, which facilitates contracting relations (Beck and Levine, 2005). Finally, vertical integration that is facilitated by centralization is also a way to minimize on transaction costs (Williamson, 1998).

2.3 Property Rights Institutions

Property rights institutions regulate the relationship between ordinary citizens and politicians or the elite with access to political power and are, therefore, linked to the distribution of the political power in the society. The property rights hypothesis is advocated by Jones (1981), DeLong and Shleifer (1993) and Olson (2000). Bad property right institutions fail to constrain those who are in charge of the state because the state is the ultimate arbiter of contracts (Acemoglu and Johnson, 2005). The incentive to innovate and invest is larger in the presence of secure property rights because the proceeds from the investment go to the entrepreneur.

Property right institutions are of particular importance to the development and dissemination of technology. Acemoglu *et al*. (2005a) argue that without property rights individuals would lack incentive to adopt more efficient technologies and, therefore, this would ultimately impact technological progress within a society. Similarly, in the absence of secure property rights, human capital may be used for rent-seeking instead of productive pursuits; thus further retarding economic growth (Torstensson, 1994). Bad property rights institutions are, furthermore, frequently associated with autocratic, as opposed to a democratic, regimes. Democracy encourages independent thinking and creativity while autocratic regimes delay implementation of educational reforms because the leaders in autocratic regimes fear that educated people will push for democracy, freedom and equal rights and because they are unlikely to blindly follow authorities and are more inclined to think independently. As such, leaders in autocratic countries tend to draw the focus away from educating their citizens, so as not to undermine the power they have over followers. Conversely, in societies where more democratic practices exist, the development of new technologies or the improvement of existing practices is encouraged as incentives are provided, and therefore technological progress is promoted (Acemoglu *et al*., 2005a).

3. Modeling strategy

A two-step procedure is adopted here in which per capita income is influenced by institutions and culture indirectly through S&T and human capital and directly through channels independently of S&T and human capital for country *i* at time *t* as follows:

$$ln\, y_{it} = \alpha_0 + \alpha_1 S\&T_{it} + \alpha_2 HC_{it} + \alpha_3 \ln Cul_{it} + \alpha_4 \ln Con_{it} + \alpha_5 \ln Pro_{it} + CD + \varepsilon_{it}, \qquad (1)$$

where *y* is productivity or per capita income, *S&T* is science and technology, *HC* is human capital, *Cul* is culture, *Con* is contracting institutions, *Pro* is property right institutions, *CD* is fixed effect dummies, and ε is a stochastic error term. The model is estimated using data over the period 950 to

1850 for 12 countries. The data cover one observation per century; thus, yielding 120 observations in total.

The variables *S&T* and *HC* are instrumented using culture and institutions as instruments:

$$S\&T_{it} = \beta_0 + \beta_1 ln\, Cul_{it} + \beta_2 ln\, Con_{it} + \beta_3 ln\, Pro_{it} + CD + \varepsilon_{1,it}, \quad (2)$$

and

$$HC_{it} = \gamma_0 + \gamma_1 ln\, Cul_{it} + \gamma_2 ln\, Con_{it} + \gamma_3 ln\, Pro_{it} + CD + \varepsilon_{2,it}. \quad (3)$$

Eqs. (2) and (3) are the primary regressions and Eq. (1) is the secondary regression.

This framework follows standard growth modeling in which productivity is predominantly driven by technological progress along the balanced growth path; however, culture and institutions further enhance productivity to the extent that they improve the effectiveness of production at a given level of technology. Technological progress is driven by science, technology and human capital. Innovations are determined by the incentive structure of the economy as suggested by the cultural hypothesis, the contracting institutional framework and the property rights institutional framework. The identifying restrictions in this framework are that productivity is determined predominantly by *Cul*, *Con*, and *Pro* through the channels of *S&T* and *HC*. The advantage of this identifying approach is that, to some extent, it overcomes potential feed-back effects from productivity to *S&T* and *HC*. The drawback of this method is that technological progress may not be adequately explained by *S&T* and *HC* because of measurement errors.

4. Data

Quantitative as well as qualitative data are used and each data point covers a century. Qualitative data are used to construct data for culture, contracting and property rights institutions while the quantitative data are used to construct S&T, human capital and per capita income.

4.1 Scoring criteria for qualitative indicators

Common for all the qualitative scoring criteria is that they start from a common base. Note that the initial score does not affect the regression results to the extent that fixed effect dummies are included in the regressions. The primary sources of events used to construct the qualitative variables are Langer (1972), Acemoglu *et al*. (2005b), Pirenne (1963), Dunan (1964), Pacey (1990), Davies (2002) and several other papers that are detailed in the scoring list, which is available from the authors upon request.

4.1.1 Culture

The score of 2 is given for major positive events, 1 for positive events and 0.5 for minor events. The score of -2 is given for major negative events, -1 for normal negative events, and 0.5 for minor negative events. The scores are then accumulated over time. Positive scores are given for events that render a society more *secular* and independently thinking and negative scores for reverse events such as religious triumph over secular power. Thus, no points are given or taken for a change in the type of religion such as the Reformation in the 16th century where some countries in Northwestern Europe converted from Catholicism to Protestantism. Although Weber (2002) and Mokyr (2005) discuss other cultural factors as being influential for economic development, they both stress secularism as a key factor for economic development. Furthermore, according to cultural psychologists, one of the key aspects that distinguish cultures is *individualism* versus *collectivism* (Heine, 2007). While individualism emphasizes personal freedom and achievement, collectivism emphasizes group interests and discourages behavior that makes the individual stand out (Heine, 2007). Since a secular society encourages individual behavior, while a non-secular society emphasizes collective behavior, we would expect secular societies to be more innovative and to invest more in human capital. An individualistic and, thus, secular society would try to control its own fate and not appeal to supernatural powers, while non-secular societies believe that they cannot do much to influence their fate.

