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RELIGION AND ECONOMIC GROWTH : WAS WEBER RIGHT?

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RÉSUMÉ

L'évidence que les salaires réels ont diminué dans les villes catholiques et non dans les villes protestantes entre 1500 et 1750, période d'extension de l'alphabétisation dans le vernaculaire, contredit la plupart des modèles théoriques de croissance économique. Dans *L'éthique protestante*, Weber a suggéré une théorie alternative basée sur la culture. Ici un modèle théorique confirme qu'un petit changement dans le coût subjectif de coopérer avec des étrangers peut générer une transformation profonde des réseaux d'échange. Lors d'une tentative d'expliquer la croissance urbaine en Europe pré-industrielle, des spécifications compatibles avec la théorie néoclassique et avec la théorie de la croissance endogène sont rejetées en faveur d'une formulation de la thèse de Weber qui incorpore des effets de réseau.

Mots clés : croissance, religion, réseaux, culture, Europe

ABSTRACT

Evidence of falling wages in Catholic cities and rising wages in Protestant cities between 1500 and 1750, during the spread of literacy in the vernacular, is inconsistent with most theoretical models of economic growth. In *The Protestant Ethic*, Weber suggested an alternative explanation based on culture. Here, a theoretical model confirms that a small change in the subjective cost of cooperating with strangers can generate a profound transformation in trading networks. In explaining urban growth in early-modern Europe, specifications compatible with human-capital versions of the neoclassical model and endogenous-growth theory are rejected in favor of a "small-world" formulation based on the Weber thesis.

Key words : growth, religion, networks, culture, Europe

On the eve of the Industrial Revolution, in 1750, the skyline of London was dominated by the towering baroque dome of St. Paul's Cathedral. Completed in 1710, the massive church was longer, wider and higher than Paris's gothic Cathedral of Notre Dame. As for London itself, with almost 700,000 inhabitants, it was now the greatest city in Europe. Yet 250 years earlier, at the end of the Middle Ages, London had been less than a quarter the size of Paris. An equally striking change over this period was divergence in real incomes between the two cities. In the years from 1500-1549, the real wage rate had been higher in London than in Paris. Over the following 250 years, instead of converging, real wages rose slightly in London but fell by over 20 percent in Paris (Allen, 1998, 38).

At first glance, growth rates of population and real wages in pre-industrial Europe might seem to be a subject of limited interest. However, the facts set out above pose a major challenge for currently accepted models of economic growth. In the first half of the sixteenth century, literacy levels were higher in England than in northern France, but during the seventeenth and eighteenth centuries, the north of France caught up with its neighbor. By the second half of the eighteenth century, male literacy rates in both England and northern France stood at about 60 percent (Graff, 1991; 143, 152, 195, 232). The augmented neoclassical model proposed by Mankiw, Romer and Weil (1992) predicts that the closing of the gap in human capital per worker should have led to convergence in the marginal productivity of labor. However, as mentioned above, real wages in London and Paris diverged considerably over the period.

As for models of endogenous growth proposed by Lucas (1988) and Romer (1990), they predict that accumulation of human capital will raise the growth rate of total factor productivity. Real wages had risen across Europe between 1300 and 1500 (Cameron, 75,76). Yet despite substantial increases in human capital per worker over the following 250 years, the long-term growth rate of real wages fell to close to zero for London and became negative for Paris.

One possible explanation for the poor performance of models that emphasize the role of human capital lies in the metaphor of the two cathedrals. Recently, in a provocative study

comparing national economies since the Middle Ages, Landes (1998, 174-179, 516-518) suggested that the explanation for this north-south divergence in the centuries that preceded the Industrial Revolution might lie in the realm of cultural evolution. He referred his readers to the famous thesis of the German sociologist Max Weber. In *The Protestant Ethic and the Spirit of Capitalism*, published in two parts in 1904 and 1905, Weber had contrasted the economic performance of northern and southern Europe during the early-modern period (Weber, 1930, 37). Expressed in contemporary terms, Weber's thesis was that by the eve of the Industrial revolution, Europe had been divided into two distinct networks, each with its own standards for productive effort, the accumulation of capital and contractual dealings with others. After reviewing the historical evidence, Landes concluded that Weber had been right: cultural factors seem to be the key to explaining inter-country differences in rates of economic development.

Our goal in this paper is to assess somewhat more formally than Weber and Landes have done the role of cultural factors in determining economic performance. To do so, we make three departures from the methodology that has been used in most recent empirical studies of economic growth. First, since cultural evolution requires a change in the information that adults transmit to their children, its effects are unlikely to be observable in a society as a whole over the relatively short periods covered by postwar international data sets. We therefore study a very long period; namely, the interval of two and a half centuries between the end of the Middle Ages and the beginning of the Industrial Revolution. This choice has an important cost, since real income data are incomplete for the period 1500-1750. Accordingly, following a procedure employed by De Long and Shleifer (1993), we use urban population growth as a proxy for changes in income levels. Unlike the latter authors, however, we are able to use the limited real wage data available for this period (collected by Allen, 1998) to evaluate our choice.

Second, most studies of economic growth assume that production can be modeled by aggregation from the decisions of a representative agent. When culture is changing, however, the contractual relationships between agents may be modified, making aggregation into a single production relationship problematic. To overcome this problem, we follow Greif (1994) in using

game theory to determine the optimal strategies of individual agents. With the help of a methodology proposed by Heckathorn (1996), we are then able to assess the impact of culturally generated shocks to the underlying parameters of a coordination game on the equilibrium strategies and payoffs of the agents. Unlike these authors, however, we are able to test empirically the predictions of the resulting model.

Third, we attempt to deal with the most important criticism that has been levied against Weber's hypothesis; namely, that the choice of religion was endogenous relative to economic growth. Weber's thesis is that Protestants' choice of intense worldly activity favored the rise of modern capitalism. However, it has been argued that it was rather merchants who chose the Protestant states as good places to do business. For example, Trevor-Roper (1963) maintained that many prominent members of the business community of the Dutch Republic in the seventeenth century were at best nominal Calvinists who had emigrated from the southern Netherlands. We use Hausman's (1978) instrumental-variable technique to test the exogeneity of religion in a model explaining economic growth.

The question that we ask in this paper is the following: can religious beliefs affect a society's long-run economic growth? Our answer is made up of three parts, the first descriptive, the second theoretical and the third econometric. First, the total population of cities that adopted the Protestant faith increased by a multiple of five between 1500 and 1750, while that of those that remained Catholic did not quite double. Over the same period, Allen's (1998) data show that real wages rose by an (unweighted) average of four percent in a sample of Protestant cities but fell by 19 percent in a sample of Catholic cities. Finally, there was a structural reordering of the relative population sizes of Protestant cities that had no counterpart in Catholic Europe. According to Zipf's Law, in an integrated economy, the slope of the logarithmic regression of the population of cities on their population rank should be -1 (Gabaix, 1999a). In Catholic Europe, the estimated slope became only slightly steeper, passing from -0.66 to -0.76 between 1500 and 1750. However, in Protestant Europe, the slope nearly doubled, from -0.43 to a near-contemporary level of -0.83 over the same period.[1]

Second, we use non-cooperative game theory to suggest a possible theoretical explanation for these developments. The dissenting Protestant denominations rejected the Catholic sacrament of penance, whereby a person could obtain pardon for sins committed, provided that he perform certain acts of reparation. For Catholics, the cost of defection in any contractual relationship consequently remained low since such pardon could always be obtained with the intervention of a priest. For members of the ascetic Protestant sects, however, the hedonic cost of defection was high. Among Calvinists, any defection weakened the individual's conviction that he was predestined to be saved. In the other ascetic Protestant denominations, including the Pietest movement within the Lutheran church, although predestination was not an article of faith, the dogma had a wide influence (Weber, 1930, 125). As a result, the probability of default in a one-time game of exchange fell substantially in states that adopted Protestantism. For the individual trader, market relationships could be widened far beyond the limited number of people whose defection he or those he knew could punish in repeated transactions.

Third, the hypothesis that the choice of Protestantism was endogenous relative to population growth is rejected. Moreover, there is little support in our results for the augmented neoclassical growth model or for the human-capital version of endogenous growth theory. The economic success of Protestant Europe in the pre-industrial period does not even appear to be due to a tendency of individual Protestants to work harder and save more than individual Catholics.

Rather it would appear that Protestant Europe created for the first time a distributed economic network that spread across state borders. Unlike their Catholic counterparts, Protestant merchants were able to take advantage of the new arbitrage opportunities available in cities bordering on the Atlantic. In doing so, they required a wide range of information made available in Protestant printing centers but not in Catholic centers. Finally, these growth effects were positively related to the proximity to London, the financial and commercial hub of a new hierarchical structure of international economic institutions.

I. North-South Divergence in Early-Modern Europe

This section describes three aspects of divergence between north and south Europe between 1500 and 1750. The first is the relationship between real wages and urban population growth for a small number of cities. The second is a comparison of the rank-size distribution of Protestant and Catholic cities. The third aspect is the appearance in Protestant Europe but not in Catholic regions of a network of literate individuals able to interact at low cost.

