# Chapter 11

# Fragmentation, Competition, and Cultural Change

As we have seen, one bias in cultural evolution is what I call *coercion bias*, the ability of those in power who have a strong stake in the cultural status quo—be it religious, artistic, or scientific—to suppress innovation and persecute heterodox cultural entrepreneurs who deviate from the received wisdom. Innovations can undermine an existing structure of beliefs and in the process "erode beliefs" that provide certain groups with rents and legitimization (Benabou, Ticchi, and Vindigni, 2014). Another way of looking at this bias is to note that incumbents erect high barriers to entry into the market for ideas to protect their monopoly. These barriers often rely on such terminology as "heresy," "apostasy," and "blasphemy" and depend on raw political power to prevent new ideas from competing. In other cases, the educational system may have built-in protection for the intellectual status quo, such as the Chinese civil-service examination system or Jewish religious education. Unlike highly competitive economic systems—where entry and exit in the limit are effort- and cost-free—at some level *all* evolutionary and cultural systems must have such a system in place, to lend some modicum of stability to existing beliefs and prevent complete chaos. The question is to what extent is such resistance too hermetic? If it is too airtight, it may make innovation of any kind practically impossible and condemn a society to cultural stasis. Degree is everything here. By the early sixteenth century, the forces of repression and resistance were beginning to lose ground in Europe in every cultural domain, making accelerated change possible. But the old culture did not leave without a fight. The forces of reaction regrouped in the Counter-Reformation, and the power of the Jesuit order in southern Europe and Latin America slowed down the diffusion of the *nuova scienzia* innovations and the rise of the Enlightenment in these areas. Influential conservative thinkers, such as Hobbes in England and Bossuet in France, fought intellectual innovation tooth and nail. The

proponents of the new philosophies fought back. One common denominator that most citizens of the Republic of Letters (otherwise a diverse and fractious lot) shared was that they recognized their enemies, the opponents of new ideas and pluralism.[1]

What changed history was that in Europe, over the long term, the innovators defeated conservatism. This did not happen anywhere else. How do we explain the unique European experience? One serious candidate for explanation is what E. L. Jones (1981) has dubbed the European "states system," consisting of highly fragmented units, constantly at loggerheads with one another. Europe enjoyed significant advantages from political fragmentation although at considerable cost. The idea that political fragmentation yields benefits because of the salutary effects of competition among those who seek power dates back to the great thinkers of the Enlightenment.[2] The most widely cited quote stressing the blessings from political fragmentation is from David Hume:

> Nothing is more favorable to the rise of politeness and learning than a number of neighbouring and independent states, connected together by commerce and policy. The emulation, which naturally arises among those... is an obvious source of improvement. But which I would chiefly insist on is the stop [constraint] which such limited territories give both to power and authority ... The divisions into small states are favourable to learning, by stopping the progress of authority as well as that of power. Reputation is often as great a fascination upon men as sovereignty, and is equally destructive to the freedom of thought and examination. But where a number of neighbouring states have a great intercourse of arts and commerce, their mutual jealousy keeps them from receiving too lightly the law from each other, in matters of taste and of reasoning, and makes them examine every work of art with the greatest care and accuracy. The contagion of popular opinion spreads not so easily from one place to another. It readily receives a check in some state or other, where it concurs not with the prevailing prejudices Hume, [1742] 1985, pp. 119–20].

Modern scholars such as North (1981, p. 27), Jones (1981, pp. 109–10), and more formally Karayalçin (2008) have largely interpreted the

[1] In 1640, Descartes wrote to the Dutch author and diplomat Constantijn Huygens (the father of the better-known mathematician) that "he was going to war with the Jesuits" because of their aversion to intellectual innovation and his radical novel ideas in philosophy and mathematics (Ariew, 2003, pp. 157–60).

[2] The canonical statement by modern scholars is clearly Eric L. Jones, 1981. For more recent restatements, see for example Bernholz, Streit and Vaubel, 1998.

advantages of political fragmentation as fiscal and administrative, in the sense that political competition restrained rulers to some extent from misruling their domains and overtaxing and exploiting their most productive but mobile citizens. Historically, the fiscal argument is rather tricky: it is true, of course, that in many European nations competition imposed constraints on the executive that in one form or another limited their ability to tax their citizens into poverty. To be sure, competition among states is not like that among firms or consumers in that there are no enforceable rules (whether imposed by a third party or by a self-enforcing mechanism) to tame and constrain competition and set the parameters on what forms it can take. State competition can often resort to extreme violence or mindless trade restrictions and tariff wars as well as state-sponsored piracy, weakening all economies. But it can also take highly productive forms. The same political fragmentation that led to frequent and expensive wars among the European powers, which required high taxes (and imposed other serious deadweight costs on the population as well), was associated with economic success. The two most progressive nations in eighteenth-century Europe, the Netherlands and Britain, were the most heavily taxed on average, even if their taxes had been consented to by their representative bodies (which rarely represented more than a small fraction of the taxpayers in any case).

There is validity to the argument that interstate competition in Europe at times did mitigate and soften the worst forms of mis-governance in Europe and led to institutional progress, such as it was.[3] Reforms were often introduced after a major military defeat (such as the Prussian defeat by Napoleon in 1806 or the Russian debacle in the Crimean War), or in an attempt to improve the economy so as to expand the tax base. Eric Jones notes that "the states system was an insurance against economic and

[3] This was quite keenly noted by Immanuel Kant. In the eighth proposition of his 1784 essay "Idea of a Universal and Cosmopolitan History," Kant observed that

> Now the States are already involved in the present day in such close relations with each other, that none of them can pause or slacken in its internal civilisation without losing power and influence in relation to the rest; and, hence the maintenance, if not the progress, of this end of Nature is, in a manner, secured even by the ambitious designs of the States themselves. Further, Civil Liberty cannot now be easily assailed without inflicting such damage as will be felt in all trades and industries, and especially in commerce; and this would entail a diminution of the powers of the State in external relations. ... But if the citizen is hindered in seeking his prosperity in any way suitable to himself that is consistent with the liberty of others, the activity of business is checked generally; and thereby the powers of the whole State, again, are weakened. Hence the restrictions on personal liberty of action are always more and more removed, and universal liberty even in Religion comes to be conceded. And thus ... the spirit of Enlightenment gradually arises as a great Good which the human race must derive even from the selfish purposes of aggrandisement on the part of its rulers, if they understand what is for their own advantage. Kant ([1784], 2010, pp. 30–31).

technological stagnation" (1981, p. 119). Yet at all times, the benefits of this competition must be weighed against the tremendous costs of destructive warfare and military spending. Indeed, the cultural changes after 1500 poured oil on the fires of war by adding religion as a casus belli and leading to a host of violent conflicts, made increasingly destructive by ever-more sophisticated weapons and larger armies that could be raised in part thanks to the profits made in the New World and in part through expanding economies.

The passage from Hume shows that he was clearly more concerned with culture than with taxes. Edward Gibbon, undoubtedly influenced by his friend Hume, added a somewhat exaggerated picture of the benefits of the European system of political fragmentation:

> Europe is now divided into twelve powerful, though unequal, kingdoms, three respectable commonwealths, and a variety of smaller, though independent, states: the chances of royal and ministerial talents are multiplied, at least, with the number of its rulers ... The abuses of tyranny are restrained by the mutual influence of fear and shame; republics have acquired order and stability; monarchies have imbibed the principles of freedom, or, at least, of moderation; and some sense of honour and justice is introduced into the most defective constitutions by the general manners of the times. In peace, the progress of knowledge and industry is accelerated by the emulation of so many active rivals; in war, the European forces are exercised by temperate and undecisive contests. (Gibbon, 1789, vol. 3, p. 636)

The Age of Enlightenment coined a new term for the competition among people of different nations, regarded as a salutary force. National *emulation* was regarded as the key to the "competitive pursuit of national economic excellence" and produced in this view "proficiency in the arts and sciences" (Hont, 2005, pp. 115–16). But, as Adam Smith pointed out in a memorable passage, "in such [technological and scientific] improvements each nation ought not only to endeavour itself to excel, but from the love of mankind, to promote instead of obstructing the excellence of its neighbours" (Smith [1759] 1969, p. 229). The boundary between "emulation" and "jealousy" was as vague as the boundary between peaceful competition and a more pernicious nationalism that could end in international violence.[4]

[4] Hume ( [1742] 1985) used the term "jealous emulation" to describe one of the elements that would lead to economic development. Both Adam Ferguson and Adam Smith fully realized the danger of this double-edged sword even before the "national jealousy" erupted with full violence in 1793 (Hont, 2005, p. 122).

Competition among states, then, implied two things for cultural change. One is that rulers competed with one another for the best citizens, be they astrologers, painters, artisans, sea captains, musicians, or armorers. But more important, they provided a major reason for coordination failure among the powerful forces of conservatism trying to suppress intellectual innovators. Unless suppression was well coordinated among the reactionary powers, ingenious cultural entrepreneurs would play these powers against one another and survive. In 1415, Jan Hus still ended up at the stake in Constance, because the emperor and the pope were able to work together to eliminate this dangerous heretic. A century later this strategy no longer worked, and the Reformation could not be stopped. While most peasants may rarely have ventured outside their villages, and even most traveling journeymen stayed within the neighborhood of their place of birth (although more of them moved about than is commonly thought), members of the "creative classes"—top-rated craftsmen, engineers, physicians, architects, musicians, astrologers—moved all over the Continent.[5] Political fragmentation inevitably weakened the forces of reaction. The Jesuit Order, the most effective and consistent conservative force in Europe, did all it could to suppress new ideas, such as Copernican cosmology and infinitesimal mathematics. Had they gained more control in France, Britain and the Netherlands—say, because of decisive Spanish military victories—the intellectual development of Europe inevitably would have been impeded.

The precise reasons Europe remained fragmented the way it was whereas China and the Middle East were unified into coherent empires have been debated at some length (Hoffman, 2015, pp. 107–34, provides an excellent summary; see also Ko, Koyama, and Sng, 2015). Geography has undoubtedly played some role: the Pyrenees and the Alps may have helped preserve Spain and Switzerland as independent political states, and the Dutch rivers repeatedly kept out larger and more powerful neighboring armies.[6] Another argument is the interrelatedness of European monarchs and rulers, who formed coalitions based on family ties and preserved the status quo. Even when relatives fought one another, as happened repeatedly, they usually refrained from dethroning a brother or a cousin. Instead, Hoffman proposes a model based on ideas derived from cultural evolution. Strong beliefs about the value of courage and heroism in battle plus a cul-

[5] No more than 75 percent of all engineers working in sixteenth-century Spain were born there; the others came from Italy, Germany, Flanders, and England (Davids, 2013, p. 182).