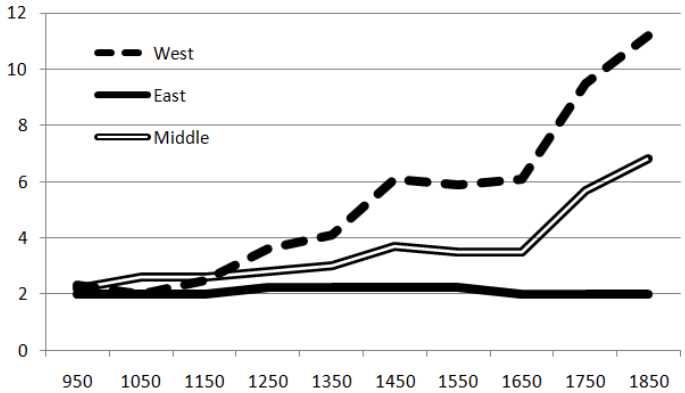
More importantly, in his seminal papers Schwartz's (1994, 1999) constructs a system of human values that revolve around three dimensions in which individualism is valued in a democratic non-authoritative system while collectivism is encouraged in authoritative system such as a society that is ruled by religious authorities. The first dimension relates to the group versus the individual. At one end of the spectrum lie conservative cultures in which the individual is viewed as embedded in, and identified with, the group and finds meaning in life through participation in the collective. Embedded cultures emphasize maintenance of the existing social order and encourage individuals to subdue personal inclinations that may disrupt the status quo. Autonomous cultures, in which the individual is regarded as a unique and self-sufficient being, lie at the opposite end on the spectrum. These cultures encourage individuals to express and develop their special gifts and to challenge conventional wisdom where it hinders personal fulfillment.

The second dimension in Schwartz's value system is certification of social order, which is achieved by authoritarian cultures at one end of the spectrum and egalitarian distribution of power at the other end of the spectrum. Since new ideas are judged on the social status of the originator in authoritative religious systems, while judged on merits in non-authoritative secular societies, we

would expect the creation of human capital and S&T to be higher in secular as opposed to non-secular societies. The third dimension in Schwartz's value system is whether individuals should adapt to the given environment or change it. At one end lay cultures that encourage individuals to shape the environment to the benefit of the society and endorses ambition, success, and competitiveness. Cultures at the other end of the spectrum emphasize harmony and that individuals should adapt to their environments rather than try to change them. Common for all these dimensions is that values are closely related to the secularity of a society. Cultures that emphasize adaptation towards the environment as given are more non-secular than societies that seek to change their environment.

Figure 1 shows the evolution of culture over time across the world. To simplify the graphical exposition the following three groups are considered: the East (China and India), West (France, the UK, the Netherlands, Germany, and Italy) and an intermediate group (Portugal, Spain, Japan, Russia, and Turkey). The country groupings are defined in terms of their income paths although the groups do, somewhat, cluster geographically. Some may object to the grouping of Japan in the Middle group since, geographically, it belongs to the East. However, Huntington (1996) argues that Japan's cultural development has been quite independent of that of China and India. Note that the grouping used here is only for expositional purposes as only individual countries are used in the empirical analysis.

Figure 1. Accumulated score for cultural.



Notes. The graph is average scores for countries in the East (China and India), West (France, the UK, the Netherlands, Germany, and Italy) and the Middle (Portugal, Spain, Japan, Russia, and Turkey).

The figure shows that after an uneventful two centuries the West takes off from the 12th century while the East stays put for almost the whole millennium. In China, the Imperial Examination, established in AD 605 under the rule of the Sui Dynasty and first abolished in 1905, slowed any progress by preventing any independent thinking by preaching morality and obedience. Culturally

the West experienced much more cultural progression due to the weakening of religious power since the 11th century. In 800 AD, papal authority had climaxed in the West and was spreading the political justifications of the Holy Roman Empire and beginning to influence all aspects of life. However, the split of the church in the 11th century gradually weakened the Pope's control over the European societies. With rising secular power, the secular ideas, originally banned by the church, began to develop and the public started to relax the strict constraints on life imposed by Christianity at that time. As a consequence, individuals started to think more independently; thus giving birth to the development of science and technology and the accumulation of human capital.

The Renaissance was a major cultural event in Europe that promoted independent thinking and was the prime mover in the development of a strong scientific and liberal culture (Pirenne 1963, pp. 377-378). The Renaissance spanning from the 14th to the 17th century began in Florence and later spread to the rest of Europe. As a cultural movement, it encompassed a flowering of literature, science, art, religion, and politics, and a resurgence of learning based on classical sources and gradual but widespread educational reform. Traditionally, this intellectual transformation has resulted in the Renaissance being viewed as a bridge between the middle Ages and the Modern era. The most significant development of the era was not a specific discovery, but rather a *process* for discovery; the so called scientific method (Brotton, 2006). The new scientific method led to great contributions in the fields of astronomy, physics, biology, and anatomy (Brotton, 2006).

The revolutions in England in 1688 and in France in 1789 further weakened the power of aristocratic class, relatively enhancing the impacts of the bourgeoisie. Bourgeoisie and aristocrats were largely different in their working attitude since there is distinctness between the attributions of their occupations —while the landed aristocratic class mainly lived on rental income, the occupations of bourgeoisie families usually required effort, skill, and experience developed with patience and work ethics (Doepke and Zilibotti, 2008). The differences in working attitudes changed people's ways of knowledge utilization and were influential for the changing production pattern.

The Middle group experienced only modest improvements up to the 17th century. The Ottoman Empire was influential for the secular increase in the Middle group. Ottoman Turkey had benefitted economically from religious conflicts in Europe through making use of its geographic advantage in the 15th century. Implementing a religious tolerance system, named Millet, the economy attracted numerous merchants, helping little Asia prosper (Langer 1972, p. 352). However, the peak in Turkish history, as Figure 1 shows, was followed by some hibernation for more than a century. Not until the 17th century did another wave of changes reach the Middle group heavily influenced by the

expansion of the Western economic frontier, which led to religious reform in Russia in the 18th century and changing the zeitgeist in Japan and Turkey in the 19th century (Langer, 1972, p. 479).