(a) The Growth of Real Wages and Population

Ideally, in exploring the relationship between culture and economic performance, one would like to have detailed real wage or income data both before and after a major cultural change. Unfortunately, real wage and income data for Europe prior to the Industrial Revolution are scanty. Accordingly, in their study of long-term growth from the Middle Ages onward, De Long and Shleifer (1993) chose a city's population as a proxy for its economic prosperity. Implicitly, they assumed that the rate of population growth was a sign of an increased demand for labor. Thus rising real wages would lead to a growing urban population, principally by attracting workers migration from the countryside. However, a rapidly increasing urban population might also result from supply-side pressures of demography upon resources though net natural increase. If so, population growth would be correlated negatively with real-wage levels.

To distinguish between these two possible economic interpretations of urban demographic change, it is helpful to compare population and real-wage growth in the ten cities for which long-term wage data are available. In Figure 1, the horizontal axis measures average annual growth in real wages for building laborers with data from Allen (1998). The vertical axis measures the average annual population growth rate between 1500 and 1750, calculated with data from Bairoch et al. (1988). The latter data have been controlled for the initial population, whether or not the city was a capital, and whether or not the city's economy suffered substantial damage from warfare. The positive slope of the regression line is consistent with the position that the major differences

between these ten urban labor markets were on the demand side. The slope, which is significantly greater than zero at the one percent level, implies that a one percent increase in the growth rate of real wages led to a 1.5 percent increase in the population growth rate.[2]

[Insert Figure 1 about here.]

We conclude that the use of population growth rates as a proxy for real wage growth may be justified for the period under consideration.[3]

(b) Urban population growth in Protestant and Catholic Europe

Let us then look at population growth rates for the complete set of Western European cities assuming that that this variable may be used as a measure of economic prosperity. At the dawn of the modern era in 1500, the territories along the north-western fringe of Europe -- the British Isles, the northern Low Countries, Scandinavia and northern Germany -- were sparsely settled and lacking in economic ties to one another. Consider the West-European cities and towns with populations of 10,000 or more in 1500 in regions that were to adopt Protestantism by 1750. The lower graph in Figure 2 shows the relation between the rank of each future Protestant city, as measured by population, and the city's size, again measured by population. The resulting curve is relatively low, indicating that in 1500 the cities of northern Europe were small and few in number. Indeed, there were only 36 centers with 10,000 or more people; their average size was 15,000 inhabitants.

[Insert Figure 2 about here.]

To the south, the regions in the West that were to remain Catholic -- Italy, Spain, France, the southern Low Countries and southern Germany -- constituted the economic core of Europe in 1500. The upper graph in Figure 1 shows the rank-size distribution in 1500 for those cities with populations of at least 10,000 that would still be Catholic in 1750. The higher level and longer

length of the curve with respect to its northern counterpart indicates that cities in southern Europe were more numerous and much larger than those in the north. There were 133 cities or roughly four times as many as in the north, and their average population was over 26,000; that is, some 75 percent larger than those of the north.

By 1750, the relative situation of north- and south-European cities had changed considerably, as shown in Figure 3. Although both curves have shifted upward, the vertical distance covered with respect to 1500 was significantly greater for the northern cities than for those of the south.[4] The number of cities in the Protestant regions had more than doubled (from 36 to 82) and their average population had more than doubled (from 15,000 to 35,000). In Catholic Europe over the same interval, the number of centers with a population of 10,000 or more had also increased, but only by about 50 percent (from 133 to 205). Since their average size had risen by only about 20 percent, the typical Catholic city was now smaller than its Protestant counterpart. All told, the urban population in the Protestant regions in 1750 was five times greater than it had been in 1500, while that of the Catholic regions had not quite doubled.

[Insert Figure 3 about here.]

The estimated slopes of the rank-size distributions also contain valuable information. As Gabaix (1999b) has recently shown, random shocks to a set of cities will lead to an equilibrium distribution in which the slope of a log-linear relationship between a city's population and its rank is -1, a regularity known as Zipf's Law. However, in all four graphs of Figures 2 and 3, the slope is significantly lower than -1 in absolute value. De Vries (1984, 92) has suggested that these negative slopes for the early-modern period should be interpreted as a sign of a lack of integration of individual regional systems. If so, then by this measure in 1500, the cities northern Europe were considerably less integrated than those of southern Europe. The size-rank line of the former had an estimated slope of -0.43, while that of the latter had a slope of -0.66. In terms of network structures, northern Europe at the end of the Middle Ages was significantly more decentralized than southern Europe.

By the end of the early-modern period, the relative degree of integration had been reversed. The estimated slope of the size-rank line for the Protestant cities had almost doubled to -0.83 by 1750. The corresponding slope for Catholic cities was only -0.76. At the dawn of the Industrial Revolution, then, the cities of Protestant Europe were beginning to form an integrated network with functions distributed hierarchically by city size.

[Insert Figure 3 about here.]

(c) Literacy networks in Protestant and Catholic Europe

In the late Middle Ages, the highest literacy rates were to be found in regions that were to remain Catholic. In the commercially most developed regions of northern Italy and Flanders, a primary education was considerably more common than in the rest of Europe. In addition, instruction was beginning to be given in the vernacular (Graff, 1991, 64-65). By the mid-eighteenth century, however, the relative situation of north and south had changed. Literacy rates were considerably higher in Protestant than in Catholic Europe. England, for example, had a male literacy rate of about 60 percent in 1750 (Graff, 1991, 232). Meanwhile in France, one of the most literate of Catholic countries, the male literacy rate was about 40 percent (Graff, 1991, 194).

Another important difference between north and south by the mid-eighteenth century was in the distribution of literacy between states. Whereas literacy rates were relatively uniform in the Protestant regions, there was a substantial gap between the north and south across the Catholic states. Literacy rates had increased in France over the sixteenth and seventeenth centuries, while they had fallen in Italy (Graff, 1991, 189). Finally, within individual Catholic states, the variance in literacy rates across regions was much higher than within the Protestant states. In France, for example, over one half of the residents of the north-east regions of Alsace, Lorraine and Franche-Comté were literate in 1750. However, fewer than 20 percent of those living to the south-west of a line running from St. Malo on the coast of Brittany to the Swiss border at Geneva could read (Graff, 1991, 192-196).

It is interesting to combine the urban population data with the literacy data in order to indicate the regions that had concentrations of literate adults by 1750. The map presented in Figures 4 show all cities in Catholic Europe with 10,000 or more literate adults in 1750. Figure 5 shows the corresponding situation in Protestant Europe. Three features of these maps stand out. First, although by that year there were many more cities in Catholic Europe than in Protestant Europe, there were more centers of literacy in the Protestant regions (15) than in the Catholic regions (13). Second the individual Protestant centers had on average more literate residents (35,000) each than the Catholic centers (25,000). Indeed in southern Europe, only Paris, Vienna and Naples had more than 20,000 people able to read and write, while to the north, London, Amsterdam, Berlin, Copenhagen, Dublin, Stockholm, and Hamburg all satisfied this criterion.[5] Third, the cost of communication between the leading Catholic literacy centers was much higher than between the leading Protestant centers. Paris and Vienna were both inland; they were separated by three to four weeks of travel from each other and from Naples (Braudel, 1981, 427). Although Berlin was inland, London, Amsterdam, Dublin, Hamburg and Copenhagen were all seaports and were consequently only a few days apart from one another, weather permitting.

[Insert Figures 4 and 5 about here.]

Was the rapid growth of the Protestant cities then simply a case of geography that favored access to the sea? To answer this question, consider the stability of the city rankings of the two regions between 1500 and 1750. Of the ten largest cities in northern Europe in 1500, only two (London and Edinburgh) remained among the top 15 cities in 1750. The places of inland cities such as Nuernberg, Utrecht, Erfurt and Magdeburg were taken by port cities such as Amsterdam, Dublin, Copenhagen and Hamburg. In southern Europe, no such development occurred. Eight of the ten largest cities in the south in 1500 remained in the top 15 in 1750. Both inland cities such as Paris, Milan and Florence and port cities such as Naples, Venice and Lisbon had similar population growth rates over the period. In short, we must explain why the urban network of northern Europe was restructured between 1500 and 1750 so as to favor rapid, low-cost communication while no such development occurred in the south.

II. Small-World Networks

On the whole, the facts set out in the previous section are consistent with the general idea of endogenous growth theory. As proposed by Romer (1986), this theory argues that individuals do not take account of the positive externalities that their investment decisions generate for the productivity of all other producers in the economy. As a result of differences in these internal scale effects, large economies such as those of northern and southern Europe could diverge from each other in terms of per-capita income over a very long period.

However, the disaggregated data are not consistent with the *human-capital* versions of endogenous growth theory that have been proposed by Lucas (1988) and Romer (1990). Their models predict that the growth rate of an economy should rise monotonically with its total or per-capita stock of human capital. As mentioned in the introduction, northern France caught up with England in terms of literacy yet fell behind in real wages. Within Catholic Europe, total and average literacy were much higher in France than in the kingdom of Naples, yet real wages were higher in the latter and they decreased at about the same rate in each economy between 1500 and 1750. Might literacy have been a necessary but not a sufficient condition for economic growth? And if so, what else needed to be added? To answer these questions, we turn back to a hypothesis proposed almost a century ago.