[6] Ko et al show that through most of its history China faced a severe, unidirectional threat from the Eurasian steppe, whereas Europe confronted several smaller threats from Scandinavia, Central Asia, the Middle East, and North Africa. They argue that empires were not viable in Europe, and political fragmentation turned out to be the norm. In contrast, empires were more likely to emerge and survive in China, because the nomadic threat endangered the survival of small states more than it did larger ones.

turally-learned dislike of other groups were included in the socialization of youngsters, which made it more difficult to create a common European identity that a unifying warlord might exploit. Beyond that, Hoffman argues that Western Christianity was a factor here, as the popes used their religious influence to prevent any European ruler, and above all the Holy Roman Emperor, from amassing too much power (Hoffman, 2015, pp. 132–34). One might add that contingency may have played a role as well: had the Spanish Armada succeeded or Napoleon won at Waterloo, perhaps the story might have ended differently.

What emerged in medieval Europe, and turned out to be of great importance is that political fragmentation was coupled with an intellectual and cultural unity, an integrated market for ideas, that allowed Europe to benefit from the obvious economies of scale associated with intellectual activity.[7] This unity derived from both Europe's classical heritage and the widespread use of Latin as the lingua franca of intellectuals, and the Christian Church. While for much of the Middle Ages the level of intellectual activity (in terms of both the number of participants and the intensity of the debates) was thin compared to what it was to become after 1500, it was *transnational*. This unique combination of political fragmentation with the pan-European institution of the Republic of Letters holds the key to the dramatic intellectual changes after 1500.

Thus, as Jean Baechler (2004) has stressed, the political fragmentation and the concomitant pluralism of Europe became a key to its intellectual development. The dark forces of reaction in the sixteenth century were no less benighted than those of the fourteenth, but it became increasingly difficult for those forces to work together, in part because some defenders of the conventional wisdom were Protestant and others Catholic.[8] The forces of the Catholic reaction were fragmented among themselves.[9] Authorities could not agree on who were heretics and what to do about them, and the heretics took full advantage of this. The unique situation in

[7] Cohen (2012, p. 206) refers to these economies of scale, as he points out that one of the factors that may have given early modern Europe (as opposed to early Islamic civilization) an advantage in making scientific breakthroughs as opposed to early Islamic civilization is sheer numbers, in which Europe had an advantage of 1:4.3 (adjusted for time). That number, one should add, is attained by aggregating *all* European scientists—implicitly assuming that Europe constituted a single intellectual community.

[8] Consider Luther's disciple Philipp Melanchthon's denunciation of Copernicus: "some think it a distinguished achievement to construct such a crazy thing as that Prussian astronomer who moves the earth and fixes the sun. Verily, wise rulers should tame the unrestraint of men's minds" (cited by Kesten, 1945, p. 309). Luther himself said caustically of Copernicus, "the fool wishes to turn the entire art of Astronomy on its head" (cited by Merton, 1973, p. 245).

[9] Thus for instance the reactionary Pope Paul IV in the 1550s alienated the main Catholic power, the Habsburgs, as well as the English Catholic legate, Cardinal Reginald Pole, the leader of the Catholic reaction in England whom he denounced as a heretic.

Europe, then, was that intolerance and the suppression of cultural heterodoxy, long before they fell out of fashion, could not be properly coordinated. Many innovators—not least Martin Luther, who was protected by the powerful prince-elector Frederick III of Saxony and later by the latter's brother and successor John—were able to game the political system to avoid persecution. Hostility among the European powers led each ruler to protect the gadflies that irritated his or her enemies. One noteworthy example is Tommaso Campanella, (1568–1639), an Italian monk who studied astronomy, astrology, and occult philosophy, like many others became skeptical of the Aristotelian orthodoxy. He was accused from an early age of heresy by the Inquisition; his ability to play one power against another in fragmented Italy failed him when he was sentenced to life imprisonment in 1599 (for anti-Spanish activity rather than for heresy) and spent twenty-seven years in a Neapolitan jail. However, his conditions there were sufficiently benign that he could write seven books in jail as well as a pamphlet defending Galileo during his first trial in 1616. In the end, he was released from jail through the intervention of Pope Urban VIII, but got in trouble again. He had succeeded, however, in endearing himself to the French authorities (anxious to embarrass the Spanish). Through the intervention of the French ambassador he made it out of Italy to France, where he was honored by the court of Louis XIII and eventually accepted even by the suspicious Cardinal Richelieu and died in Paris (Headley, 1997, pp. 117–27).[10] In other cases, the ability of intellectual innovators to move about the Continent to escape potential persecutors left the incumbents powerless to suppress innovations, though the causality between mobility and intellectual innovation is of course rather complex.

By the eighteenth century, the attempts of reactionary forces to suppress innovations had become a bit of a charade, and while the more outrageous *philosophes* such as Helvétius and Lamettrie still had to move about when the local authorities became disenchanted with them, they usually found welcoming hosts abroad. By the closing decades of the eighteenth century the forces of the Enlightenment had become too powerful to resist, and even in much of Catholic Europe persecution of heretics

[10] Another, earlier, case is that of Bernardino Ochino (1487–1564), a highly controversial Siennese Franciscan monk and preacher, committed to free inquiry and controversy, and famous for an unusual eloquence. He managed to alienate the Catholic Church, especially attracting the hostility of the reactionary hard line Cardinal Giovanni-Pietro Caraffa (later Pope Paul IV, 1555–1559). An equal-opportunity gadfly, Ochino also alienated most protestants. He was summoned to appear before the Roman Inquisition established in 1542 (one of the first "heretics" to be so persecuted) and fled to Geneva in 1547, eventually ending up in England, whence he was driven by the ascension of the intolerant Mary Tudor. Returning to Zurich, he was again expelled and ended up in Poland (at that time a relatively tolerant nation) but was banished from it in 1564 at the instigation of the papacy and he died in Moravia. Among other things he advocated divorce and was suspected of supporting polygamy (Benrath, 1877).

slackened even if heterodox views had to be cast in prudent terms.[11] The Jesuits were suppressed by the pope in 1773, and intellectual pluralism became increasingly the dominant modus operandi everywhere in Europe west of the Elbe river.

Moreover, the fragmentation of Europe into many independent states and statelets was only part of the underpinning for a competitive market for ideas and seriously understates the degree of political fragmentation. In ostensibly unified countries, such as the Netherlands and Spain, local and regional authorities had a large degree of independence (Grafe, 2012). Moreover, within each state, there were many more or less autonomous, mostly self-governing entities or "corporations," in which heterodox opinions could flourish.[12] Among those entities in early medieval Europe, monasteries had been in the vanguard. Gradually they were joined by universities, where the sons of the elite were offered information and beliefs beyond their early socialization and could be exposed to intellectual innovations. Much like monasteries, universities were quasi-autonomous self-governing bodies. Despite their independence from the central government, European universities were, however, rarely the taproot of intellectual innovation. Indeed, as much as any organization, they helped maintain the *auctoritates* of the canon (mostly religious texts, Aristotle, and some of the classical textbooks of medicine), which were the classical books that any educated person was expected to read and discuss. Universities were usually bodies that guarded tradition and the intellectual status quo. They thrived on exegesis and commentary, and made sure that the knowledge of one generation was passed on whole and unaltered to the next. Even those scientists who started their careers as part of universities escaped them when their fame had risen enough to enable them to find better patronage (Galileo and Newton immediately come to mind). Universities in early modern Europe were, then, mostly highly conservative organizations in which, for the most part, "critical learning" meant purging classical texts of distortions introduced through copying and translation errors in a later time. The goal of the typical university scholar was "textual purity rather than scientific truth" (Debus, 1978, p. 4). This was the kind of scholarship that we find in

[11] The Spanish Benedictine monk Benito Jeronimo Feijoo (1676–1764), one of the leaders of the Spanish Enlightenment, published essays in which he considered the arguments for and against the Copernican system. While he was careful to remain formally loyal to the scriptures, he laid out the arguments on both sides. His eight-volume book of essays, *Teatro Critico Universal* (1726–1739) was not only approved by the censors; it was actually praised lavishly by them (Castellano, 2004, p. 34).

[12] As Slack (2015, p. 65) points out in the case of England, "in the seventeenth century every aspect of social welfare was being managed by corporate bodies, by parish vestries, charitable trusts, civic corporations, and companies of merchants, whose collective cultures communicated and sustained shared values."

the kaozheng movement in China at the time, and while it was clearly critical and evidence-based, it was fundamentally backward looking.

All the same, some universities, especially newly founded ones or those that had been rejuvenated by the arrival of a few leading scholars, could generate heterodox cultural elements. The newly founded university at Wittenberg was barely fifteen years old when one of its professors famously nailed his ninety-five propositions to the church door. Galileo did some of his best work at the University of Padua, as did Andreas Vesalius; it counted both William Harvey and Nicolaus Copernicus among its graduates.[13] For much of the period between 1500 and 1700, it was the best university in Europe, and the government of Venice bent over backward to accommodate its distinguished if opinionated faculty and protected them from papal and Jesuit obscurantism. The University of Leyden in its golden age in the first half of the eighteenth century was perhaps the most dynamic and successful institution spreading the new Newtonian physics and cutting-edge medicine. In Britain the eighteenth-century Scottish universities famously became a center of innovation in science, political philosophy, medicine, and many other areas. Some, though not all, German universities reformed during the age of Enlightenment and encouraged new styles of learning oriented toward contemporary issues and practical disciplines (Moran, 1991b, p. 178). Progressive universities rose and fell, and few remained innovative over the very long haul. But because they were numerous, of them, it was rare that there was not some innovative activity taking place at *some* university in Europe. When such intellectual innovation occurred, central authorities had difficulty suppressing it. Furthermore, universities had to compete with other scientific organizations, such as the various academies and learned societies that sprang up all over Europe in the seventeenth century.