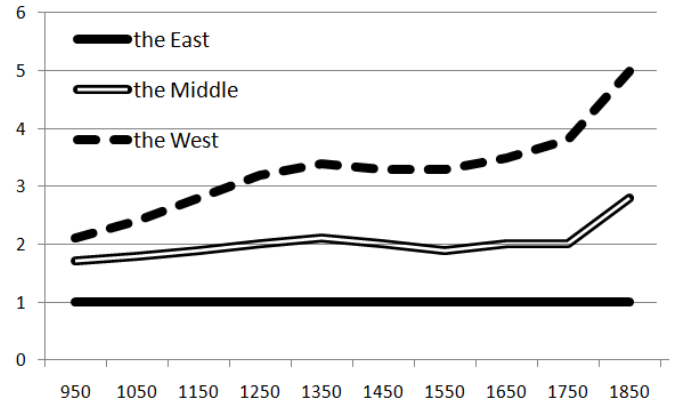
4.1.2 Property rights institutions

The data on property rights institutions for the UK, Turkey, the Netherlands, Portugal, Spain, Germany, Italy, and Belgium are from Acemoglu *et al*. (2005b), and we follow their method to construct data for Japan, China, Russia and India. The data collected by Acemoglu *et al*. (2005b) are available over the entire time-span 950-1850 although they do not use the whole length of the data in their regressions. Constraints on the executive are coded according to the criteria of Polity IV: "Operationally, this variable refers to the extent of institutionalized constraints on the decision making powers of chief executives, whether individuals or collectivities," (Dataset User's Manual for Polity IV Project, 3.4). The scores 1, 3, 5 and 7 are given, where the score of 1 is given if there are no regular limitations on the executive's actions and the score of 7 is given if "accountability groups have effective authority equal to or greater than the executive in most activity."

The scores are displayed in Figure 2. Throughout the thousand years covered by the graphs Japan and China were ruled by Confucian elites and India was ruled by Hindu elites who failed to protect the property rights of regular citizens. These elites enjoyed absolute power and were not subject to any constraints. Landes (2006) posits that the Chinese state continually interfered with private enterprises and this interference came in many forms: expropriation, prohibiting and inhibiting others, manipulating prices and forbidding all overseas trade. By contrast, property rights institutions improved substantially in the West during the first four centuries covered in the figure. Two milestones in the emergence of political institutions constraining the royal power in England are the Civil War of 1642-1649, when Parliamentary forces defeated Charles I, and the Glorious Revolution of 1688-1689, where James II was deposed by Parliament and replaced by William of Orange and a parliamentary regime with a constitutional monarchy. These events introduced major checks on royal power.

The Middle group started up with almost as good property rights institutions as the West; however, no significant improvement occurred until the 18th century, triggered by events such as the chartering of corporate rights to the nobility in Russia in 1785 (Langer, 1972, p. 517), abolition of serfdom in Russia in 1803 (Langer, 1972, p. 749), the introduction of a new constitution in Japan in 1889 (Langer, 1972, p. 921), and the reformation in Ottoman Turkey in 1839 (Langer, 1972, pp. 772 and 774).

Figure 2. Accumulated scoring for constraints on executives.



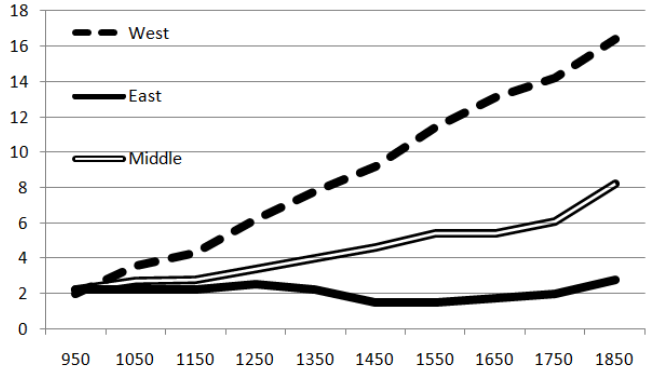
Note. See notes to Table 1.

4.1.3 Scoring for contracting institutions

The coding criteria follow the coding criteria used for culture in which the score of 2 is given for major positive events, 1 is given for normal positive events and 0.5 is given for minor events. Negative scores of 2, 1 and 0.5 are given for events that are in reverse of positive events. Positive events include events such as (1) promotion of parliamentarianism, which, in contrast to monarchy rule, economizes transaction costs as well as increases the bourgeoisie's investment incentives; (2) a political reform that strengthens the legal institutions; (3) development of rule that vertically integrates an economy's organizations; (4) formation and improvements of legal institutions that reduce transaction costs; and (5) capitalistic development such as financial development, territorial unification, promotion of international trade or other ways of overseas expansion.

Figure 3 shows the evolution of contracting institutions over time. The score starts from index 2 in year 950 to ensure that all scores are positive throughout the whole period. In the East, contracting institutions deteriorated over the period from 1250 to 1450, predominantly due to the introduction of closed door policies in China. The subsequent recovery in the East was due to reforms such as Cornwallis' Code, in India (Langer, 1972, p. 574). The Middle group experienced significant advances in its contracting institutions during most of the considered period. The founding of the Ottoman Empire in the 13th century increased the organizational efficiency in Turkey (Langer, 1972). Furthermore, in the 15th century, Portugal and Spain started voyages along the coast of Africa, America and Asia (Davies, 1996, pp. 175, 176 and 186). The decline in the 17th century was predominantly by the Japanese isolation policy in which the Japanese were forbidden to leave the country from 1636 (Langer, 1972, p. 586). Not until 1854 did Japan formally end its isolation policy (Pacey, 1990, p. 153). Thereafter there are modest advances in contracting institutions due to a series of industrial and institutional reforms in Russia and Turkey (Langer, 1972, pp. 482, 772, 774).

Figure 3. Accumulated scoring contracting institutions.



Note. See the notes to Figure 1.

The West witnessed a vast improvement in their contracting institutions during the whole period. The first ascent, starting in the 11th century, was brought about by increasing trade associated with the First Crusade (Pirenne, 1963, pp. 124-126), the emergence of guilds (Langer, 1972, p. 314), and the growth of feudalism (Langer, 1972, p. 241). This was followed by a series of financial developments that started in the 15th century such as the foundations of the Bank of St George, Genoa, in 1407 (Davies1996, p. 548), and legalization of charging interest on loans in Florence in 1403 (Davies, 1996, p. 219-220). This trend continued over the next centuries. Meanwhile, trade prospered in the low parts of Germany (Pirenne, 1963, p. 289).