(a) Ethical codes in Protestant and Catholic Europe

Virtually all discussions of Weber's (1930) provocative thesis about the economic effects of ascetic Protestantism have focused on the behavior of *individual* Catholics and Protestants. Many have taken issue with Weber's suggestion that a representative Protestant would be inclined to participate more actively in economic life and would be more likely to refrain from consuming the fruits of his labors than would a representative Catholic. Citing studies by Delacroix (1992, 1995), Iannaccone (1998, 1474) concludes that "the most noteworthy feature of the Protestant Ethic thesis

is its lack of empirical support." Even if such differences in the behavior of Protestants and Catholics existed, they would have altered the equilibrium *level* of income in each region, but could not equilibrium long-term *growth rates*. To explain sharp north-south economic divergence in Europe lasting over more than two centuries, one must therefore look elsewhere.

How then might one explain the higher growth rates in the Protestant territories than in the Catholic regions of Europe over the two centuries that preceded the Industrial Revolution? We suggest that the Reformation created the decisive momentum for economic development in northern Europe by modifying contractual relationships among believers. A re-examination of Weber's *Protestant Ethic* indicates that what was important for long-term economic growth was not a greater propensity to save and work of *individual* Protestants but rather the manner in which a *group* of Protestants interacted compared with a group of Catholics.

In the fourth chapter of the *Protestant Ethic*, "The Religious Foundations of Worldly Asceticism," Weber emphasized that ascetic Protestantism generated what would today be called positive network externalities. He pointed out that among Catholics only the monks were obliged to live a truly religious life. As a result, an increase in the intensity of religious conviction drove Catholic believers away from worldly involvement. For ordinary Catholics who had not taken holy orders, feelings of guilt for unworthy acts could be relieved by the sacrament of penance. In the language of game theory, defection in any given round of a repeated game could be excused by cooperation in some subsequent round.

For members of ascetic Protestant denominations who believed in predestination, there was no such escape through institutionally sanctioned pardon. The conviction of salvation, Weber (1930, 115) explained, consisted in a "systematic self-control which at every moment stands before the inexorable alternative, chosen or damned." In practice, the proof that one belonged to the elect who were to be saved came in the form of intense worldly activity (Weber, 1930, 120-121). Whereas Catholics could be granted pardon by a religious institution, Calvinists, like Greif's (1994) Jewish traders, were subject to a strict system of norms defined by their peer group. But unlike

Greif's (1994) Maghribi merchants, application of the norms among Calvinists was a question of individual conscience rather than one of reputation among a small group.

Among ascetic Protestants, it was never clear whether one's material success was sufficient to be considered a sign of predestination. In other words, in the repeated game of economic interaction, one must never allow oneself to defect, since such behavior weakened the inner conviction that one had been chosen. Ascetic Protestants were therefore more likely to respect the conditions of economic contracts with those they did not know personally than were Catholics.[6] There were four major forms of ascetic Protestantism -- Calvinism, Methodism, the Baptist movement and the Pietist movement within Lutheranism (Weber, 1930, 95). Although predestination was not an article of faith among members of the latter three denominations, many in their congregations believed in it (Weber, 1930, 125).[7]

As the adherents of these groups increased in number over the period prior to the Industrial Revolution, all adhering to a strict code of behavior in their contractual relations, they generated important *network externalities* for one another. In the theory of networks of Katz and Shapiro (1985, 1994), the number of bilateral links in a group of size n, namely, $n(n-1)/2$, increases with the square of the size of the group. Recently, Watts and Strogatz (1998) have demonstrated that the addition of a few random links to a regular array network can greatly reduce the expected length of the path required to link any two points. Might such a development have transformed the network of north-European cities into a "small world" between 1500 and 1750? We turn next to this question within a formal model of coordination between pairs of individuals.

(b) Human capital, network size and production

Heckathorn (1996) used evolutionary game theory to model the effects of technological shocks on the equilibrium strategies of pairs of agents playing a non-cooperative game.[8] We extend Heckathorn's framework by specifying a production function that allows not only for physical and human capital but also for network externalities. Let Q be the gains from trade, the number of units

of additional output produced through the interaction of two individuals in a non-repeated game. By contract, the players agree to divide this output evenly.

Assume the following Cobb-Douglas production function:

$$Q = AH^{\alpha} l^{\beta}, \qquad 0 \le l \le 1 \tag{1}$$

where l is the fraction of the two agents who cooperate, H is their total human capital, and $\alpha + \beta = 1$.

Let total factor productivity, A, be an increasing function of the proportion of the other agents in the economy, n, who will cooperate in a non-repeated game.

$$A = n^{\gamma}, \qquad \gamma > 0.$$

The complex relations among producers explain this specification. Each depends for his inputs and ability to pay his suppliers on the reliability of many other individuals.

If each agent has h units of human capital, then the amount of capital used in production will be,

$$H = 2lh \tag{2}$$

Assume also that there is a hedonic cost of cooperation equal to c. This hedonic cost will depend on the social and psychological sanctions one incurs for violating a contract. If such sanctions are light (heavy), then the cost of cooperating will be high (low).

In their interaction, the players each have two possible strategies; namely, to cooperate or to defect. The possible payoffs for the players are shown in Table 1.

[Insert Table 1 about here.]

If both players cooperate, then $l = 1$. The result for each player is the REWARD payoff, R, obtained by the substitution of this value into equations (1) and (2):

$$R = 2^{\alpha-1} n^{\gamma} h^{\alpha} - c . \tag{3}$$

If one player cooperates while the other defects, then l=1/2 and the defector receives the TEMPTATION payoff of:

$$T = (1/2)^{1+\beta} n^{\gamma} h^{\alpha} . \tag{4}$$

Under these circumstances, the cooperator receives the SUCKER payoff of:

$$S = (1/2)^{1+\beta} n^{\gamma} h^{\alpha} - c . \tag{5}$$

Finally, if both players defect, they each receive the PENALTY payoff of the subsistence wage:

$$P = w.$$

(c) Two games of coordination

As is well known, the nature of the game will be determined by the relative ranking of these four payoffs. The new element here is that these rankings depend on human capital, on network effects, and on the subjective cost of cooperating. Let us assume that for all values of the parameters of interest here, the following condition is satisfied:

$$(1/2)^{1+\beta} n^{\gamma} h^{\alpha} < c + w$$

If so, then the SUCKER payoff is less than the PENALTY payoff and the possibilities depend on the relative size of the other two payoffs, TEMPTATION and REWARD.

If $T > R$ (where $R > w$), we have the game of *Prisoner's Dilemma*. In a game that lasts only one round, joint defection is the unique Nash equilibrium. Only if the game is repeated (for an uncertain number of times), will the threat of future punishment, as under a tit-for-tat strategy, induce players to cooperate. However, since an outcome of this type depends on reputation effects, it can hold only among a relatively small number of players.

If $R > T$, the game is known as *Assurance*. This time, in addition to the joint-defection equilibrium, there is a second Nash equilibrium in which both players cooperate. In this case, the gains from exchange are sufficiently high that they offset the subjective effort involved in cooperating for each player. If he can be assured that the other will cooperate, neither has an incentive to defect. From equations (3) and (4), the necessary condition is:

$$2^{\alpha-1} n^{\gamma} h^{\alpha} - c > (1/2)^{1+\beta} n^{\gamma} h^{\alpha}.$$

Recalling that $\alpha + \beta = 1$, we may rewrite this condition as:

$$2^{-(1+\beta)} n^{\gamma} h^{\alpha} > c. \qquad (6)$$

In Figure 6, letting $\alpha = 1/3$, $\gamma = 0.6$ and w=0.5, we plot human capital per-capita (h) along the horizontal axis and network size (n) along the vertical axis. When the cost of cooperating is relatively high (c =1/3 in our example), inequality (6) will be satisfied by all points above the solid curve, in the zone marked "Assurance". Points below this line fall into the zone marked "Prisoner's Dilemma." For example, in the year 1530, it may be supposed that although northern France had a somewhat lower stock of physical and human capital per capita than England, networks of

cooperating individuals were probably small in both regions. Consequently, both would have fallen within the lower zone of the Prisoner's Dilemma, at points such as *A* and *B* respectively.

[Insert Figure 6 about here.]

How might an economy escape the Prisoner's Dilemma? One way of violating inequality (6) is to experience a fall in *c*, the hedonic cost of cooperation. For example, with α and γ unchanged, a fall in *c* from 1/3 to 1/4 would shift the *T*=*R* frontier downward to the position of the slashed line in Figure 6. If Weber's argument is correct, ascetic Protestantism lowered this cost by abolishing the sacrament of penance. No longer was there an institutionally certified pardon for defection in contractual agreements. Instead, the individual was obliged to adjust his daily behavior so as to dispel doubt that he would be saved. To cooperate with others became an unavoidable moral obligation. The victory of Reform in England and its defeat in France is consistent with the position of this slashed curve relative to the points *A* and *B*. The Assurance game's outcome of joint cooperation became a possibility in England, but not in northern France.