Something similar can be said about guilds. They, too, were autonomous organizations that to a large extent were self-regulating and enforced their own institutional elements. A long and acrimonious debate has developed over the question whether craft guilds were technologically progressive or conservative in European economic history (for recent summaries, see Prak and van Zanden, 2013 and Ogilvie, 2014). But guilds lasted at least half a millennium in many regions and regulated many crafts. They often crystallized existent skills and techniques and resisted innovation in an attempt to protect the exclusionary rents of incumbents. In other cases they encouraged innovation, diffused new ideas geographically, and encouraged younger members to think for themselves. Guilds, despite their local autonomy, were often allied with kings; hence they were known as *choses du roi.* Kings were often interested in technological innovation as a

[13] Another innovative Padua professor was Girolamo Fracastoro (1478–1553), possibly the first physician to propose that diseases were caused by minute invisible organisms.

way of strengthening their tax base or their military capability, and thus guilds could be seen on both sides of the line.

Another of the independent corporations that Europe—and few other societies—offered was the autonomous, largely self-governing city. The Republic of Letters, much like the Reformation, was largely an urban phenomenon.[14] Not all cities were welcoming to heterodox intellectuals: not the Rome of Pope Clement VIII who was personally involved in the execution of Giordano Bruno; not Calvin's Geneva; and not the Utrecht dominated by reactionary theologians such as the Calvinist theologian Gisbertus Voetius (Gijsbert Voet, 1589–1676).[15] But there were always enough towns where one could go, or at least find an audacious publisher who would print one's works. Venice in the first half of the seventeenth century (which included Padua) was an exceptionally tolerant and open-minded environment in which unconventional and heterodox thinkers such as Galileo, Paolo Sarpi (1552–1623), and Cesare Cremonini (1550–1631) could thrive (Muir, 2007). It banished the Jesuits, who fought for a more conservative and orthodox curriculum between 1606 and 1657.[16] Strasbourg, a cosmopolitan border town, was famous for its tolerance, as was Basel, "a city ever hospitable to refugees from oppression in their native countries" (Grafton, 2009a, p. 7). Wittenberg, Leyden, Louvain, and Montpellier were university towns that at one point or another were home to important intellectual innovators and scholars. The miraculous growth of London after 1570 had an obvious cultural effect (Harkness, 2007, esp. pp. 160–69; Slack, 2015, p. 75). The urbanization of the age of the great voyages and the flourishing of commerce in the Renaissance towns thus provided an unintended underpinning for future development. It is also striking that some of the smaller independent political entities in Europe punched above their weight in the Republic of Letters. The important role of the Netherlands as a site of tolerant pluralism (at least most of the time) is well known. Barnett (2015) has pointed to the Swiss towns as a pivotal location in connecting the Italian Republic of Letters with its Northern counterparts, as

[14] For an argument about the importance of cities in cultural change in the sixteenth century, see Wuthnow, 1989, pp. 41–45.

[15] Hooykaas (1972, p. 100) writes that especially commercial and industrial cities were intellectually dynamic, far more so than sleepy university towns. These cities also tended to be more tolerant of different religions and multilingual. Modern research has found that especially cities involved in Atlantic trade were institutionally dynamic (Acemoglu, Johnson, and Robinson, 2005).

[16] In his play *Life of Galileo*, Bertold Brecht has the University of Padua curator explain to Galileo that while the university may not pay quite as much as some wealthy patrons, "it guarantees freedom of religion and even admit Protestants to our lectures" (cited by Muir, 2007, p. 16).

well as their polyglot character, which produced a set of translators needed when more and more intellectuals began publishing in their vernacular.

Political fragmentation was thus important for more than restrained taxes and effective governance; it was a major factor in the emergence of cultural pluralism. In the sixteenth century, heterodox cultural variants emerged in many fields, meaning that existing barriers to entry were being compromised and penetrated. New people challenged the conventional wisdom in every area of knowledge and thought. To be sure, a variety of conservative bodies made serious attempts to suppress innovators, and some of the most innovative cultural entrepreneurs paid with their lives.[17] No European country was completely free of suppression. Protestant nations were at times more intolerant than Catholic ones. The leading religious reformers were themselves far from paragons of tolerance, and philosophers of the early Enlightenment did not all believe in a level playing field in the market for ideas.

Notwithstanding the formidable powers of conservative forces, dissent and innovation flourished. Fragmentation, footlooseness, and the proliferation of printing presses meant that it became increasingly difficult for politically powerful incumbents to suppress subversive and heretic new beliefs generated by cultural entrepreneurs. Any such suppression would only mean that the persons targeted would flee elsewhere.[18] Studies of European intellectuals show that they had a high rate of mobility, despite the obviously high costs of traveling (Mokyr, 2006c).[19] The Moravian intellectual Jan Comenius (né Komensky, 1592–1670), is an example, albeit an extreme one. His career spanned at least four major and quite different countries (Bohemia, England, Poland, and Holland), as he repeatedly fled persecution for his views. He declined a fifth when he turned down an offer to serve as the first president of Harvard. Desiderius Erasmus was as peripatetic as one could get in an age of poor transport. Born in Rotterdam, he studied in Paris, holding appointments in Basel, Leuven, and Cambridge. During his stay in Leuven he felt victimized by critics, who opposed his

[17] An example is the execution of Jan of Leiden, an early leader of the Anabaptist reformation in 1536—oddly enough by the deposed bishop of Münster, Franz von Waldeck, who had known Lutheran sympathies. Yet it is telling that the harsh violence used against Anabaptists failed to put an end to the movement.

[18] A striking example is that of Pierre Bayle (1647–1707), a highly critical and skeptical French intellectual, who switched from Catholicism to Calvinism and eventually fled to Rotterdam while his works were burned at the stake in France (which greatly increased their popularity); less innocuously, his brother was arrested *faute de mieux* and died in jail. See Labrousse (1983, p. 28).

[19] It is indeed striking that, despite the obvious improvements in inter-European transportation, the distance between place of birth and place of death among notable Europeans, a rather rough measure of footlooseness, has changed little since the Middle Ages (Schich et al., 2014, p. 560).

devotion to a more progressive text interpretation, and took refuge in Basel. Later in his life, when he was the most eminent and widely respected humanist scholar of his age and one who refused to take strong positions on the most disputed issues of his day, there is no evidence that he was ever seriously threatened by people who disagreed with him. Erasmus's close friend, Juan Luis Vives, the son of persecuted Spanish *conversos,* left Spain at age sixteen never to return and spent much of his life commuting between Bruges and England.

Many other intellectuals moved from country to country in search of learning, patronage, and teaching positions, escaping religious intolerance and at times creditors, jealous husbands, and other sources of distraction, but they also traveled to find the newest and best knowledge and to sell their own ideas in larger markets than their place of birth. Traveling, despite the discomforts and the hazards, to study with the best and most prestigious scholars remained a central mode of learning, and few European intellectuals followed the example of Newton who never left England and never ventured north of the Lincolnshire hamlet of his birth near Grantham. Above all, traveling was a safeguard against oppression and intellectual persecution, and the common knowledge that moving elsewhere was an option for heterodox scholars helped cultivate the rise of tolerance in Europe.

It is telling for the way the Republic of Letters worked that Hobbes wrote *Leviathan* in Paris and Locke his *Letter on Toleration* in Amsterdam. The Dutch jurist Hugo Grotius fled the Netherlands and took refuge in Paris. Descartes, who lived for much of his life in the Netherlands, left the country when Prince Maurice took the side of hard-line Calvinists in 1619. Two centuries after Erasmus's death, European intellectuals still took advantage of its fragmentation. Voltaire famously purchased his property in Ferney in the 1750s close enough to the Swiss border to make an escape if push came to shove, but within France to avoid repressive Geneva regulations on having a private theater on his estate. As Gibbon observed, in Europe "a modern tyrant" would discover that "the object of his displeasure would easily obtain in a happier climate, a secure refuge, a new fortune adequate to his merit [and] ... the freedom of complaint" (1789, vol. I, p. 100). The fragmentation of Germany and Italy, as we have already seen, protected many intellectual innovators from the fury of the reaction.[20] Many intellectual innovators were able to thrive by moving with virtuosity on the

[20] Thus, for instance, the heterodox friar Paolo Sarpi was protected by the Venetian Republic, which blithely ignored the papal summons by Paul V to send him to Rome and the ensuing excommunication (1607). The pope tried to get the Spanish king to support him militarily, but the equally Catholic king of France supported Venice, and the pope had to resort to a heavy-handed attempt to assassinate Sarpi (which failed).

seams between competing powers.[21] Moreover, even when intellectuals could not move easily, their books and writings did—in great part thanks to the printing press and the growing ease of shipping books. In this kind of world, suppressing heterodoxy became simply unworkable.

Political fragmentation in the early modern period meant not so much that Europeans were more tolerant than those residing in other parts of the world from the outset (the opposite was the case) than that in Europe intolerance became ineffective in the long run. After 1660 or so, tolerance of heterodox views, not matter how objectionable, was on the rise and effective suppression of disruptive or subversive intellectuals (hoping perhaps to become successful cultural entrepreneurs) was fading. Most regimes still felt the need to pay lip service to the accepted orthodoxies and prohibit certain publications, as when the works of Spinoza banned by the Dutch Estates General in 1678 but then published and disseminated clandestinely. Much the same happened to Voltaire's *Lettres Philosophiques* in 1734 (they were actually burned symbolically by executioners). The last person to be executed for blasphemy in Britain was one Thomas Aikenhead, hanged in pre-Enlightenment Edinburgh in 1697, for explicitly anti-Christian beliefs. Unitarianism, which could be a capital crime in the sixteenth century and still left Newton uncomfortable, was more or less tolerated in his later years.[22] The free-thinking Irish intellectual John Toland (1670–1722), whose writings slaughtered virtually every sacred cow imaginable and "generated great hostility," experienced no worse persecution than being ordered by its vice chancellor to leave conservative Oxford (Daniel, 2004). In France, the best-known Enlightenment writers found themselves "playing a game of harmless charades" with the censors (Gay, 1969, p. 77).[23] Most rulers began

[21] Another example is Johann Joachim Becher (1635–1682), a German alchemist, engineer, and entrepreneur, one of the founders of phlogiston theory, who worked alternately for a variety of German rulers, including the elector of Bavaria, the emperor, and smaller German princes as a court scientist and counselor, moving each time that his enemies and rivals got the better of him. Becher's ability to exploit the political fragmentation in Europe bordered on the virtuosic, enabling him to move rapidly between the Imperial court and various German princedoms. In Vienna he was able to play the Habsburg emperor against his own Hofkammer. When his German patronage ran out, he ended up in England in 1680 (Smith, 1994).