In the early 17th century, colonial expansion emerged in the Netherlands and England (Pirenne 1963, pp. 562, 563 and 571). The colonization increased organizational complexity and enlarged the feasible set of transaction cost savings. In 1688 the Glorious Revolution transformed England into a constitutional monarchy in which de facto power for economizing transaction costs shifted from the king or nobility to the bourgeoisie. This trend continued in the 18th and the 19th centuries due to events such as the French revolution in 1789 and the introduction of parliamentary rule in the Netherlands and Germany in the 19th century (Dunan, 1964, p. 319 and Langer, 1972, pp. 674, and 723-726).

4.2 Scoring criteria for quantitative indicators

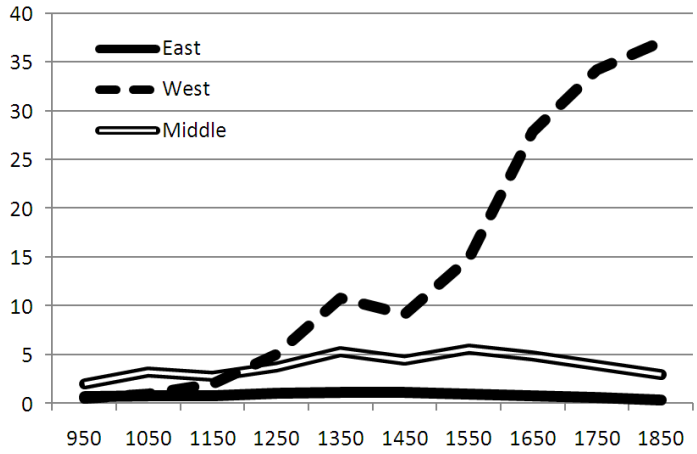
4.2.1 Science and technology

S&T is measured as the number of significant innovations over time for each country and is obtained from the detailed chronologies of significant innovations classified in Pacey (1990) and Murray (2003) and added together. The total number of entries for S&T is 492. As noted above, the S&T indicators are accumulated over time under the assumption that technological advances are

permanently increasing the level of the available technology of a nation. Without discrimination, a score of one is given for any significant scientific achievement or technological discovery listed in Pacey (1990) and Murray (2003). Addition of the scores from Pacey (1990) and Murray (2003) ensures that the most significant innovations get double weight in the scoring algorithm, while less significant innovations will be listed in only one of these two sources

The S&T data from Pacey (1990) are collected as follows. Pacey makes a chronology of major innovations in all countries in the world over the centuries covered in this paper. The chronology is not a schematic listing of events in an appendix of his book but the events are integrated into the text of the book. From his writing, the events he discusses are recorded in our chronology. A large advantage of Pacey's classification is that he accounts for the fact that innovations in one country stimulated dissimilar but related inventions elsewhere. The importance of allowing for technology spillovers and inventions of dissimilar but related inventions can be illustrated using paper manufacturing as an example. Paper manufacturing first appeared in China in the early 1st century (Pacey, 1990, p. 42). Manufacturing of paper started in India in the late 6th century and entered Islamic Spain and Sicily in 1100, France in 1326, Germany in 1390 and the England in 1490 (Pacey, 1990, p. 42). Scores are given in all these instances because they advance the level of technology in the counties in which the technology is adopted. The chronology from Murray (2003) contains central events in astronomy, biology, chemistry, earth sciences, physics, mathematics, medicine, and technology. Scores are given to the country in which the work was done and not the country of origin of the inventor. Scores are given for discoveries containing an answer to a causal or structural issue that is central to a field. They may also signify turning points in paradigms that have decisive effects on subsequent work in the field.

Figure 4. Accumulated per capita achievements in S&T.



Notes. See notes to Table 1.

Figure 4 shows the development of S&T in the three country groups. The data are normalized by population since the likelihood of innovating is proportional to the population size. The innovations in Figure 4 are dominated by advances in book production, shipbuilding techniques, textile making and non-human energy production and mechanics. Book production first appeared in China, quite a while later than paper manufacturing. According to Pacey (1990, p. 93) the Chinese two-color book printing technique began in 1340, and five-color book printing started in 1580. The paper book production started later in Europe. Metal was used instead of paper for book production in Europe by the 14th century (Pacey, 1990, p. 56).

China was the leader in the development of shipping and sailing technology before the counts starts in year 950. China's shipping technology reached its peak in the early 15th century; however, the massive decline in Chinese international trade starting in the 15th century discouraged further innovations in shipbuilding (Pacey, 1990, pp 54-55). At the same time European shipbuilding technology gained momentum and Europeans quickly became dominant within ship-building technology. A break-through in the Spanish and Portuguese shipbuilding technology, such as the avoidance of exposed ironwork, enabled long distance voyages and colonial explorations (Pacey, 1990, p 66).

Regarding textile manufacturing, most scholars suggest that India was the world leader in textile technologies before the second millennium in areas such as the spinning wheel, cotton cultivation and processing (Pacey, 1990, p. 23). However, China was catching up to the Indian technology and went on to develop the water-driven spinning machine by 1300 (Pacey, 1990, pp. 26-30). In Europe the earliest basic illustration of the spinning wheel appeared in 1280 (Pacey, 1990, p 23). However, the Europeans were slow at developing the textile industry. Prior to the 18th century, the European textile industry was lagging behind the Indian and Chinese textile industries. From the 18th century onwards, however, there was a reversal in dominance in terms of the textile technology in favor of the Europeans. The inventions of Hargreaves spinning jenny in the 1760s and the rollers and cylinders cloth printing techniques by 1785 heralded the age of European textile manufacturing (Pacey, 1990, p. 119).