Another way out of the dilemma was to invest in human capital sufficiently that the reward from joint production was preferable to that of defection. The difficulty here was the decreasing returns to capital accumulation.

This issue is captured in the following proposition.

Proposition 1. *In discouraging defection in a non-repeated game, a given decrease in the hedonic cost of cooperation is equivalent to a proportionally larger increase in human capital per capita.*

Proof

From (6), the equation of the boundary between the TEMPTATION and REWARD payoffs is:

$$2^{-(1+\beta)} n^{\gamma} h^{\alpha} = c \tag{7}$$

Take logarithms in (7).

$$\gamma \ln n + \alpha \ln h - (1+\beta)\ln 2 = \ln c. \tag{8}$$

Differentiate with respect to $\ln c$ holding n constant.

$$d \ln h / d \ln c = 1/\alpha$$

Since $\alpha < 1,$ it follows that to generate an effect equivalent to that which results from a given decrease in c requires a proportionally larger increase in h.

By the end of the pre-industrial period, northern France was at a position such as *C*, still within the Prisoner's Dilemma zone despite a largely literate labor force.

In addition to these comparative-static developments, there may also have been scale effects. Externalities generated by the decision of one pair of agents to respect their contract in a non-repeated game would have encouraged others to cooperate. Consider the following proposition.

Proposition 2. *When transactions costs are a monotonically increasing function of distance, the decision of one pair of agents to cooperate rather than defect in a non-repeated non-cooperative game will lead a spatially distributed network of other agents also to cooperate.*

Proof:

Assume that agents are distributed uniformly over a plane and that the cost of cooperating, $c(d)$, rises monotonically with distance, d. If all other traders are Catholic, Protestant trader i will trade only with the n_0 traders that he knows from past experience will be willing to cooperate with him. All will be situated within the radius d_0 of his location, where from (7),

$$\gamma \ln n_0 + \alpha \ln h - (1+\beta)\ln 2 = \ln c(d_0).$$

Now if all other traders were *Protestant*, trader i would trade with those n_1 who lie within a radius d_1, where $d_1 > d_0$ is the distance of the n_1 th trader and:

$$\gamma \ln n_1 + \alpha \ln h - (1+\beta)\ln 2 = \ln c(d_1).$$

Now let trader j at distance d_j, where $d_0 < d_j < d_1$ convert from Catholicism to Protestantism. Equation (7) indicates that by trading cooperatively with i, he increases i's productivity, enabling the latter to expand the radius of those Catholics with whom he cooperates from d_0 to d_0^*, where $d_0^* > d_0$. Non-Protestants in the ring $d_0^* - d_0$ will receive an externality from their proximity to one or both of the two Protestant traders and consequently expand their trading circles. In his famous critique of the Weber hypothesis, Samuelsson (1961, 104) pointed out many of the leading merchants in seventeenth-century Amsterdam were Catholics or Jews. The presence of externalities offers a possible explanation for this apparent anomaly.

INCORPORERINCORPORER In this way, the network of cooperating individuals willing to respect contracts with strangers may be considered to have augmented considerably in England, bringing the economy to a position such as D in Figure 6. Meanwhile, in northern France, the expulsion of the Protestants after the revocation of the Edict of Nantes in 1685 undoubtedly had the opposite effect, destroying small existing networks of cooperating individuals. The economy remained trapped in a position such as C.

These two propositions suggest explanations for the puzzling negative growth of real wages in Catholic Europe during a period of rising literacy and for the urban restructuring into a hierarchically ordered network of cities that occurred in Protestant Europe.[9] In Catholic regions, Proposition 1 suggests, the effects of accumulation of human capital may have been offset by the breakup of incipient trading networks through the expulsion of Protestants (and Jews). In Protestant regions, Proposition 2 suggests, not only were individual pairs of Protestants induced to form contractual relationships, but also their interactions generated positive externalities for other traders.

III. An Empirical Test

(a) The model

Let us assume the following growth equation for the population of city *j* over a certain interval of time.

$$d\ln POP_j = \beta_0 + \beta_1 \ln POP_{0j} + \beta_2 Literacy_j + \beta_3 Literacy_j^2 + \beta_4 Distance + \Sigma_{i=1}^{I} \delta_i X_{ij} + u_j \quad (8)$$

where $d\ln POP_j$ is the growth in the city's population over the interval, POP_{0j} is its population in the base year, $Literacy_j$ is the city's literacy rate, $Distance_j$ is the distance in thousands of kilometers from a central point, u_j is a random disturbance and the X_{ij} are *I* explanatory dummy variables which can take on the values 0 or 1. There are four such dummy variables; namely, *Capital, Protestant, Atlantic* and *Printing*.

The augmented neoclassical model is captured by the coefficients of *Literacy* and $Literacy^2$. If there are decreasing returns to the accumulation of human capital, the sign of β_2 should be positive while that of β_3 should be negative. The human-capital version of the endogenous-growth hypothesis is also captured by these variables. Since, under this hypothesis, an increase in human capital raises not the static marginal productivity of labor but the growth rate of total factor productivity, the signs of β_2 and β_3 should both be positive.

Gabaix (1999a) observes that capitals should be expected to grow more rapidly than other cities. The sign of this variable's coefficient is therefore expected to be positive for both Protestant and Catholic centers.

The individualistic version of the Weber hypothesis suggests that the economic behavior of individual Catholics and Protestants differed. Protestants, to put it simply, are thought to have

worked harder and saved more. If so, then the coefficient of the dummy variable, *Protestant*, should be significantly greater than zero.

Network theory is captured in the coefficients of three further variables. *Atlantic* indicates whether a city was a port with direct access to the Atlantic Ocean. Network theory suggests that arbitrage opportunities through globalized trade would be more readily accessible to ports with access to the new sea routes to southern and eastern Asia and the Americas. *Printing* indicates whether the city was a major printing center. Since profitable arbitrage demands reliable information, centers with a flourishing press would have an advantage over other cities. *Distance* measures the distance of the city in thousands of kilometers from the center of the appropriate network. In the initial specification, the center was deemed to be Milan, while for the split sample described below, the center was London for Protestant cities, and Milan for Catholic cities.

Levine and Renelt (1992) found that the estimates from cross-section growth models such as that of equation (8) may be sensitive to both the observations used and the explanatory variables included in the specification. Accordingly, in one test of robustness, we split the sample into two groups; namely Protestant and Catholic cities. In a second test of robustness, we added two other variables not directly related to the hypotheses being tested. First, Olson (1982) suggested that over time rent-seeking activities by established interest groups will slow growth unless a shock overturns the political structure. Accordingly, *DRegime* shows whether or not the state changed its constitutional regime during the period being studied. The source for the regime changes is De Long and Shleifer (1993, p. 683), who indicated for the medieval and modern period whether or not a state's government reflected the interests of merchants or those of an authoritarian ruler. Second, for each sub-group of cities, it might be thought that proximity to the other network's center could also have an effect. Accordingly, the variable *Distance-other* measures the number of kilometers from London for all cities and for Catholic cities and from Milan for Protestant cities.

(b) Data

Urban population estimates for the years 1500 and 1700 come from the Bairoch et al. (1988) data set. Our sample is comprised of the 316 cities for which the 1500 population was 5,000 or more. Of these cities, 90 were Protestant in 1750 and 226 were Catholic.[10] Sources of literacy rates in 1750 were for England: Cressy (1980, 177); France: Graff (1991, 193); Sweden: Graff (1991, 229); Germany: Graff (1991, 187); Italy: Graff (1991, 191); Netherlands (1991, 223). The 1750 rate for Spain was estimated from the Italian rate for that year plus the Spanish-Italian difference in 1850 from Cipolla (1969, 115). Estimates for Austria, Belgium and Scotland in 1750 were calculated in the same manner from the 1850 rates for Germany, Austria and England respectively.[11] Information on centers of printing from Eisenstein (1979) refers to the late sixteenth century; however, there was little change over the following two centuries.

(c) Results

One important issue with respect to the specification of equation (8) is the question of exogeneity. Weber's thesis is that Protestants chose intense worldly activity. However, it has been argued that it was rather merchants who chose the Protestant states as good places to do business. For example, Trevor-Roper (1963) maintained that many prominent members of the business community of the Dutch Republic in the seventeenth century were at best nominal Calvinists who had emigrated from the southern Netherlands. In defense of Weber, de Vries and van der Woude (1997, 169) have pointed out that it was the Protestants of the northern Netherlands who during the last quarter of the sixteenth century had established the conditions under which mercantile interests were favored.

In order to determine whether the variable *Protestant* could be considered exogenous, we carried out a Hausman (1978) test on equation (8) using the entire sample of cities. Under this instrumental-variables procedure, one requires variables correlated with *Protestant* but not with the error term, u. One of the chosen regressors, *RomanEmp*, indicated whether or not the city lay within

the boundaries of the Roman Empire at end of the reign of Augustus. A second variable was the city's latitude. The justification for these two variables was that the choice of religion was determined on the battlefield, with the winning prince getting to choose his religion of his subjects in accord with the principal *cuius regio, eius religio* of the 1555 Peace of Augsburg. The resulting χ^2 statistic with two degrees of freedom was 0.8031, indicating that weak exogeneity cannot be rejected.