[22] Snobelen (1999) has pointed out how toothless the laws against heresy had become in Britain after 1700 through the examples of Newton's students and friends William Whiston and Samuel Clarke in the early 1710s. There was a cost in terms of patronage: Whiston's anti-trinitarianism cost him his professorship and any further hope of public office. Clarke's heterodoxy prevented further ecclesiastical preferment. Still, neither man was jailed or fined —let alone defrocked. Whiston wrote a highly successful book popularizing Newton's work and went on to obtain patronage from the nobility, while Clarke retained his rectorship at St James's in London.

[23] Jean-Jacques Rousseau still found himself persona non grata at Montmorency after the 1762 publication of *Émile*, and ended up traveling throughout Europe, especially in Switzerland and Britain, but soon all was forgiven, and he was able to live out his last decade in France. Claude-Adrien Helvétius's *De l'Esprit*, published in 1758, was condemned by the Sorbonne and

to see the futility of the effort and attempts to persecute people regarded as troublemakers were half-hearted at best. David Hume was denied a tenured professorship at Edinburgh because of his alleged heterodox views, but otherwise he was not much harassed. Kant, too, felt the harshest side of suppression when he was "reprimanded" by the king of Prussia for his heterodox views. There remained some uncertainty for authors, but not nearly enough to put an end to the flow of new radical ideas and the people producing them.

By the middle of the eighteenth century it is fair to say that even in so-called absolutist countries, the suppression of dissenting and even heretical voices had become more of a ritualized formality than a real threat. The more conservative rulers of Europe found themselves pushed toward a policy of "if you cannot beat them, join them" and co-opted many of the ideas of the Enlightenment, creating the somewhat oxymoronic "enlightened despots" (Scott, 1990). The liberal ideas of religious tolerance, free entry into the market for ideas, and belief in the transnational character of the intellectual community were essential to Enlightenment thought. These were the cultural underpinnings of the institutions that not only supported a functioning market for ideas, that is, a market in which innovators had a fair chance to persuade their audiences. They also actively encouraged intellectual innovation and thus laid the foundation for the emergence of the modern economy.

the books burned in public; Helvétius had to formally retract his ideas and found himself in England, later on in Potsdam. Yet the entire reaction did not last, and in 1765 he was allowed to return to France and back in favor again. Even more striking is the history of the radical atheist gadfly Julien La Mettrie (1709–1751), whose heretical works first forced him to take refuge in Leyden, but even there his hedonism so annoyed his hosts that he was forced to leave for Berlin, where Frederick the Great delighted in his often outrageous opinions. After 1750, censorship in France was left to Guillaume-Chrétien de Lamoignon de Malesherbes (1721–1794), a kind and somewhat ineffectual lawyer, who actually maintained tight friendships with opposition intellectuals such as Diderot and Grimm.

# Chapter 12

# Competition and the Republic of Letters

The institutional background of the intellectual community in early modern Europe consisted of a polycentric political environment coexisting with a transnational Republic of Letters, which included scholars and literati. The importance of that community was huge. For one thing, it overcame the limitations of fragmentation by providing the intellectual innovator with a much larger audience than his or her own countrymen. While the power of the ruler was limited by the borders of the realm, the influence of intellectuals paid no heed to political boundaries. Moreover, precisely because the knowledge was not rooted primarily in local conditions, it could make stronger claims to universality. Above all, it was this community that provided a set of institutional incentives encouraging academic and artistic "superstars."[1] Erasmus himself thought of his scholar friends as "amicarum communia omnia" (Schoeck, 1982, p. 303). A century later, Thomas Browne, while he may not have used the exact term, uses terms such as "Latine Republique" and "common wealth of learning" and stressed the importance of the sharing of knowledge as a duty of all its members or citizens (Denonain, 1982, p. 371). The community provided a competitive marketplace not only for ideas but also for the people who generated them in their struggle to gain recognition, fame, and patronage.[2] It was the ultimate

[1] The idea of academic superstars over whom patrons would compete was already present in the late sixteenth century: the eminent French classical scholar Joseph Scaliger (1540–1609) was tempted to join the faculty at Leyden University in 1593 with the promise of a salary higher than that of the law professors and a complete release from teaching duties.

[2] Perkinson (1995, p. 74) stresses the importance of a community of scholars forming "a collection of widely scattered readers ... who kept abreast of the state of knowledge in a given field" and who subjected each new idea to a critique and a set of validity tests, yet he insists on ascribing this community entirely to the printing press.

realization of the Talmudic wisdom that *kin'at sofrim tarbeh chochma*—the jealousy of the learned shalt increase wisdom.

We should not overrate the quantitative importance of the Republic of Letters. The vast bulk of the women and men who lived in Europe between 1500 and 1700 would have had no idea of its existence. It was a small, often-endangered species, whose precarious existence depended on the power of the minds of its founding parents and those who followed in their footsteps. It was not an enlightened age, and the ideas of tolerance and universalism were still in embryonic form, if that. Yet, as Anthony Grafton (2009a, p. 5) has put it so well, within an ocean of darkness, small bands of intellectuals navigated in fragile crafts, little communities of scholars with their own values and rules. What should be added, however, is that these small bands were not insulated: their strength came from the close ties they maintained with one another and the astonishingly effective network that emerged as a result—not by design, not by intention, but all the same capable of bringing about a historic sea change. Moreover, the emergence of the "state" in early modern Europe is widely believed to be central to the story. "The holders of authoritative positions made decisions with respect to culture producers that greatly enhanced or impeded the work of these producers," argues Wuthnow (1989, p.17). This loses sight of the transnational nature of the community of "culture producers" and the fierce competition among states and wealthy individuals for having the privilege to host the best and the brightest Europeans, whatever their nationality, as Wuthnow acknowledges elsewhere. Authorities had an influence on the evolution of culture, but it was constrained, and often depended on the political accident that determined the persons and personalities in power and thus lacked consistency (Wuthnow, 1989, pp. 167–68).

The Republic of Letters was decidedly not a construct of modern historians. It was very much an institution of which contemporaries were fully conscious, and they realized its significance.[3] Pierre Bayle began publishing his newsletter *Nouvelles de la République des Lettres* from 1684, printing it in his relatively safe abode in Holland. Bayle said of his "citizens" that "we are all equal, because we are all the children of Apollo" (quoted in Dibon, 1978, p. 45). But "all" pertained to an elite that was estimated in Bayle's age to have 1,200 members, and a century later perhaps 12,000 (Brockliss, 2002, p. 8). While the evidentiary base of these estimates can be questioned, there is no doubt that the number of people involved was tiny relative to the population. As noted, it existed primarily as a virtual

[3] Marc Fumaroli (2015, pp. 50, 294–96) assigns special significance to the Venetian satirist Trajano Boccalini (1556–1613) who published in 1612 a best-selling work, *Ragguagli de Parnaso* (*Newsletter from Parnassus*), which was translated into many languages. In Fumaroli's opinion, this work established the idea of an independent intellectual community among a large transnational and transreligious constituency and constituted a precursor of Bayle's later work.

entity, kept alive by letters and publications that were open to all. But some of it was clearly located in formal organizations—the Royal Society, the French Royal Academy, and the many Continental academies founded in the eighteenth century.[4] The Republic of Letters was the institution that resolved the problem of rewarding creative individuals for efforts and talent and above all for originality and creativity.

Competitive patronage was the chief, but not the only incentive mechanism in the Republic of Letters. Prince-savants and other patrons were supposed to be able to recognize and value high ability and cultivate it, a signal of their legitimizing wisdom. This tradition was still respected in the eighteenth century by Frederick the Great, whose patronage of the best of Europe's intellectuals is well known. In practice, however, reputation based on peer evaluation was what counted (David, 2008). While patronizing learning and the arts was clearly a form of conspicuous consumption, there were other pragmatic advantages: some wealthy merchants had a deep interest in natural history and the details of the material world in areas that directly affected their activities such as navigation and accounting, as well as in engineering, medicine, and astrology. To inform them, they needed contact with experts and intellectuals. While the superstars enjoyed the tight competition for their services and could bargain for the best appointments, many lesser lights had to struggle for such patronage. In general, the higher one's scientific reputation, the better the chances (David, 2008). Reputations increasingly were no longer based just on erudition and knowledge of the classics; one had to make *original* contributions to be assessed by one's peers in the scholarly community. In this way the system encouraged and incentivized intellectual innovation.

Continent-wide reputations required good communications. During the Renaissance, Europe witnessed the creation of increasingly dense epistolary networks of scholars and engineers that transcended political and ethnic boundaries (Collins, 1998). These networks grew throughout Europe due to commercialization and the growth of medium- and long-distance trade. The improvements in shipping and other transport technologies were key to the expansion of the Republic of Letters. Reputations and correspondence networks were strongly complementary: intellectuals measured themselves by their ability to communicate with the superstars of the scholarly world. D'Alembert, one of the most prominent citizens of the eighteenth-century Republic of Letters, wrote in his eulogy for Jean Bouhier (1673–1746), another respected member and president of the French Academy in 1746 that "nothing is better for furthering the reputation of a man of letters ... than a large epistolary commerce ... and even the great Leibniz

[4] Some scholars, such as Goodman (1991, p. 184), see the Parisian salon as the primary form that gave the Republic of Letters a source of organizational order for its social relations and discourse, a somewhat Francocentric point of view perhaps (Melton, 2001, p. 211).

himself employed it responding even to the most obscure writers " (D'Alembert, 1821, vol. 3, p. 325).

It was expected that in return for patronage, intellectuals display loyalty to the monarchs and nobles who sponsored them, but such loyalty rarely extended to a direct control over the writings of scholars beyond fawning dedications. Many of the most prominent scholars and patrons, even in the age of religious fanaticism, could be quite flexible in their religious loyalties.[5] The international competition among courts, rich private patrons, universities, and later academies for the best and most eminent scholars meant that in the long run the power of the patron and the local religious authorities to control or dictate their views to the intellectuals he or she employed was limited. This competition implied a relatively high level of freedom for people to propose new ideas in an increasingly open market for ideas.[6] In the seventeenth and eighteenth centuries, some princes formalized their patronage and rather than having scientists and intellectual at their courts, they were appointed to formal academies and universities under their control. While the patronage enjoyed by intellectual innovators was often fickle and intrusive, on the demand side there was enough competition among rulers to ensure a reasonable amount of independence from political and religious institutions for most members of the community.