Finally, the most important factors of industrial development are non-human energy and mechanics such as the water mill, the steam engine and clock-making. The water mill was first used in the Middle East, and then its use spread to Europe, China and India (Pacey, 1990, p. 10). In Europe, the water mill inspired other inventions. According to Lucas (2005), the malt mill first appeared in France in 770 AD, while the fulling mill first appeared in France in 1080 A.D. Clock-making techniques first appeared in the 1080s in China and Toledo (in now present day Spain) almost simultaneously. However, the Chinese clock-making technique radically disappeared after the

Mongolian invasion in the early 12th century (Pacey, 1990, pp. 36-37). At the same time non-human energy advanced in Europe; and, according to historical records to which we refer, after the 16th century, almost all non-human energy technologies and mechanics were invented and used by Europeans.

In terms of scientific achievements earlier on in time, India, China and Italy were relatively more advanced than other countries. For example, according to Murray (2003, pp. 163-204) Ptolemy's astronomical theories had been studied in India before 500 AD and the Chinese had astronomers describing sunspots in 165 BC. In Italy in 180 AD Galen had already dissected animals, demonstrating a variety of physiological processes and founded experimental physiology. However, according to what we code from the chronology in pp. 163-204 of Murray (2003), scientific developments in India and China stagnated after the 5th century. The combination of only a few innovations post 950 and the large and increasing populations resulted in no significant increase in the accumulated per capita S&T in China and India.

After only modest progress in S&T, Europe saw vast developments in the field of science after 1450. Our coding results of Murray (2003) and Pacey (1990) show significant scientific advances after the 17th century in the UK, the Netherlands and Italy. The middle group experienced some increase in per capita S&T up to 1550; however, the progress was watered down by population increases.

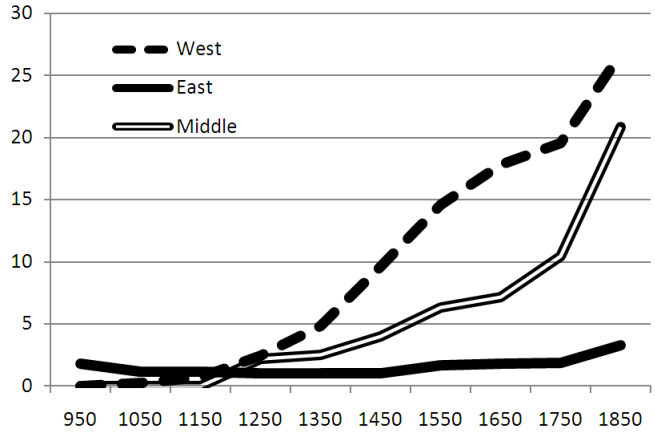
4.2.2 Human capital

Since human capital data among the broad population are not available, intellectual capital is used here and is measured as the number of students enrolled in all universities divided by the size of the population. Enrolment is measured as the number of universities multiplied by the number of students enrolled in each university in 1850 – approximately the first year at which data on student enrolment becomes available. The advantage of using intellectual capital is that intellectuals have the theoretical background to develop new technologies and adapt technologies that have been developed abroad.

The development of intellectual capital density is displayed in Figure 5. The first significant advancement in education began in the West from the 12th century, while the Middle group advanced two centuries later and the increase gained momentum in the 17th centuries fuelled by a marked increase in human capital in Russia, Turkey and Japan. In contrast, although the East had a higher level of human capital density than the West and the middle in the 10th century, it remained at a standstill for centuries and first advanced slightly after the 15th century. India was the country with the highest human capital level at the turn of the 2nd millennium; however, the Muslim and

Mongolian invasions destroyed the existing Buddhist education system. India's educational system first recovered in the 19th century.

Figure 5. Human capital.



Notes. See notes to Table 1. The vertical axis is an index with 1250 = 1. Human capital is measured as the number of students divided by population.

4.3. Per capita income and the emergence of the Great Divergence

To test the hypotheses set out in this paper we need to construct the best possible per capita income data for each century between the 10th and the 19th centuries. Annualized income in each century is, to the extent that the data allow, measured in the middle of each century. Three different income measures are considered here: Maddison's (1995, 2003) estimates of per capita GDP, urbanization (*Urban 1*), and the urbanization data constructed by Acemoglu *et al*. (2005b) (*Urban 2*). The Urban 1 data are spliced with Maddison's purchasing power parity (PPP) per capita income in 1850 to ensure that the data are comparable across nations. Urban 1 is used to backdate Maddison's data from the year 1650 since data are not available from Maddison in the 10th century and between the 12th and the 16th centuries. Furthermore, the estimates in year 1000 are nothing more than qualified guesses and, as such, are not based on concrete evidence.