[Insert Table 2 about here.]

As explained above, we then carried out three sets of estimates. In an initial pass, we estimated equation (8) using all 316 observations. In a second set, we explored the robustness of these estimates by dividing the sample according to religion. In a third set, we carried out a further test of robustness by adding two regressors to the specification.

Column (1) of Table 2 presents the original specification, estimated for all 316 of the cities in the sample. This initial set of results suggests a variety of influences on economic growth. First, the convergence coefficient is significantly less than zero, indicating that an important amount of population change was reversion to an equilibrium level perturbed by earlier shocks. Second, the literacy rate and its square had non-significant effects, a result that is inconsistent with both the augmented neoclassical model and human-capital versions of endogenous growth theory. Third, there seems to have been a significant shift of economic activity westward to the Atlantic coast. Fourth, the Protestant cities seem to have had a higher base rate of growth, ceteris paribus, than the Catholic cities. Fifth, there seem to be some important network effects. Although all cities tended to grow, there was a significant degree of centralization in capital cities and printing centers. Since the literacy-rate variables were non-significant, we estimated equation (8) without these variables. The results, presented in column (2), are similar to those of the preceding column; however, *Protestant* is no longer significant. In this initial specification the effect of religion seems somewhat fragile.

The next step was to split the sample by religion. Note that since the literacy variables were never significant in any of the subsequent specifications, they have been dropped from these and the following estimations.[12] Column (3) tests the model for the 226 cities that were Catholic in 1750. Although these cities make up over two-thirds of the initial sample, their estimated coefficients are quite different from those of the preceding columns. *Atlantic* and *Printing* no longer have a significant effect. Only the convergence and *Capital* coefficients and the constant are statistically significant. The low adjusted R^2 indicates that apart from the dampening of previous shocks and the growth of centers of taxation, urban population change in early-modern Catholic Europe was essentially random.

The picture is quite different when we look at column (4). Although the convergence and capital effects were not significantly different from the results for Catholic cities, the coefficients of the four remaining variables all changed significantly. The Protestant cities' underlying rate of growth, as measured by the constant, was significantly higher that of the Catholic cities. Moreover, all three of the network coefficients were significantly different from zero with the expected signs. Whereas the Catholic regions do not appear to have significant ties that spread over state borders, the Protestant cities seem to have formed a closely knit network integrated by means of print-based information technology, with a hierarchy of specialization as one moved inward toward London.

In columns (5), (6) and (7), we present a second robustness test in which the variables *DRegime* and *Distance-other* have been added to the specifications just described. On the whole, the earlier results seem quite robust to this test. All signs remained unchanged and estimated values were approximately the same as in the preceding models. The only important change was that the constant term for Protestant cities was no longer significantly different from that for Catholic cities. In other words, the earlier conclusion that Protestants seem to have worked harder and saved more than Protestants would appear to be fragile.

Finally, we performed a Chow test of the null hypothesis that the Catholic and Protestant observations were generated by the same process. The F (90, 218) statistic, estimated with the variables of specifications (6) and (7), was 3.97: the null hypothesis is rejected at the 0.01 level.

These results clearly indicate the need to distinguish between northern and southern Europe when studying economic growth in the early-modern period. They also suggest the importance of information networks for explaining why some economies grow faster than others.

It is interesting to compare our results for early-modern Europe with those from recent empirical studies of the contemporary period. In an econometric study of the augmented neoclassical model with data from 1965 to 1985, Benhabib and Spiegel (1994) found that although *initial* levels of human capital were important in explaining growth, *increases* in human capital had no significant effects on differences in growth rates across 78 countries. In another study for the period 1960-1985, Dinopoulos and Thompson (1999) showed that the augmented neoclassical model gives implausible factor shares when more precise measures of human capital are substituted for secondary-school enrolment rates.

As for the endogenous growth hypothesis, looking at growth rates in 74 developed and developing countries between 1960 and 1992, Graff (1999) failed to find a significant effect of the first six years of schooling on growth. Dinopoulos and Thompson (2000, 19, 26) found that differences in growth rates in low-income countries were essentially random; moreover, among high-income countries, a specification of the endogenous-growth hypothesis that used secondary school enrollment rates as a measure of human capital was rejected. However, openness to trade and greater labor efficiency tended to be associated with higher per-capita growth. Similarly, Ben-David (1997) showed that countries tend to form "convergence clubs," converging to growth paths similar to those of their trading partners.

Weber's study of cultural evolution in early-modern Europe, as formulated and tested here, offers a possible explanation for these results. Simply put, greater human capital, other things being

equal, is not a sufficient condition for higher incomes or more rapid growth in low-income economies. Unless there is a concomitant change in the behavior of individuals in their contractual relations with one another, both within and beyond national borders, the economies will remain mired in their previous underdeveloped state.

Conclusion

It has become part of the conventional wisdom that European economic growth before 1750 was Malthusian, with imperceptibly slow population growth and stagnant levels of real income (Galor and Weil, 2000). However, if one zooms in on the Protestant regions of early-modern Europe, there are signs that something unprecedented was occurring. Real wages were beginning to rise above subsistence levels and population growth was accelerating without encountering the Malthusian "positive" checks of famine and disease. Between 1500 and 1750, lands that had previously been on the periphery of the European economy became the focal point of a set of market relations that spanned the globe. This period therefore provides an ideal setting to test theories of long-run economic growth.

The results presented here, based on a comparison of population growth rates in 90 cities of northern Europe and 226 cities of southern Europe, provide scant support for conventional explanations of the growth process. Neither the augmented neoclassical model nor theories of endogenous growth based on human capital are able to account for the north-south divergence that occurred over the quarter millennium that followed the discovery of the Americas.

Was Weber right? The great leap forward of northwestern Europe does not seem to be explained by the economic behavior of *individual* adherents to the new Protestant denominations: all other things being equal, urban economic growth seems to have been no more rapid in the north than in the south. However, other things were not equal. There is strong support for an interpretation of Weber's hypothesis in terms of *information networks*. Protestant cities, but not Catholic cities, with direct access to the Atlantic were able to take advantage of advances in transportation technology that reduced the cost of ocean shipping. Protestant printing centers experienced high growth rates while heavily restricted Catholic printing centers stagnated. Above all, there emerged a hierarchy of specialization among Protestant cities based roughly on distance from London that had no equivalent in Catholic Europe. Generalized literacy along with a high propensity of Protestants to honor contracts with people they did not know personally seem to have provided the random links that converted regional economies with tenuous ties into a "small world" network.[13]

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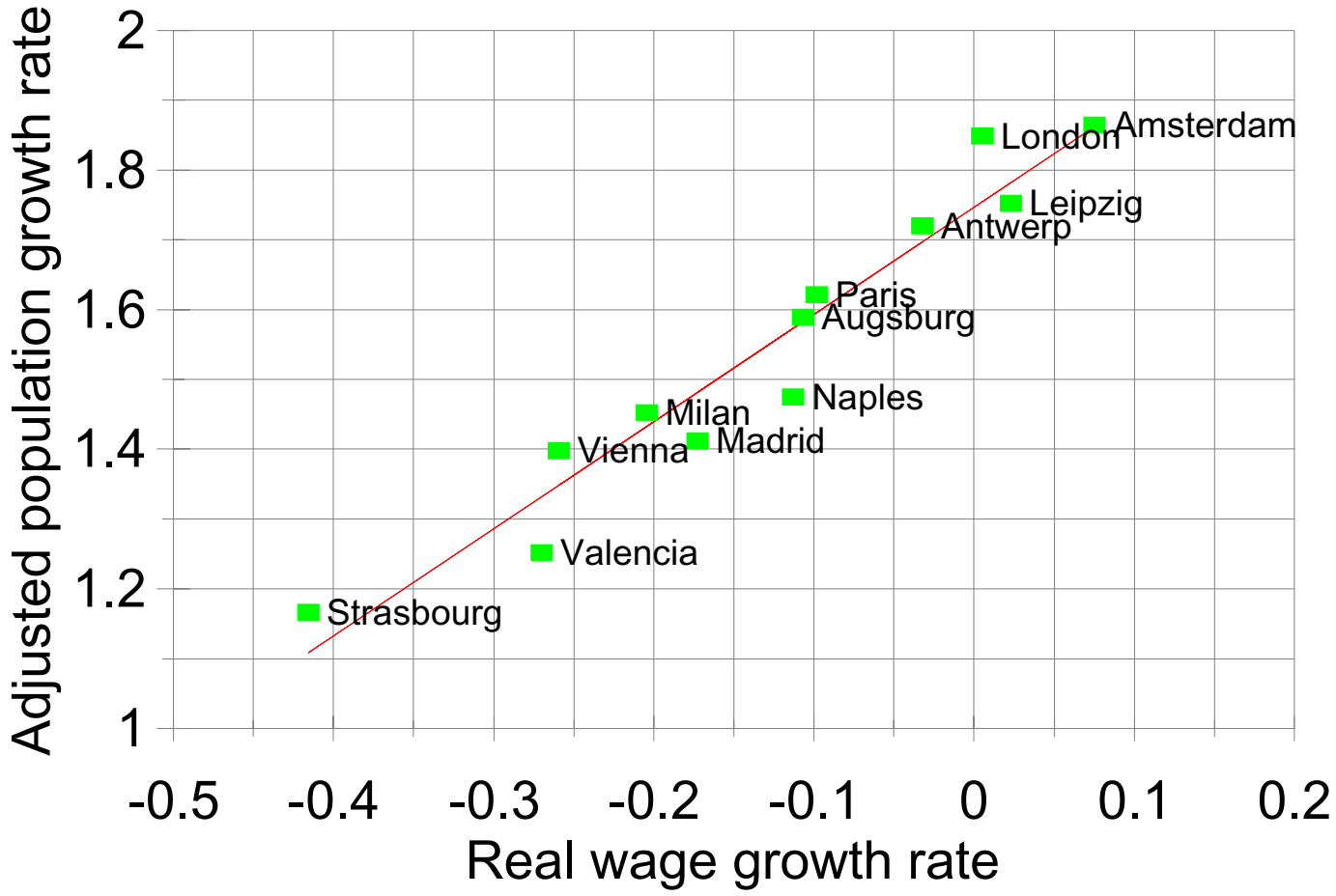