This relative independence from rulers helped turn the scholarly community into an institution that incentivized the educated elites in Europe to produce intellectual innovations that led to an unprecedented flourishing of new ideas in every area. It also led to the emergence of an impressive number of heterodox scholars who thought outside the box and promulgated original hypotheses and notions, in the hope of acquiring the respect of their colleagues and peers. Court patronage provided some of the best minds of Europe with the freedom and leisure to pursue their interests. In a few cases, such patronage liberated scholars from universities, when these were unfriendly to innovative intellectuals. Moreover, for scientists and artists to be recognized by figures of high social standing and power mattered because such recognition conveyed respectability in an age in which outside the scholarly community "whom you knew" conveyed as much social prestige as "how much you owned" (Hahn, 1990, p. 7). In early modern Europe, intellectuals as such (with the exception perhaps of a handful of superstars) still had fairly low social status. Powerful and high-

[5] The renowned Flemish philological and humanist scholar Justus Lipsius (1547–1606), though a lifelong Catholic, seemed to have little trouble conforming formally to Lutheranism while teaching at Jena between 1570 and 1572 and in Calvinist Leyden between 1579 and 1592. The Habsburg Emperor Rudolf II, nominally a Catholic, was the patron of Protestant scholars, including Kepler (who had steadfastly refused to convert to Catholicism).

[6] This was equally true at a more local level: Cohen (2012, p. 585) points out that it was during the "unruly" English interregnum in the mid-seventeenth century when censorship broke down and hence all kinds of "half-baked ideas and projects had a chance to gain a hearing."

status patrons supplied them with an opportunity for a secure existence as well as elevated social status; thus, patronage provided powerful incentives to creative and learned people to exert themselves. In the eighteenth century, as the economic power of the urban bourgeoisie increased, the population of potential patrons and customers widened.

There was a close connection between the competition of the political entities in the European states system and a new feature of the European intellectual elite that arises in early modern Europe, namely, the rise of "open science" (David, 2008). With remarkably few exceptions, European scholars who made discoveries or generated new insights of any kind placed the information in the public realm through books, pamphlets, personal correspondence, and periodicals. Only in that fashion could others know and recognize their work and their reputation grow. In his magisterial work on the topic, William Eamon (1994) has described how science in early modern Europe became less and less secretive.[7] By reducing the secretiveness of knowledge and turning useful knowledge into what today would be called an open-source system, European intellectuals created an institution that reduced access costs. It is easy to dismiss the importance of codifiable (written) knowledge and the networks that diffused them by arguing that "not a single premodern innovation was transferred by print alone" (Epstein, 2013, p. 53). It is also a bit shortsighted. Formal knowledge, be it mathematical or experimental, was largely disseminated through written or printed communications. Can we really dismiss its importance for the subsequent technological development of the Continent?

The growth of open science as the central institutional principle of the intellectual world of early modern Europe did not occur by any conscious design. It was an emergent property, the unintended consequence of a different phenomenon: scholars trying to build reputations among their peers in order to gain various advantages, including the much-hoped-for financial security, freedom, and time to do undisturbed research through patronage positions. The resulting decline in access costs was central to the way that useful knowledge affected technology and eventually productivity and economic performance (Mokyr, 2005). It also serves as a good example of how institutions were internalized and then "fed back" into cultural beliefs: open science and free access to knowledge as a social method of organizing knowledge became itself a value, something to be savored and protected. The question that it resolved was the classic dilemma of an inappropriable but valuable resource: if knowledge was regarded a public

[7] Not all members of the Republic of Letters adhered loyally to its principles of openness and transparency; the great Jesuit polymath Athanasius Kircher (1601–1680), for example, still clung to secrecy and concealed much of his evidence. He was concerned that the ancient wisdoms he thought he had unearthed should not fall into the wrong hands and should be kept from the common people (Malcolm, 2004). Such attitudes, however, increasingly fell into disrepute as the Republic of Letters matured during the seventeenth century.

good and dispensed freely, as open science demanded, how would those who created it be incentivized and rewarded? What kind of property rights could intellectual innovators secure?

What do property rights in new knowledge actually mean? As economists have long realized, the economics of useful knowledge is complex precisely because of the appropriability issues associated with all knowledge creation, which makes it practically impossible to impart it to some and exclude others. An innovator can either keep the new knowledge secret and tell know no one or can reveal it to a few, but then there is obviously the risk of losing control and experience full disclosure. The knowledge is, moreover, non-rivalrous in that by sharing it the innovator has no less of it, though he or she risks having a smaller share of the market if they try to sell a newly invented product. For propositional knowledge, in any event, the likelihood that it can be "sold" in any form is small, and so the incentive system is not well structured. One could speculate that most societies that ever existed produced less useful knowledge than they could have, simply because the rewards were not there and the risks were substantial.

It is remarkable that only Western Europe after ca. 1600 managed to create the conditions for this knowledge to accumulate at an ever more rapid pace, enough eventually to affect every aspect of production. But the solutions found were complex. Roughly speaking, the property rights in useful knowledge trifurcated into three categories. First, propositional knowledge was normally placed in the public realm, with the hope that others would recognize it and attribute it henceforth to the author and thus enhance his or her reputation. Here property rights meant credit but not the exclusion of others—on the contrary. Publication and correspondence were critical to the proper operating of the system, spread over most of the continent. Eisenstein (1979, p. 229) noted that "scribal culture ... worked against the concept of intellectual property rights" but in fact stresses that authors and their publishers did all they could to publicize themselves, to the point of writing blurbs and other forms of "the art of puffery."

Second, in contrast, those who generated new prescriptive knowledge—that is, technology—in many cases tried to earn rents by exclusion. In some areas inventions could be patented. In theory that meant that the inventor released the information in exchange for a temporary monopoly or, in some cases, a payment from some public agency. The alternative was to try to keep the knowledge secret. Secrecy could and was still attempted by Italian craft guilds in the eighteenth century (Belfanti, 2004, pp. 574–75) and by some inventors (most famously the British steelmaker Benjamin Huntsman). Secrecy only made sense when the knowledge could not be readily reverse-engineered. In intermediate cases the open-source ethics of the Republic of Letters, in which the free sharing and open distribution of useful knowledge were moral imperatives, applied to the world of

technology as well (Allen, 1983).[8] Third, in other cases, engineers and inventors whose work created novel prescriptive knowledge sought publicity, because reputations could gain them lucrative commissions. Many of the successful inventors of the age were rewarded by public recognition, academic status, patronage, and well-paying assignments and consultancies. In that sense they were entirely part of the cultural sphere of the Republic of Letters.[9] This blurring between the spheres of open science and proprietary technology reduced the monetary rewards of many inventors, but it speeded up the dissemination of new technology by applying the ideology of open science to the realm of technology.[10] Many of the great inventors of the British Industrial Revolution, including Abraham Darby (who invented coke-smelting), the innovative potter Josiah Wedgwood, and John Smeaton (the inventor of the breast wheel), largely stayed away from the patent system.

Of those three categories, the first set of incentives may be the poorest understood and yet in the long run it was decisive. To understand how and why this happened, it helps to rely on Elinor Ostrom's idea of a *community-management* of a commons resource, since knowledge shares many of the characteristics of a commons (Ostrom and Hess, 2007). Such a community was essential in creating the norms and rules that in turn generated the useful knowledge necessary for sustained economic growth, rewarding those who play by the rules and punishing those who break them. At first blush, a community of this kind may appear unlikely: as already noted, Europe was heavily fragmented politically, and managing any

[8] The English inventor Hugh Plat was knighted in 1605 in recognition of his many inventions which he placed in the public domain through such books as his *The Jewell House of Arte and Nature, Conteining divers rare and profitable Inventions, Together with Sundry new Experiments in the Art of Husbandry, Distillation, and Moulding,* (1594). The book contains a plethora of practical detailed prescriptions but also illustrates the appropriability issues involved in invention by listing "An offer of certain new inventions which the author proposes to disclose upon reasonable considerations." He also considered opening his own shop to sell the "excellent sweet oils and waters" that he had invented, implicitly recognizing an alternative way in which an inventor could be remunerated: first-movers advantage (Harkness, 2007, p. 232). None of this led to much, and he complained that "happy men are rewarded with good words, but few or none, in these days, with any real recompense" (Harkness, 2007, p. 233).

[9] An example is the Dutch engineer and alchemist Cornelis Drebbel (1572–1633), whose inventions included improved (compound) microscopes, clocks, thermostats, pumps, a tin mordant for dyeing scarlet with cochineal, and, most famously, the first submarine. Yet his career depended entirely on a sequence of royal patrons and official commissions, including the Emperor Rudolf, the English Crown Prince Henry Frederick, and the Duke of Buckingham. His older compatriot, the engineer and inventor Simon Stevin, earned many commissions and served on a variety of boards thanks to his reputation as a mathematician and engineer. Most of the engineers in the British Industrial Revolution operated in a similar way (Mokyr, 2009a, pp. 91, 409).

[10] At times, arguments from this blurry area were used by European rulers to acquire private information that they regarded as valuable to the state (Bertucci, 2013).

common resource by a public institution on more than a local scale seems to be beyond the power of any entity. Yet in the late Renaissance, an institution emerged that was able to create conditions that were conducive for sustained knowledge creation.