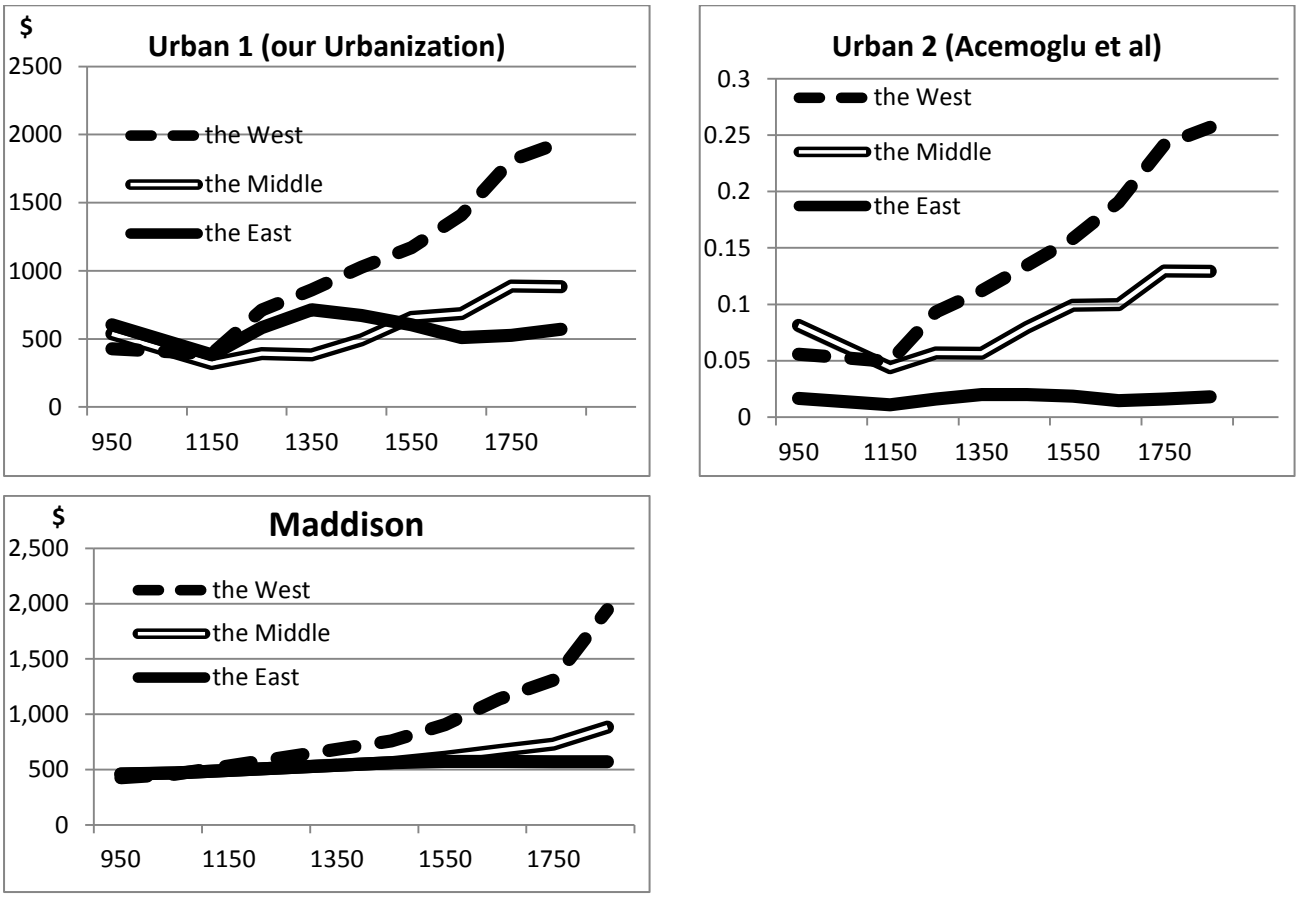
Urban 1 is constructed as the proportion of the population living in towns with more than 1,000 inhabitants while Urban 2 is based on the proportion of the population living in towns with more than 5,000 inhabitants. While the number of 1000 may seem small to modern eyes, cities and towns were incredibly small during the medieval period and first started to become large after the Industrial Revolution. Urbanization may act as a per capita income proxy in that in a country in which the major fraction of the population is living at subsistence level, food takes up almost the whole budget. As a country develops items other than food take a higher weight in the budget, simply because their

income elasticity exceeds that of agricultural produce. Urbanization takes place as the manufacturing and the service sectors grow. Towns start growing as soon as non-agricultural goods and processed agricultural goods start being produced. Manufacturing and services tend to cluster in towns and cities because of agglomeration benefits and reduced transaction costs.

The advantage of using urbanization as a proxy for income is that it is available for all the centuries used in this study, covers the whole economy, and, implicitly, measures the evolution of the fraction of income that is not spent on basic staple consumption. According to van Zaden (2001) in Pamuk (2007, p. 305) "recent studies have confirmed the strong correlation in the early modern European context between the rise in the urbanization rate and the rise in average productivity and income". Using overlapping urbanization and national account per capita income data, Acemoglu *et al*. (2002) identify a highly significantly positive correlation between per capita income and urbanization and DeLong and Shleifer (1993) argue that urbanization is the best available proxy for per capita income far back in history. Finally, note that Urban 1 and Urban 2 are moving very closely together. When fixed effect dummies are included, the correlation coefficient between Urban 1 and 2 is 0.97. Fixed effect dummies are included to cater for the difference in income levels since Urban 1 is adjusted to Maddision's data in 1850. The slight differences between Urban 1 and 2 is, beyond the fact that Urban 2 is based on towns larger than 5000 inhabitants, is that the data for the 12^{th} century are interpolated between the 11^{th} and the 13^{th} centuries.

The three income data series are displayed in Figure 6. The graphs give some intriguing insights. First, based on Urban 1and Maddison's data, the initial annual income level was around USD 450 in 1990 prices at PPP. Second, per capita income stayed low during the whole period for the East, increased only slightly in the Middle group and increased several fold in the West. The West appears to have already escaped the Malthusian trap from around the year 1000. Thus, the graphs de-emphasize the importance of the First Industrial Revolution in the UK as the watershed of the Great Divergence. After the First Great Divergence between 1500 and 1350 the gap between east and west widened continually

Figure 6. Real per capita income.



Notes: See notes to Table 1. Urban 1 is the fraction of the population living in towns that exceed the size of 1000 and is adjusted to Maddison's (2003) 1850 per capita income data in 1990 USD in purchasing power parity. Urban 2 is the fraction of population living in cities of with more than more than 5000 inhabitants and is taken from Acemoglu *et al.* (2002). Maddison's (2003) data are backdated from 1650 using Urban 1.

5. Empirical estimates

The results of regressing restricted and unrestricted versions of Eq. (1) are presented in Table 1. Consider first the results of regressing income against *Cul* (culture), *Con* (contracting institutions), and *Pro* (property right institutions) in the first three columns. The coefficients of *Cul*, *Con* and *Pro* are significant at the ten percent level regardless of which income measure is used as the dependent variable, suggesting that they all have contributed to economic development over the past millennium. Furthermore, they jointly explain between 66 and 81 percent of the variance in per capita income.

Consider next the regressions in columns 4-6 in which per capita income is regressed on *S&T* and *HC* only. Both regressors are highly significant and explain a high fraction of the variance in per capita income, suggesting that both human capital and S&T are important determinants for economic

development; a result that is not surprising given that almost all endogenous growth models are based on growth that is driven by R&D and human capital. What is, perhaps, more surprising is that significant events in the history of S&T and tertiary education explain productivity so well. An important factor here is that significant events in S&T lead to subsequent supporting innovative activities that pushed the technology frontier out further. Mokyr (2005) gives numerous examples of how theories developed by great minds were subsequently used by practical people to develop new technologies and find new ways of doing things.