Figure 1. Average annual population and wage growth, 1500-1750

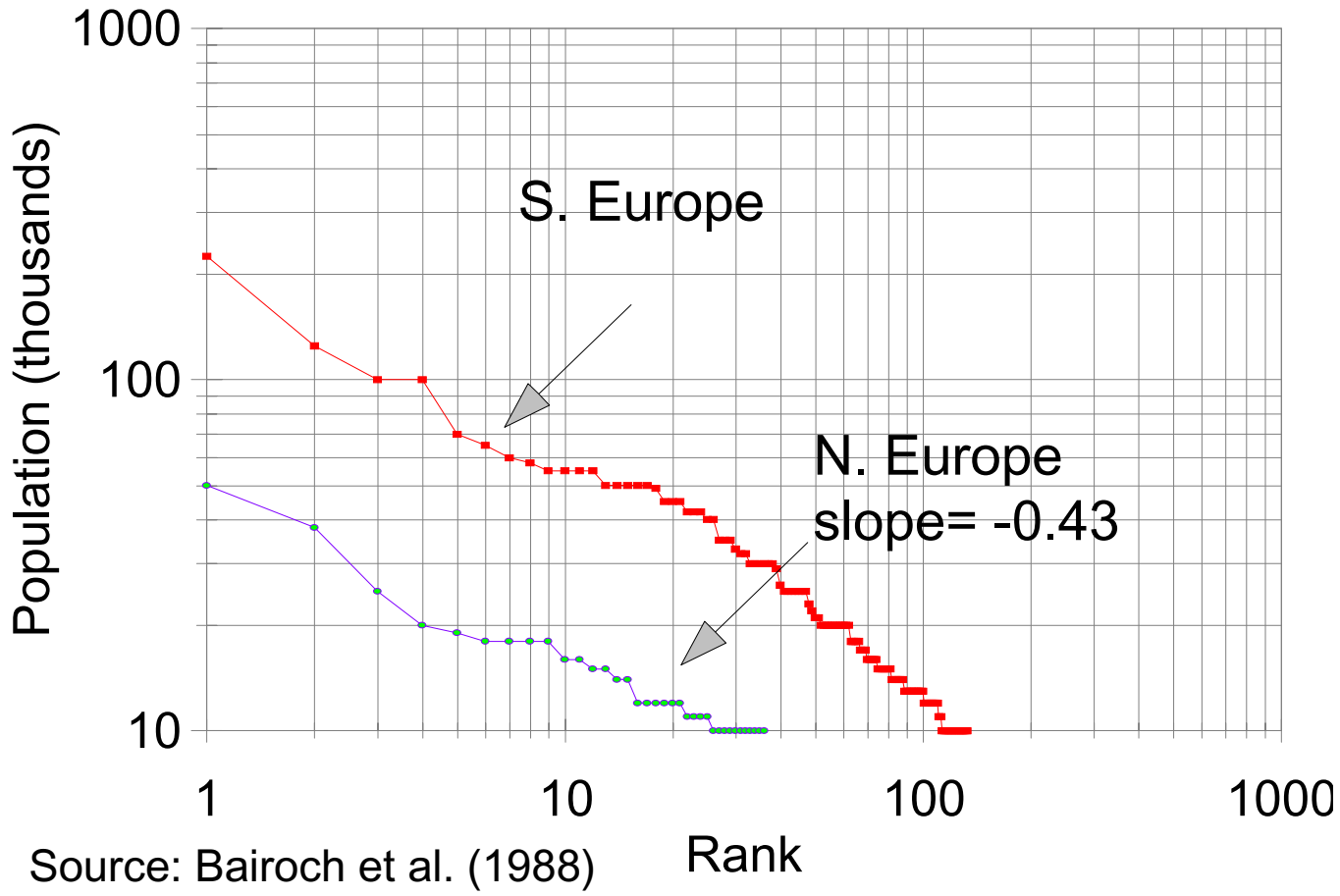
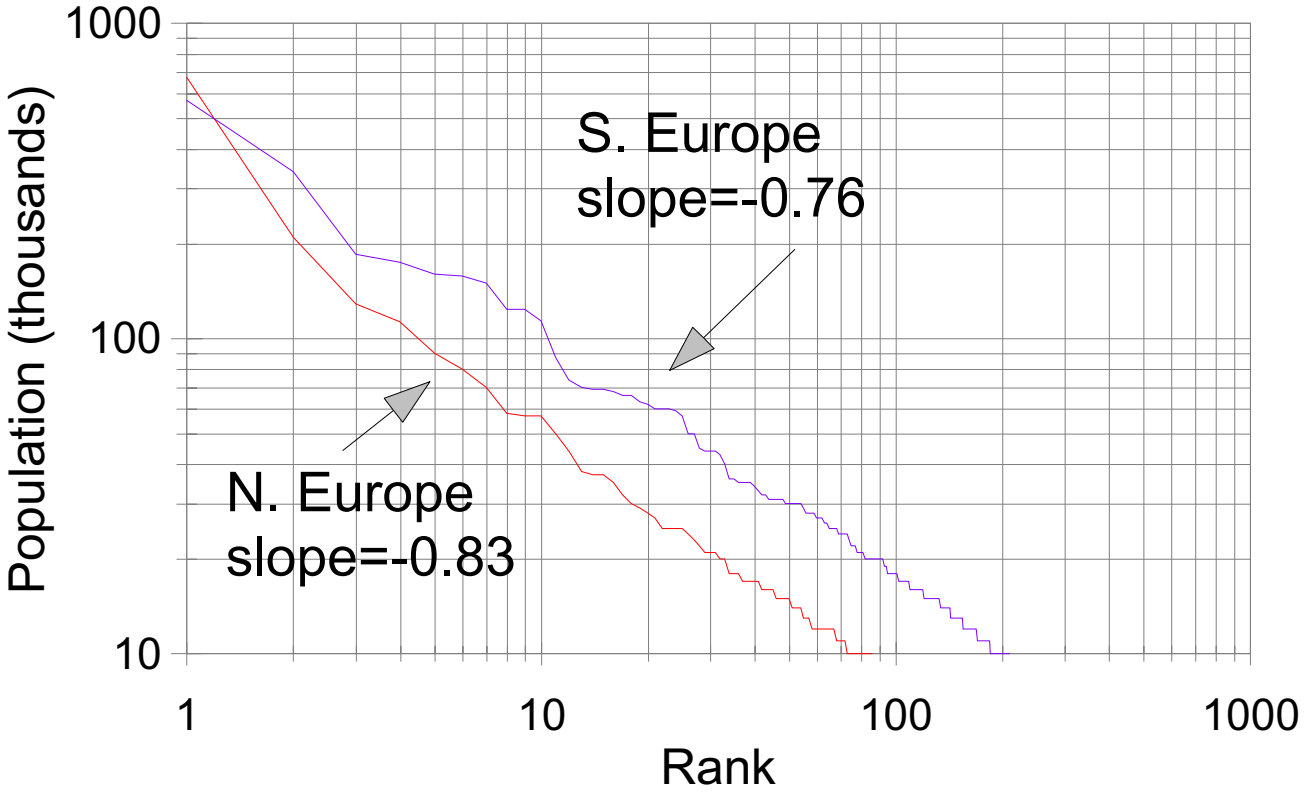


Figure 2. Urban rank-size distributions, Western Europe, 1500



Source: Bairoch et al. (1988)