The community in question was known in its time as the *Respublica Literaria* or the Republic of Letters, an institution already encountered repeatedly. It has received a great deal of attention from historians (Daston, 1991; Brockliss, 2002; Darnton, 2003; Grafton, 2009a; Fumaroli, 2015), but its significance as an institution that generated and diffused useful knowledge has not been sufficiently appreciated. It was an "invisible college" of internationally connected scholars and intellectuals, based on the implicit understanding that knowledge was a nonrivalrous good to be distributed and shared by the community. The community constituted an elite group of intellectuals and scientists who circulated and checked new knowledge through an epistolary network, the printing press, and local meeting places of scholars. The tightness of the network was a testimony to its success: the citizens of the Republic of Letters were morally obliged to respond to letters. As always, the professional network had a social aspect: members of the virtual community could become true friends as well as mortal enemies. Having a lingua franca in which significant work was published was important in the early stages, but by the late seventeenth century the Republic of Letters was efficient and large enough for its citizens to publish in vernacular languages (though French to some extent replaced Latin as the new lingua franca), counting on translators, often themselves distinguished scholars, to make their work available elsewhere in Europe. Indeed, such translations served both as powerful signals as to who was an intellectual star, and as opportunities for epigones to borrow liberally from others and publish it as original work.

The historical roots of the Republic of Letters in Renaissance Europe were a mixture of admiration for the common classical heritage being rediscovered and being made accessible, and a set of traditions (real or imaginary) of an intellectual unity harking back to the classical world, the medieval church, and the *Respublica Christiana* that harked back to St. Augustine's City of God. The scholastic intellectuals of the late Middle Ages had constituted a loose transnational intellectual community under the aegis of the church. What emerged in the sixteenth and seventeenth centuries was a very different institution: originally dominated by Italians, it moved north of the Alps and was infected by Gallicans and Protestants, increasingly skeptical of many tenets that hitherto had been axiomatic. It became increasingly divorced from the "educated aristocracy of the Roman Church." Yet the idea of a mystical but coherent scholarly community working together for a common good was retained until and beyond the Enlightenment (Fumaroli, 2015, pp. 121–23).

In practical terms the Republic of Letters was both an institution supporting the operation of a marketplace and an identity. The market was

one in which persuasion was akin to a successful sale, and the payoff was an enhanced reputation. It provided an unusual institutional framework that eventually proved of crucial importance to the economic development of Europe by setting up norms and incentives that made the market for ideas work. In so doing, it motivated talented and educated men and women to explore new ideas in science, medicine, philosophy, and other fields, and placed their findings in the public domain. A more open-minded constituency helped improve incentives: "good" (by the rhetorical standards of the time) intellectual innovations had a better chance of being selected and thus rewarded.[11] The improved incentives in the market for ideas encouraged new entrants on both the extensive and the intensive margins. On the extensive margin, by creating such rewards, it sent a signal to bright young individuals that careers in natural philosophy and other intellectual pursuits could be rewarding, and thus encouraged them to make the substantial investment in human capital necessary to embark on such careers. On the intensive margin, those who did so may have increased their efforts and ventured into more innovative areas.

While the beginnings of the Republic of Letters as a major intellectual institution can be dated to the earlier days of Erasmus of Rotterdam (MacLean, 2008, p. 18; Fumaroli, 2015, pp. 45–47), it developed and progressed over time and reached full maturity in the early decades of the Enlightenment, 1680–1720 (Ultee, 1987, p. 97).[12] From the very beginning, it fully realized that intellectual property was held in common (Grafton, 2009a, p. 9). The Republic of Letters was above all a *virtual* community: it had at first no formal institutions, no annual congress, it did not publish its own periodical, and yet it managed to create and enforce a substantial number of rules that supported the emergence of open science in Europe. Unlike the other self-governing communities that form the basis of Ostrom's critique of the commons "tragedy," the Republic of Letters, then, was not a local affair and was not bound by space (Eisenstein, 1979, p. 138). Its operation by and large transcended distance by means of travel or the written or printed word. In fact, it was the opposite of local—it was a transnational network of individuals connected by letters, books, and pamphlets, punctuated by relatively rare but intense personal visits and study periods

[11] A similar view is expressed in Grafton's (2009a, p. 11) summary of the Republic of Letters: "[it] stood, in the first instance, for a kind of intellectual market—one in which values depended, in theory at least, not on a writer's rank but on the quality of his or her work."

[12] The earliest mention of the term actually goes back to 1417 (Waquet, 1989, p. 475). The same idea was expressed by other writers. In a 1517 letter, Erasmus—who could make a credible claim to be one of the founding fathers of the Republic—wrote that "as if on a given signal, splendid talents are stirring and awakening and conspiring together to revive the best learning. For what else is this but a conspiracy, when all these great scholars from different lands share out the work among themselves and set about this noble task" (quoted in Huizinga, [1924] 1984, p. 219).

at foreign universities. The institution was truly cosmopolitan, in the sense of paying little heed to boundaries or religion and mostly ignoring ascriptive characteristics, such as ethnicity or language. It was spread over much of Europe, including areas far from Paris (which is imagined by some Francophile scholars to have been the core of the Republic of Letters). Thus, for instance, the brilliant Croatian mathematician Marin Getaldić (1568– 1626) was widely known throughout Europe but he settled back in his place of birth, Dubrovnik. The Greek Theophilos Corydalleus (1563–1646), like so many ambitious scholars from the European periphery, studied at the University of Padua, taught neo-Aristotelian secular thought in the Greek communities in the Ottoman Empire, and refashioned their educational institutions along lines similar to Padua. Probably the most distinguished Polish citizen of the Republic of Letters was probably the mathematician and physician Jan Brozek (1585–1652), a great admirer of Copernicus, who studied at Padua as well and taught at Krakow University. Scholars like Jonston and Comenius worked in Poland, Hungary, and other parts of Central Europe, depending on the religious atmosphere and the presence of a patron or a commission.[13]

The market for ideas supported by the Republic of Letters was somewhat peculiar by the standards of markets. The payoff for successful efforts was enhanced reputation; the magnitude of the payoff usually had little to do with the actual economic or social value of an intellectual innovation to society except insofar as it was judged meritorious by peers, although at times the state was keen on finding a military application, as was the case with the first telescopes. As every academic knows, to be recognized by one's peers as a master is enormously desirable and this was the driving motive behind most scholarly effort in early modern Europe. While positive incentives thus became stronger, the negative incentives became weaker. Repression of innovation by entrenched interests declined in the late seventeenth and eighteenth centuries, so that the study of nature became distinctly less hazardous, even for radical innovators. Intellectual innovators were still constrained by the moral and religious conventions of the times, but these could be readily circumvented.[14] As the generation of intellectual innovations became more attractive, more people in search of fame and patronage tried their hand at suggesting new ideas. Most new ideas were rejected, and not all ideas that were accepted stood the test of

[13] The itinerant Venetian historian Giovanni Michele Bruto (1517–1592) spent years working in Transylvania and Silesia, enjoying the patronage of a number of rulers culminating with that of Rudolf II in Prague.

[14] Thus Antonie van Leeuwenhoek used his microscope to identify spermatozoa in 1677, but prudently remarked that the specimen he chose was the result of the excess bestowed on him by Nature in his conjugal relations with his wife Cornelia and was not obtained by any "sinful contrivance" (quoted in Cobb, 2006, pp. 202–3).

time, but with the selection system firmly in place, its long-term effect on technological development was assured. Other conditions were necessary for such new ideas to lead to sustained, technology-driven economic growth, above all sufficient certainty that those who successfully implemented new ideas into the production sphere would keep their profits and gain the respect of their fellow citizens.

The Republic of Letters was not entirely virtual. Some brick-and-mortar organizations helped make it work. Some of its citizens resided at universities, although the relationships were often uneasy because, as noted, most universities tended to be conservative and protective of entrenched knowledge, which limited their ability to transform elite cultural beliefs. Eisenstein points to the role of European printing houses in providing a material base for the institution. They produced periodicals and books, which provided their authors with both income and prominence. Furthermore, print shops were "international houses" where dissident foreigners could find shelter and a meeting place (Eisenstein, 1979, pp. 139, 449).

But publishers did more: they were spread all over Europe, and they rendered censorship by reactionary governments essentially impotent. In that sense they neatly complemented the mobility of intellectuals. In the Age of Enlightenment, Amsterdam became the location for presses that published books prohibited elsewhere, "the central city of the Republic of Letters" in that limited sense (Eisenstein, 1979, p. 420). The most famous French authors of the age of Enlightenment were published primarily by printers outside France. As discussed below in chapter 15, formal academies and scientific societies represented the institutionalization of the Republic of Letters, but did not play a central role until the closing decades of the seventeenth century.

Virtual or not, the Republic of Letters was the main institution behind the meteoric takeoff of useful knowledge in Europe during the Scientific Revolution and the Enlightenment. In this context institutions should be seen as a set of rules by which the economic game is played. In this case, the rules were of a game where the payoff was academic success, fame, and reputation, correlated with some material payoffs and enhanced social status. The main rules governing the Republic of Letters were freedom of entry, contestability, that is, the right to challenge any form of knowledge, transnationality, and a commitment to placing new knowledge in the public domain. This last rule is the key to what we now call open science was the ethical foundation of the Republic of Letters. Free exchange and open circulation of knowledge were the tacit rules of the self-identified "Republic"—these rules "set them morally apart from the world of trade in which information was bought and sold" (Bertucci, 2013, p. 838). On most issues in theology, philology, astronomy, medicine, and natural philosophy, the members of the Republic could differ a great deal. However, they generally agreed on the rules by which such disputes should be conducted and how they could be resolved (as a few disputes were).

The scholars who considered themselves citizens of the Republic of Letters argued not only about points of substance but also about how inquiries into natural philosophy should be conducted and what should be on the agenda. As discussed in Chapter 7, Francis Bacon's writings on the methods of scientific investigation and experimental philosophy influenced the growth of propositional knowledge in this age. His followers took his approach further and established the principles that should guide research. Robert Hooke's famous posthumous *General Scheme* insisted that the senses and intuition would never be enough to understand "Natural Operations, which are the kinds of secret and subtile Actors" (Hooke, 1705a, p. 6). He proposed a kind of "philosophical algebra" which would direct and discipline the application of reason to natural knowledge (Hooke, 1705a. p. 7). At the end of the seventeenth century it was clear what the tools of such an investigation should be: the experimental method and observation relying on scientific instruments.

Within the Republic of Letters, practitioners developed a scientific language of communication and rhetorical conventions that determined which knowledge was tight, that is, what constituted proof and which argument was persuasive. In much of the discourse, of course, this boiled down to the question of who is credible. Shapin (1994, pp. 212 ff) lists seven criteria or "maxims for the evaluation of testimony" as he calls it in the seventeenth century. Among those were plausibility (consistency with what is already known), the integrity and impartiality of the source, internal consistency, and consistency with multiple other sources reporting on the same matter. Some of Shapin's items parallel the biases in cultural evolution discussed in chapter 5.The market for ideas, to repeat, was about persuasion. Persuasion was in part about *what* new knowledge was validated and verified, but it was also in large part about *who* was trustworthy and reliable. In the market for ideas—as in so many markets—what counted was not only the nature of the commodity transacted but also the character of the seller.