Newton's contribution to the understanding of the laws of thermodynamics was, for example, vital for the invention and development of the steam engine (Mokyr, 2005). Furthermore, the invention of the steam engine, which is classified in the scoring here as a significant event, lead to numerous minor inventions, which pushed the technology frontier out further. A major innovation was the Watt steam engine of 1776. However, it cost 500-800 Pounds Sterling and consumed coal to the value of 3000 Pounds per year (Greenwood, 1999). The equivalent energy produced by horses would annually have cost 900 Pounds in fodder. Subsequent innovations during the Industrial Revolution reduced the cost of steam power substantially. This example shows that significant events in S&T may not be productive initially; however, the subsequent myriad of inventions initiated by the invention ignites further inventions and, therefore, growth.

Tertiary education would have influenced productivity through innovations and through human capital among the general population, noting that territory education influenced education among the broad population. Universities played a vital role in educating teachers that, after graduation, taught at different levels (Houston, 1988). At the University of Prague between the 15th and 17th centuries, for example, approximately 72 percent of the graduates took up teaching positions after graduation while 14 percent went on to professional jobs (Houston, 1988, 79). Assuming that a large proportion of university graduates in other countries took up teaching positions, the growth of university graduates would have trickled down to growth in human capital among a large fraction of the population. Furthermore, university education in medieval Europe enhanced social mobility and, as such, educated the most promising students. Following the ideal from the Renaissance that talents were equally distributed among the population, universities often had bursaries for poor but able students (Houston, 1988, p. 89). In this context Houston (1988, p. 87) makes the important observation that universities in Europe became *more* rather than less elitist over time and this may explain why universities in the 19th and most of the 20th centuries may have been considered elitist.

Table 1. Parameter estimates of Eqs. (1).

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Dep. Var.	$\ln Y_1$	$\ln Y_2$	$\ln Y_3$	$\ln Y_1$	$\ln Y_2$	$\ln Y_3$	$\ln Y_1$	$\ln Y_2$	$\ln Y_3$	$\ln Y_1$	$\ln Y_2$	$\ln Y_3$
Ln *Cul*	0.47 (2.88)	0.60 (3.61)	0.52 (4.89)				0.32 (1.49)	0.33 (1.70)	0.33 (2.26)	0.48 (2.44)	0.44 (2.29)	0.44 (3.03)
Ln *Con*	0.40 (2.52)	0.36 (2.23)	0.21 (1.80)				0.29 (1.90)	0.19 (1.31)	0.12 (0.98)			
Ln *Pro*	0.40 (2.40)	0.50 (2.82)	0.35 (2.49)				-0.01 (0.56)	-0.02 (0.15)	0.14 (1.20)			
S&T				0.22 (4.82)	0.25 (4.87)	0.14 (6.15)	0.18 (3.70)	0.21 (3.91)	0.10 (3.98)	0.19 (4.09)	0.22 (4.30)	0.11 (4.70)
HC				662 (3.22)	752 (3.71)	846 (5.63)	-188 (0.48)	21.9 (0.06)	204 (0.69)	-34.8 (0.09)	114 (0.32)	206 (0.76)
R^2	0.66	0.68	0.81	0.68	0.66	0.81	0.70	0.68	0.91	0.69	0.68	0.82

Notes. The numbers in parentheses are absolute *t*-values. Number of observations = 120. Country dummies and constant terms are included in all regressions but now shown. The *t*-ratios' are based on robust standard errors. Time-dummies and country dummies are included in the regressions in the last two columns. The coefficients in the last column are multiplied by 100. The *t*-statistics in the OLS regressions are based on robust standard errors. Y_1 = Urban 1 (our urbanization data), Y_2 = Maddison's income data, Y_3 = Urban 2 (Acemoglu *et al*.'s (2002) urbanization data).

The regressions in columns 7-9 show the results of unrestricted estimates of Eq. (1). The coefficients of *Con* and *Pro* lose significance when *S&T* and *HC* are added to the model, indicating that *Con* and *Pro* influence productivity predominantly through S&T. *HC* is rendered insignificant when *Cul* is included in the estimates, which can be seen from the last three columns in Table 1 in which *Con* and *Pro* are removed from the regressions. The coefficient *Cul* is quite significant in these regressions suggesting that *Cul* impacts on income independently of *HC* and *S&T* since the coefficients of *Cul* are almost the same as those in the regressions in the first three columns. The inclusion of *Cul* renders the coefficient of *HC* insignificant partly because of the correlation coefficient between *HC* and *Cul* is a whopping 92 percent, suggesting that secularity and individualism, on the on hand, and human capital, on the other hand, go hand-in-hand.

The extremely high correlation between *Cul* and *HC* is intriguing since the data on these two variables are measured very differently and are constructed from data sources that are totally independent. The high correlation suggests that secular and individualistic societies value education higher than non-secular societies because secular and individualistic societies foster individual achievement and education among the broad population. In fact secular movements encouraged education: "co-operation between the ecclesiastical and secular authorities in the creation of national educational systems and the fostering of literacy was central to the success of initiatives before the eighteen century" (Houston, 1988, p. 42). Secular societies often fostered education during the middle ages through woman gaining access to education. Reformers tried to ensure that "women could read the works of their spiritual equals" (Houston, 1988, p. 20). Furthermore, the

secularization of the West during the Renaissance went hand-in-hand with the ideal of the Renaissance of the interdependence of learning, progress and the overall quality of a nation (Houston, 1988, p. 42). During the late Renaissance in 18th century Europe several states initiated educational reforms that suited the needs of the state, which signified a move away from the church's strong influence on teaching (Houston, p. 44).

Table 2. Parameter estimates of Eqs. (2) and (3).