Figure 3. Urban rank-size distributions, Western Europe, 1750

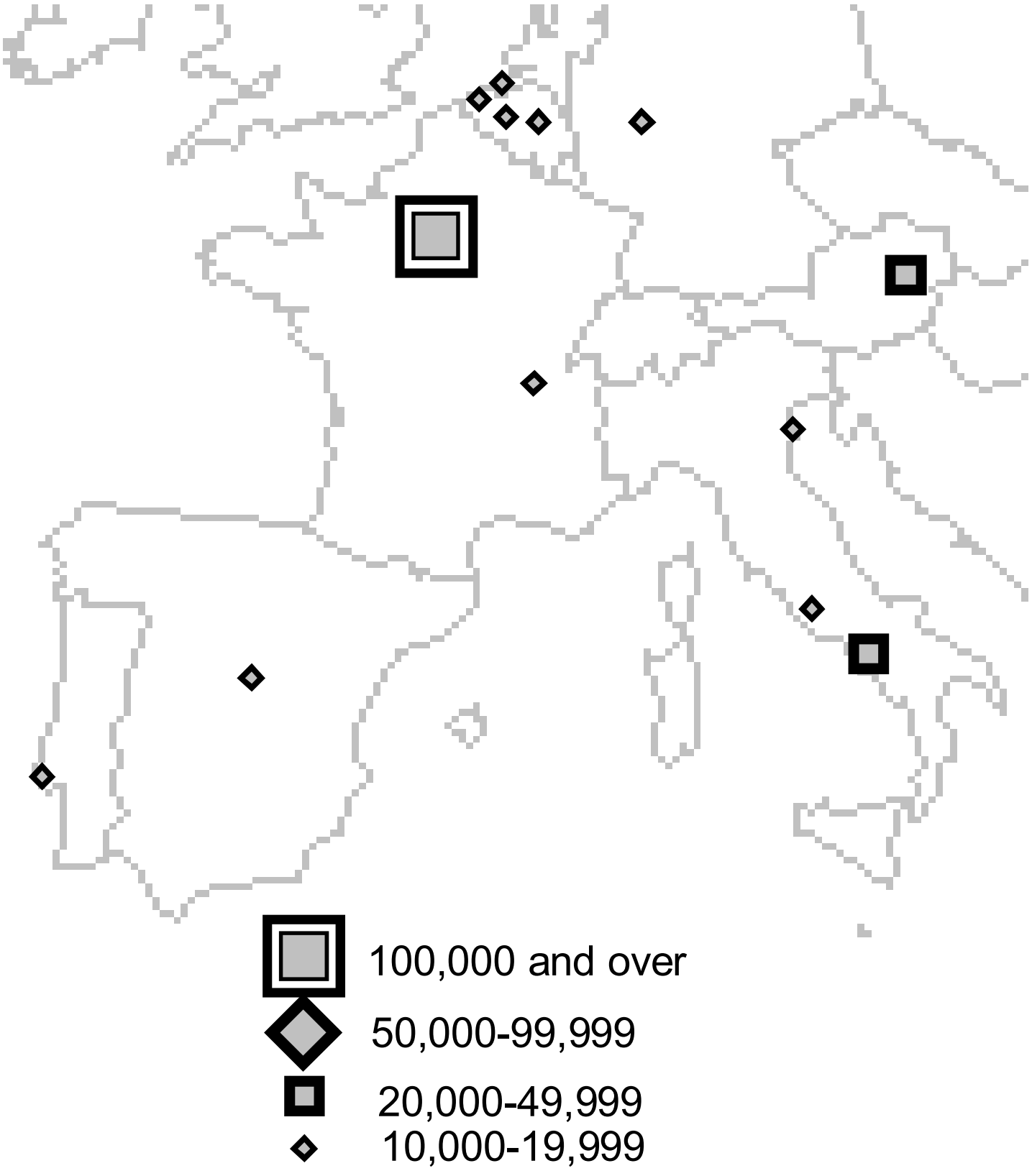


Figure 4 The Catholic urban literacy network, 1750

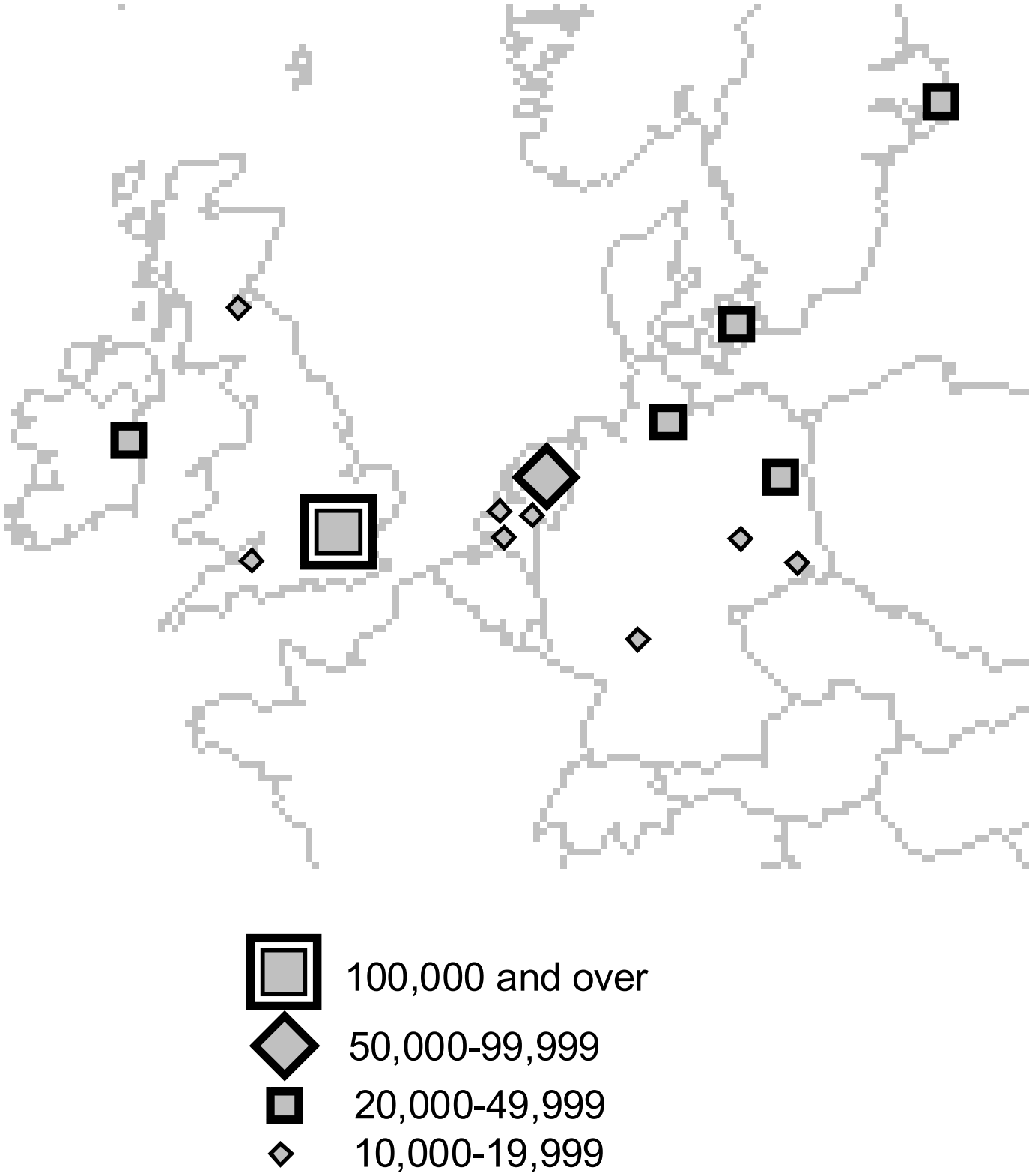
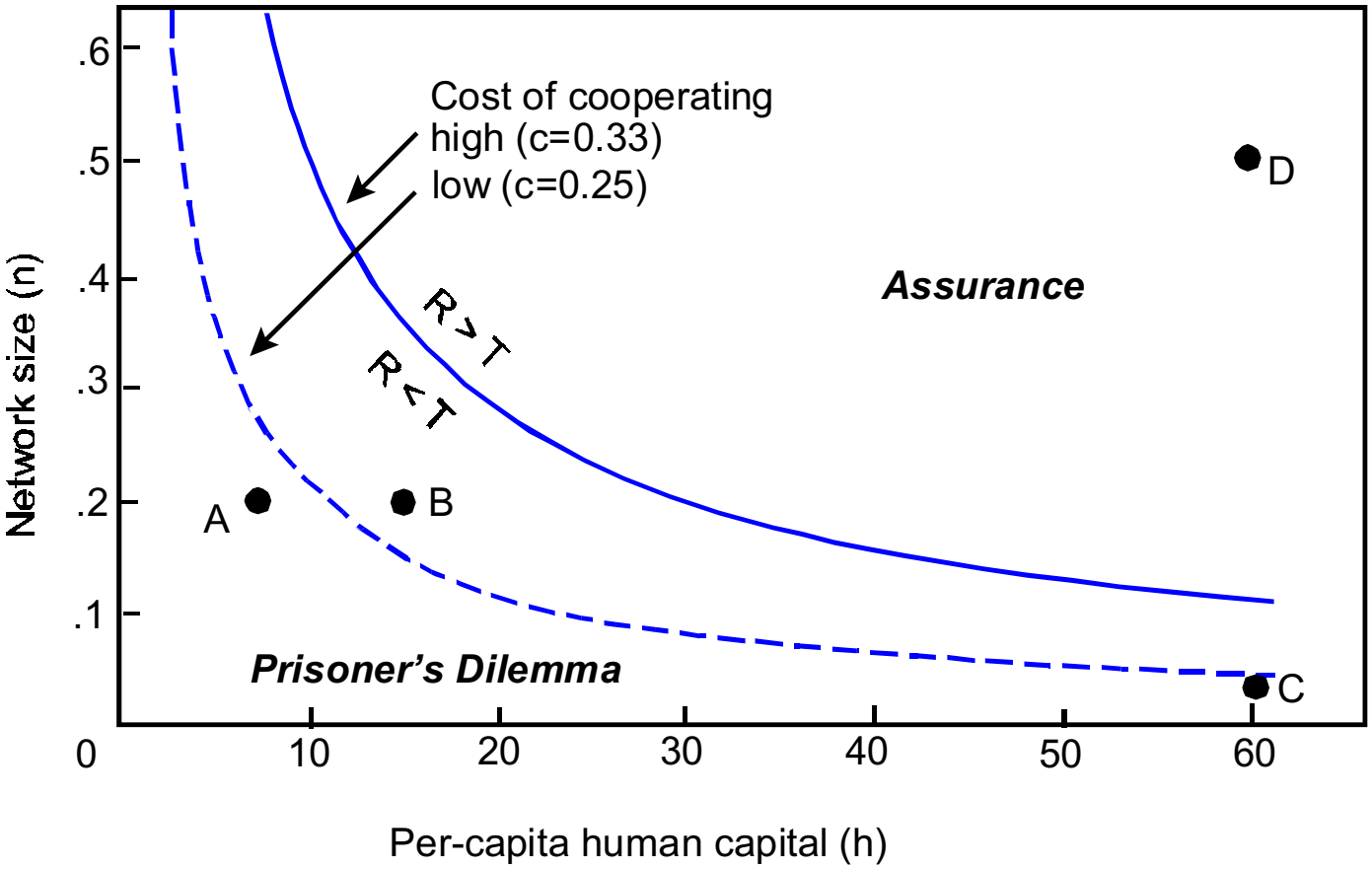