Beyond trust, however, there were new methods and standards for research and new criteria for rigor and reliability. The most important of these were the ever-growing use of mathematics where it was applicable (astronomy and mechanics), the validity of experimental data in those fields where experiments were possible, and the collection and careful taxonomy of empirical observations where neither of these approaches worked (e.g., in botany and entomology). Experimental work was also bound by rules: unbiased inference from data, replicability, accuracy in measurement and purity of materials wherever possible, reliance on credible witnesses observing the procedure; clear and transparent delineation of procedures used, and publication of results. None of those conventions were quite new at this time, but they became more central to the enterprise and increasingly overrode other considerations, such as consistency with ancient authorities, aesthetics, or metaphysical or moral concerns. The concept of an experiment

as a means of resolving disputes became particularly popular following its advocacy by Bacon. His influence was especially strong among the early members of the Royal Society, whose views were summarized by Bishop Sprat who wrote at length about the many real and imaginary virtues of experimental research (Sprat, 1667, pp. 403–30).[15] Nonetheless, given the cost and difficulty of replicating experimental work, dispute resolution inevitably retained elements of trust and social status (Shapin and Schaffer, 1985).

The Republic of Letters, and the network it created among natural philosophers, is a good example of the efficacy of networks of weak ties to use Granovetter's (1973, 1983) well-known concept. Unlike strong ties, such as families and small communities, the connections among members of the virtual community were not transitive, and the information that members could exchange did not necessarily overlap much. New information and ideas are more efficiently diffused through weak ties than through strong ones because the latter are more likely to provide redundant information. Individuals who are strongly tied are more likely to share the same sources of information and to otherwise be similar to one another. In contrast, weak ties when they are "bridges" (that is, single connections that have no substitutes), are more likely to be the avenue by which new information is introduced to an individual. Hence, more weak ties imply a more effective network for information dissemination.

Precisely because the members of the Republic of Letters often did not know one another very well, it was a highly effective community in which innovation could occur, circulate, and be evaluated. Weak ties provided bridges *between* local communities within which individuals had stronger ties, like universities and local academies (Granovetter, 1983). The main disadvantage of weak-ties networks is that the levels of trust between members may be lower than those in strong-ties network, in which interactions are much more frequent between two individuals. Even when trust is relatively low, weak ties provide more useful knowledge because of their enhanced ability to provide non-redundant information (Levin and Cross, 2004, p. 1480). The concept of ties here modifies the importance of trust, which is widely regarded as an indispensable part of the division of labor, without which no collective scientific endeavor can exist. Direct bias—accepting a new idea on the basis of authority—requires trust. At the same time, however, the emergence of new useful knowledge in the Republic of Letters depended on skepticism, on the contestability of all authority. The

[15] Galileo placed experimental research as an inevitable middle road between a "basement level" of everyday reality observations that were too messy and an "upper level" of idealized reality that was too abstract (Cohen, 2012, p. 196). Robert Hooke made a different point: human observation was limited by the five senses; experimentation provided a sixth and more powerful sense (Cohen, 2012, p. 558).

dilemma is well formulated by Shapin (1994, p. 17): "the distrust, which social theorists have identified as the most potent way of dissolving social order is said to be the most potent means of constructing our knowledge." The key words that defined much of the new thinking in early modern Europe were *doubt* and *skepticism*—about the classics, about the structure of the universe, about the physical and biological environment, eventually even about the immortality of the soul.

In fact the citizens of the Republic of Letters were quite alert to the issue of trust, and such experimentalists as Robert Boyle made supreme efforts to make sure that his social prestige was behind his experimental work, which in that age would be associated with some level of trust associated with gentlemanly "honor" (Shapin and Schaffer, 1985; Shapin, 1994, pp. 185–92). Those who did not have the elevated social standing of a Boyle sought legitimization through the formal sponsorship of high-status patrons to generate some level of trust (Biagioli, 1990). But to introduce a new idea successfully into the market for ideas at this time, obiter dictum was rarely enough; some level of evidence or logic to back up assertions was expected if a "sale" was to take place, that is, if persuasion was to be successful. It is this kind of network that produces the highest chances of innovation in codifiable knowledge that could be readily vetted and verified. By contrast, strong ties in coherent and localized groups may have been preferable in the dissemination of tacit and practical knowledge, such as artisanal skills that were exchanged through apprenticeships and personal contacts (Epstein, 2013).

In a world of codifiable (and codified) intellectual innovations, communicated by letters or printed in books and pamphlets, it was skepticism and not trust that provided an engine of creativity. Of course, knowledge expansion still required some level of trust, since it would be unthinkable for every researcher to start from scratch and verify personally every component of a new theory. But, as Shapin (1994, pp. 19–21) notes, skepticism takes place on the margins of trusting systems and, odd as it may sound, skepticism and trust were complementary in the generation of new knowledge—a variant of Ronald Reagan's famous use of the Russian proverb "trust but verify." It is on these margins that progress occurs, and these margins were mostly found in the codified knowledge that circulated in the Republic of Letters.

It is too easy to dismiss the importance of formal and codified knowledge in technological progress at this time, as Epstein (2013, p. 67) does. Such dismissals fail to recognize that major conceptual breakthroughs are required if artisanal tinkering and local improvement are not to run into diminishing returns. The argument that formal, codified knowledge depends on skepticism while tacit knowledge depends on trust is too oversimplified and schematic. Experimental knowledge always had a tacit component, and no description of what we would call today "materials and methods" could ever be complete. As Dasgupta and David note (1994, p. 495), the

complementarity between tacit and codified knowledge is critical to the way knowledge is created and disseminated.

The networks of people who rarely or never met one another turned out, paradoxically, to create a unity of purpose and method in a community that was overlaid on a highly fragmented world. At least in principle, the nationality, religion, and social origins of a scholar were irrelevant to the assessment of his or her scholarly contribution. In practice, this was an age in which these things mattered a great deal, and they mattered more than most citizens of the Republic of Letters would have liked to admit.[16] The Republic of Letters was a transnational institution, but one that had to exist in a political reality. Many of those defending Newton in his priority dispute with Leibniz did so out of national loyalty, although referring to a kind of "philosophical jingoism" in the early eighteenth century (Shank, 2008, p. 181) seems excessive. Whether the sciences "were never at war" as Edward Jenner famously remarked may still be an open question. The ideals of the Republic Letters, in which Diderot could tell Hume that the latter "belonged to all nations" and would never be asked for his birth certificate (Gay, 1966, p. 13), did not always mesh with the reality on the ground. The eighteenth century after all was not just the age of Enlightenment, it was also an age of mercantilism, and the information made available freely in the Republic of Letters was often gathered to serve the interests of the state—as Bacon had advocated. But if enlightened cosmopolitanism could not altogether suppress nationalism in an age of mercantilist ideals, the members of the Republic of Letters argued that the reputation and glory of a country would be enhanced if foreign scholars celebrated the achievements of its scholars (Daston, 1991, pp. 378–79). Despite the many claims of the citizens of the Republic of Letters about the utility of their learning and intellectual innovations, before 1700 it is quite hard to point to many breakthroughs resulting from the work that natural philosophers did that dramatically changed a technological practice. It is arguable that the very fact that so little of the science had many significant useful applications that really mattered made open science possible; had it had more consequential implications for those techniques that states considered vital, rulers may have tried to limit the free exchange of knowledge across national boundaries and imposed secrecy on some findings—precisely as Bacon had advocated. Whether such secrecy would have been successful in the long run is questionable, but it may have weakened the transnational nature of the Republic of Letters.

[16] Many Frenchmen remained loyal to Cartesian physics simply because Descartes was French, and British science at times showed signs of Francophobia. Yet at least in theory a citizen of the Republic of Letters was supposed to be a person without a fatherland, or as a 1779 issue of the *Histoire de la République des Letters et Arts en France* put it, he was "a kind of orphan, to whom fortune denies those distinctions for which nature intends them" (quoted in Daston, 1990, p. 97).

The citizens of the Republic of Letters were almost by definition highly educated, and with few exceptions literate both in Latin and their own languages. A large proportion of the membership consisted of people trained in and practicing medicine and law, though of course many of them had a wide range of knowledge and interests. While most of them were still quite religious (including many eminent Puritans in seventeenth-century England), members were open minded, eschewed rigid dogmatism, and accepted (if sometimes reluctantly) the discipline of evidence and logic. Ancient authorities in physics, astronomy, medicine, and other areas were still read with polite respect and paid lip service to, but clearly the community's fundamental premise was that it was acceptable to question anything said by the ancients and overturn their findings if the evidence called for it. It was acknowledged that ancient authorities were wrong on many matters.[17] For communications, the citizens depended on the publication of books, newsletters, periodicals, and pamphlets, and an ever-increasing set of epistolary and personal networks (Collins, 1998). Indeed, correspondence was at the very heart of the modus operandi of the Republic of Letters (Ultee, 1987). Special nodal figures whose responsibility it was to copy letters and send them on to other members were known as "intelligencers."[18] Correspondence clearinghouses or "offices of addresses" were set up, in which private communications were further disseminated.[19] In the century following, periodicals increasingly supplemented epistolary networks. More than a century later, François Rozier (1734–1793), publisher of the *Observations sur la Physique, sur l'Histoire Naturelle, et sur les Arts* (widely

[17] A typical way of dealing with the ancients by scholars of this period was to assert that if the ancients only knew what they know now, they would have agreed with them. For instance, William Gilbert in the preface to *De Magnete* states that "To those men of early times, Aristotle, Theophrastus, Ptolemy, Hippocrates, and Galen, be due honour ever rendered : for from them knowledge has descended to those who came after them but our age has discovered and brought to light very many things which they too, were they among the living, would cheerfully adopt" (Gilbert, [1600] 1893, p. li).