Dep. Var.	***S&T***	***HC***	***HC***
Ln *Cul*	1.25(2.94)	0.0003(5.98)	0.0003(5.80)
Ln *Con*	0.72(2.15)	0.0001(2.76)	0.0001(1.52)
Ln *Pro*	2.46(3.28)	-0.0002(2.95)	
F(k,n-k)	19.4	43.2	53.5
R^2	0.72	0.79	0.77

Notes. See notes to Table 1. $F(r,n-k)$ is an F-test of excluding restrictions and is distributed as $F(k,n-k)$ under the null hypothesis, where n = 120 is the number of observations, k =14/15 is the number of regressors including the constant term, and r = 2/3 is the number of restrictions.

The results of the first round regressions (Eqs. (2) and (3)) are presented in Table 2. The regression in the first column of the table shows that *Cul*, *Con*, and *Pro* are all significant determinants of *S&T*. The high value of the *F*-test of excluding restrictions suggests that *Cul*, *Con*, and *Pro* are potentially good instruments for *S&T*. The regressions in the last two columns show that *HC* is almost entirely explained by *Cul*; thus, institutions did not play any significant role in the formation of the educational system during the past millennium. This results squares with the discussion above that the increase in education was driven by secular states systems that encouraged individualism.

The second-round IV estimates are displayed in Table 3. Consider the regressions in the first three columns of the table in which productivity is regressed on the instrumented *S&T* and *HC*. Common for all regressions is that both *S&T* and *HC* are highly significant determinants of productivity through the channels of *Cul*, *Con* and *Pro*. Furthermore, the R^2's indicate that a high proportion of the variance in per capita income is explained by the model. The parameter estimates are insensitive to whether or not country dummies are included in the regressions (results without fixed effect dummies are not shown). This implies that the coefficients are predominantly identified by the time-variation in the data and not so much by cross-country variations in the data.

Table 3. IV estimates of Eq. (1).

Dep. Var	$\ln Y_1$	$\ln Y_2$	$\ln Y_3$	$\ln Y_1$	$\ln Y_2$	$\ln Y_3$
S&T	0.20(3.08)	0.23(3.23)	0.14(2.78)	0.11(1.93)	0.17(3.09)	0.12(1.83)
HC	1106(3.02)	1200(3.28)	1085(3.74)	774(1.58)	714(1.75)	1471(3.14)
R^2	0.62	0.56	0.81	0.84	0.78	0.84
Period	950-1850	950-1850	950-1850	1450-1850	1450-1850	1450-1850

Notes. See notes to Table 1. CD indicates whether country dummies are included in the regression. *S&T* and *HC* are instrumented based on the regressions in the first two columns in Table 2.

The data period is limited to the post-1450 period in the regressions in the last three columns in Table 3. The parameter estimates remain significant in most cases and the coefficients are somewhat smaller, but not significantly smaller, than the full-sample estimates and probably reflect that the sample is a bit on the small side when the sample is cut in half. The important issue here is that *HC* and *S&T* remain significant determinants of economic development in the second half of the sample period and, thus, reinforce that *HC* and *S&T* have been important determinants of economic development throughout the entire sample period.

6. Conclusion

Property rights institutions, contracting institutions and culture have been the key explanations of economic development and the Great Divergence between the East and the West; however, the validity of these theories in explaining the Great Divergence and economic development during the past millennium has not been examined. Constructing data on productivity, contracting institutions, culture, S&T and human capital for a panel of the 12 countries in the East, West and the Middle East over the past millennium, this paper has shown that property rights institutions, contracting institutions and culture have all been influential determinants of growth and development during the same period. Furthermore, it was shown that property rights institutions, contracting institutions and culture influenced productivity growth through the channels of S&T and human capital; however, while institutions influenced growth predominantly through S&T, culture influenced growth through the formation of human capital. Good institutions have given the right incentives to promote growth through innovations while secular and individualistic societies have been associated with the desire to promote a system that would bring education to a large proportion of the population.

A second finding of the paper is that the Great Divergence between the East and the West started already around 1250 and, since then, per capita income has increased least threefold in the West before the First Industrial Revolution started in the second half of the 18th century, while per capita income stagnated in the East. Increasing individualism and secularism combined with vast improvements of institutions in the west ensured an expansion in tertiary education and increasing innovative activity. Key innovations in the manufacturing of textiles, non-human energy, book production and ships ensured increasing per capita income. Remarkably, the technological advances in the West did not result in population growth rates that were sufficiently high to keep per capita income in check through the Malthusian mechanism.

The results show that the major forces behind the growth in the West during the past millennium were expansion of trade, financial development, democratization that reduced the power of the executive rulers and a strong secular movement that started with the Renaissance and continued with a reduced influence of the church. The East, by contrast, failed to develop and improve the living standard of its ordinary citizens over the millennium considered here. In India the Caste system brought about injustice and exploitation, lack of social mobility and rigid thinking (Pirenne, 1963). The Imperial Examination in China that involved selecting the individuals that would enter the state's bureaucracy through a process of exams, lasted for 1300 years, and was believed to have barred any cultural and social development in China (Elman, 2000; Lee, 2000). Most of the higher educational institutions in China after the 12th century were government controlled and functioned as schools which prepared civilians for the Imperial Examination (Lee, 2000).

DATA APPENDIX

Urbanization. Two sets of urbanization data are used, where the first set is created by us (urban 1) and the other is from Acemoglu et al. (2005b). Urban1: is estimated as the ratio of the total population in towns larger than 1000 inhabitants and total population. Urban population data of Turkey, Russia, China and India are obtained from Chandler (1987), urban population data of Western countries are obtained from Bairoch, Batou and Chevre (1988) and total population data is gathered from McEvedy and Jones (1978). Note that a big city might decline during invasions or war times and then recovers gradually. In this situation, instead of treating this city's population as 0, we count it according to the exact record. Urban 2. Acemoglu *et al*. (2005b) defined as the fraction of population living in towns larger than 5000 inhabitants. Their data are not always in the middle of the century. We have, therefore used the following convention, where the year stated by Acemoglu et al. are in parentheses 950(1000), 1150(1100), 1150(1200), 1250(1300), 1350(1400), 1450(1500), 1550(1600), 1650(1700), 1750(1800), 1850(1850).

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