Figure 5 The Protestant urban literacy network, 1750



α=1/3, γ=0.6, w=0.5

Figure 6. Capital, network size and social coordination, 1530-1750

Table 1. Matrix of payoffs to player 1

	Player 2's strategy	
Player 1's strategy	Cooperate	Defect
Cooperate	Reward: $R = 2^{\alpha-1} n^{\gamma_h \alpha} - c$	Sucker : $S = (1/2)^{1+\beta} n^{\gamma_h \alpha} - c$
Defect	Temptation: $T = (1/2)^{1+\beta} n^{\gamma_h \alpha}$	Penalty: $P = w$

If player 1 receives either R or P, player 2 receives the same amount. If player 1 receives T, player 2 receives S and vice versa.

Table 2. Explanations of Population Growth in West-European Cities, 1500 - 1750

(Dependent variable is change in logarithm of population)

	Initial specification	Without *Literacy*	Split sample		Additional regressors		
HYPOTHESIS	All cities	All cities	Catholic	Protestant	All cities	Catholic	Protestant
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
CONVERGENCE							
ln *POP1500*	**-0.209**	**-0.199**	**-0.173**	**-0.234**	**-0.1992**	**-0.165**	**-0.216**
	0.051	*0.051*	*O.058*	*0.114*	*0.052*	*0.058*	*0.118*
ENDOGENOUS GROWTH							
Literacy	0.0078						
	0.0095						
Literacy^2	-0.00017						
	0.00013						
CAPITAL							
Capital	**1.178**	**1.155**	**1.254**	**1.2752**	**1.156**	**1.215**	**1.242**
	0.253	*.252*	*0.293*	*0.391*	*0.253*	*0.306*	*0.410*
RELIGION							
Protestant	**0.312**	0.124			0.118		
	0.147	*0.079*			*0.125*		
NETWORK EFFECTS							
Atlantic	**0.441**	**0.460**	0.139	**0.768**	**0.460**	0.182	**0.695**
	0.157	*.161*	*0.202*	*0.208*	*0.162*	*0.204*	*0.232*
Printing	**0.652**	**0.5963**	0.0120	**1.107**	**0.596**	0.028	**1.088**
	0.284	*0.285*	*0.349*	*0.280*	*0.286*	*0.365*	*3.730*
*Distance-center**	-0.0002	0.0067	-0.016	**-0.406**	0.0082	-0.040	**-0.375**
	0.0627	*0.0632*	*0.067*	*0.148*	*0.070*	*0.076*	*0.220*
OTHER VARIABLES							
DRegime					-0.0062	-0.169	0.038
					0.107	*0.109*	*0.122*
*Distance-other***					-0.0028	0.028	0.157
					0.072	*0.075*	*0.199*
CONSTANT	**0.542**	**0.573**	**0.559**	**1.037**	**0.580**	**0.665**	**0.835**
	0.188	*0.152*	*0.164*	*0.287*	*0.215*	*0.216*	*0.363*
Adj. R^2	0.273	0.270	0.118	0.547	0.266	0.121	0.541
No. of obs.	316	316	226	90	316	226	90

**Distance-center* measures distance from Milan for all cities and Catholic cities, from London for Protestant cities. ***Distance-other* measures distance from London for all cities and Catholic cities, from Milan for Protestant cities. Robust asymptotic standard errors are shown in italics. Bold face indicates that coefficient is significant at five percent level.

Footnotes

[1] As Gabaix (1999b) has demonstrated, this result means that by 1750, the mean and variance of individual Protestant cities' growth rates were approaching the constant values predicted by Gibrat's Law.

[2] Regression: d ln POP = 1.75 - 0.30 (0.03) ln POP_0 + 1.54 (0.18) d ln WAGE + 0.36 (0.05) CAPITAL - 0.57 (0.07) WAR; 10 observations; adjusted R^2=0.98; standard errors in parentheses.

[3] Between 1500 and 1750, the average annual population growth rate for northern Europe was 0.27 percent. Since the cities grew at a rate of 0.43 percent, there was presumably substantial net urban immigration. In the south, the population as a whole grew at 0.22 percent. Because the cities grew at only 0.16 percent annually, there may have been net urban *emigration*.

[4] This distinction between northern and southern Europe was noted by de Vries (1984, 95-98). However, he did not distinguish Catholic from Protestant cities.

[5] Tax-collection records show that in 1732 only 32 percent of the households of Dublin were Catholic (Connolly, 1992, 146).

[6] As the Protestant network developed, it attracted Jewish merchants and financiers from southern Europe (de Vries and van der Woude, 1997, 156, 370). These immigrants seem to have found it more profitable to do business under Protestant institutions than under Catholic ones.

[7] As Marius (1999) has emphasized, Martin Luther himself, trained as an Augustinian monk, was a strong believer in predestination. However, while he affirmed that believers would be saved, he did not state that nonbelievers would be damned.

[8] Dudley (2000) examines the effects of such shocks on the political structure of Europe over the past millennium. Here this analysis is extended into the economic domain.

[9] Dudley (1999) argues that for Europe as a whole during this period, growth results from the introduction of the printing press and written versions of the vernacular languages. The present paper extends this approach, making a distinction between northern and southern Europe.

[10] De Vries (1984) has also proposed a data set for urban population in the early-modern period. However, his set includes only 48 Protestant cities and 69 Catholic cities in Western Europe with populations of 5,000 or more in 1500. Many major cities such as Edinburgh, Copenhagen, Ferrara, Marseille, Orléans and Poitiers are not covered in that year. Nevertheless, the correlation coefficient between the logarithm of the population for the cities in his sample and that of Bairoch et al. (1985) for the same cities is high -- 0.95 for both the Protestant and Catholic subsets in 1500.

[11] Estimated 1750 adult literacy rates by country are: Austria 38%, Austrian Netherlands 43%, England 48 %, France 27 %, Germany 60 %, Italy 13 %, Dutch Republic 60 %, Portugal 15 %, Scotland 60 %, Spain 15 %, Sweden 80 %, Switzerland 60 %.

[12] In response to a referee's suggestion, an interaction variable, the product of *Printing* and *Literacy*, was added to the specifications of columns (2), (3) and (4) in Table 2. Its coefficient estimate was not significantly different from zero at the five percent level. In the period under consideration, greater human capital and access to reading material alone do not seem to have been sufficient to raise productivity unless basic values also changed.

[13] Surprisingly, there does seem to be some evidence to support this position. One of the authors contacted a large German firm that manages accounts receivable and defaulting loans. Default rates are lowest in Protestant areas, followed by Catholic regions (especially Bavaria), while the worst defaulters are the atheist regions of the east.