[18] Examples of nodal figures in these epistolary networks are Samuel Hartlib (1600–1662) and Marin Mersenne (1588–1648), both of whom maintained extensive correspondences with the major intellectuals of their age (Webster, 1970, p. 8; Webster, [1975], 2002, pp. 67–77 and passim; Collins, 1998, p. 528). One recent author has remarked that "writing a letter to Mersenne was akin to publishing an article in a scientific journal" (Van Berkel, 2013, p. 59). Another compulsive letter-writer was Peiresc, whose fame and reputation were largely based on his correspondence, both local and long-distance, with scholars as well as merchants and travelers (Miller, 2015, pp. 54–59).

[19] These clearinghouses often served as exchanges, where employers could find employees, but in other cases they just traded information. One of the first was associated with the French physician Théophraste Renaudot (1586–1653), which was emulated in England by the irrepressible Hartlib, whose office of addresses purported to act as a "Center and Meeting-place of Advices, of Proposalls, of Treaties and of all Manner of Intellectual Rarities" (Webster, 1970, pp. 44–47; Jacob, 2006, p. 48).

regarded as the first independent periodical to be concerned wholly with advances in cutting-edge science), assured the American Philosophical Society that "all of Europe will be informed in less than three months" if they sent the new information first to him and that such correspondence would be "indispensable for the progress of science" (quoted in McClellan, 1979, p. 444).

Eisenstein and others have stressed the importance of the invention of the printing press to the evolution of the Republic of Letters, although Fumaroli (2015, pp. 24, 37) points out that the first use of the term, by the Venetian politician and humanist intellectual Francesco Barbaro, predates the first press by at least three decades. Much less discussed than printing but of great importance in the operation of the Republic of Letters was the improvement in the continent-wide flow of mail. It is this innovation that maintained communication among the leaders of Europe's science and technology, and allowed them to establish the kind of interconnectivity that was at the heart of the dissemination of knowledge. The improvement of the postal system took place thanks to the organizational abilities of de Tasso family, led by Francisco de Tasso (later known as Franz von Taxis) and his brothers who established regular postal services in Italy, Germany, and the Habsburg lands in the early sixteenth century. Their postal system covered much of the Continent by the middle of the sixteenth century and created one of the most durable business dynasties in history. A French system was established in 1603, when King Henri IV allowed royal couriers to accept and distribute postal material from the general public and a few years later appointed his first postmaster general. The emergence of a European continent-wide postal service was a by-product of the growing need for communications in the multinational Habsburg Empire under Emperor Charles V and other increasingly bureaucratic nation-states, as well as the needs for long-distance communication of international religious organizations, such as the Jesuit order. Above all, however, it was the growing needs of commerce and finance for information and communications as it increasingly dealt with long-distance trade, both inter- and intracontinental.[20] The infrastructure on which the Republic of Letters rested was thus an

[20] Postal rates remained quite high, in part because they were a convenient revenue-raising device for the state. As Margóczy (2014a, p. 33) remarks, "the price of mail could break friendships and scholarly networks." All the same, there is no question that by the early eighteenth century the cost was sufficiently low to sustain dense epistolary networks. The establishment of the famous London penny post in 1683 and its gradual extension in the eighteenth century meant that by 1764 most of England and Wales received mail daily (Headrick, 2000, p. 187). Postal rates depended, in part, on the cost of internal transportation, and as roads were improved, canals dug, and carriages made faster and reliable, the effectiveness of internal communications increased greatly in the age of Enlightenment.

unintended by-product of other historical phenomena.[21] In that sense cultural change may be seen as being driven by the material world, but in a far more contingent and roundabout way than historical materialism would have us believe.

Thus, the epistolary network, as it developed after 1500, was an essential part of the Republic of Letters. To be a member of the intellectual community of the Republic of Letters was to be connected with others. As Paul Dibon (1978, p. 46) has noted, "it was the strict duty of each citizen of the *Respublica Literaria* to establish, maintain, and encourage communication, primarily by personal correspondence or contact." In the 1660s, the first formal organizations embodying the ideals of the community were established. The English Royal Society was a bottom-up voluntary organization growing out of the "invisible academy" of Baconians that had formed after the death of Bacon, whereas the French Royal Academy was a top-down government initiative by J-B Colbert.[22] In between formal and officially sponsored organizations and the completely virtual epistolary networks there were the many semiformal manifestations of literary clubs such as the *societé amusante* of Berlin, which met every Wednesday at the home of one of its members "with the goal of instructing and diverting themselves at the same time" (Goldgar, 1995, p. 2). These organizations constituted the formal part of "public science" that could also be found in coffeehouses, taverns, and other informal local venues (Stewart, 1992).[23] These institutions soon started to publish scientific periodicals, such as the *Journal des Scavants* and the *Transactions of the Royal Society*, both of which began appearing in 1665 (though neither was at first wholly dedicated to scientific and technological topics). These periodicals became a substitute for printed books and personal correspondence, and they created what we call today the scientific paper (McClellan, 1979, p. 425).[24]

While there were differences in local institutions and styles, the common denominator of most citizens of the Republic of Letters was their education, their commitment to what they believed was the growth and free

[21] The commercial postal network was supplemented by a variety of private networks such as publishers, booksellers, merchants, diplomats, and religious connections.

[22] The famous diarist, horticulturist, and Royal Society charter member John Evelyn's (1620–1706) highest praise for the organization was that "Never had the *Republique of Letters* so learned and universal a correspondence as has been procured by this *Society* alone" (Evelyn [1664], 1679, unpaginated preface).

[23] John Houghton (1645–1705), a pharmacist and early writer in the best of the traditions of the Industrial Enlightenment, wrote in 1699 "coffee-houses improve arts, merchandize, and all other knowledge; for here an inquisitive man, that aims at good learning, may get more in an evening than he shall by books in a month" (cited by Cowan, 2005, p. 99).

[24] For more details on the growth of scientific periodicals in the age of Enlightenment, see Mokyr (2005).

dissemination of knowledge, and their Baconian belief that this knowledge may in the end be of service to humankind as a whole. It should be added that the social status of intellectuals was rising during this period. Men (and a few women) of letters increasingly found themselves rising in the esteem of their society, invited to fine salons, and expected to dress well and behave according to the manners and etiquette prescribed by the culture of the elite.[25] To be sure, there was also an intellectual underworld of Grub Street hacks immortalized by Robert Darnton, but its impact —outside that of spiced-up literature—was probably minor.

Within the community, the ideals of openness, contestability, and competition were increasingly prominent. A central pillar shared by the citizens of the Republic was their antidoctrinaire bent. From the earliest stages of the Republic of Letters, its citizens realized that their community was not at peace, but was "an army fighting against formidable and numerous bitter enemies" who wanted to silence the enlightened armies of the Republic. Erasmus himself spoke of "armed citizens" in a figurative sense (Fumaroli, 2015, p. 47). One central issue was what the age of Galileo called *libertas philosophendi.* The freedom to philosophize was an ancient concept revived in Renaissance Europe by the humanist scholar Marsilio Ficino (1433–1499) (MacLean, 2006, pp. 264–65), but it was accepted as a central tenet of the Republic of Letters by its giants, above all Giordano Bruno, Galileo, Campanella, Descartes, and Spinoza (the latter included the term in the subtitle of his *Tractatus*) (Sutton, 1953). They knew full well that they lived in a dangerous world, in which this freedom was not guaranteed.[26] As Stewart (1994, p. 42) points out, the concept of the freedom to philosophize is not quite the same as the modern concept of academic freedom, because it was part of an attempt to preserve disciplinary boundaries.[27] Instead we should see the concept above all as a statement of freedom from dogmatic

[25] In this regard, the Republic of Letters is a good example of what Deirdre McCloskey (2010) has called "Bourgeois Dignity"—the growing value that society placed on features that might be of general utility.

[26] Copernicus's student and the editor of *De Revolutionibus,* Georg Joachim Rheticus (1514–1574), had thought it appropriate to cite as an epigraph the dictum of the ancient Platonist Alcinous: "He that would be a philosopher must be of a free (unenslaved) mind" (Stewart, 1994, pp. 34–35). Rheticus himself prudently never published his exposition of Copernicanism titled *Epistolae de Terrae Motu,* an attempt to reconcile heliocentrism with the scriptures (published posthumously in 1651).

[27] The issue came up explicitly in the nasty dispute between Descartes and the Dutch Calvinist professors of theology. The Synod of South Holland eventually took action, imposing the resolution that "there should be no infringement on the freedom to philosophize, but ... this freedom was not to be abused" (Stewart, 1994, p. 41).

thought within the limits of each discipline; stepping outside these borders, as Descartes was accused of doing, could still imply serious penalties.[28]

The Republic of Letters was based on the shared faith that the freedom to philosophize was a foundation of their calling for expanded knowledge, both useful and metaphysical. Research, it was felt, should proceed wherever natural philosophers wanted it to go, and if the evidence ended up contradicting some venerable authority, the view of that authority should be discarded (for classical sources) or reinterpreted (for scripture). It is sometimes believed that "the rebellion against authority" and the "tradition of criticism" were specific to the Enlightenment (for example, Deutsch, 2011, pp. 12–13). While they were central to Enlightenment philosophy, the foundational beliefs of the Enlightenment themselves were born from rebellion and criticism and established in the two centuries before 1700. Knowledge, it was increasingly believed, was never final and always should be further corrected and extended. The experimental method, wrote Bishop Sprat (1667, p. 429) "teaches men humility and acquaints them with their own errors and so removes all overweening haughtiness of mind." As early as the late sixteenth century, Simon Stevin explained that the main reason he published his *Mémoirs Mathématiques* was so that "his errors [could] be corrected and other inventions added" (quoted in Rossi, 1970, p. 72). Some of its most influential leaders, such as Peiresc, called for respect and temperance in scholarly dispute (Miller, 2000, p. 43), a call that was not always heeded.

By the late seventeenth century, the Republic of Letters had come into its own as the institutional underpinning of a competitive market for ideas, in which different schools competed with one another for the minds of the intellectual elite. Bayle wrote in a famous essay that "this commonwealth is a State extremely Free. The Empire of Truth is only acknowledged in it; and under their protection an innocent war is waged against anyone whatever. Friends ought to be on their Guard against friends, Fathers against their children" (Bayle, [1696–1697] 1734, vol. II, p. 389, essay on *Catius*).[29] The Dutch mathematician and physicist Nicolaas Hartsoeker (1656–1725), a rather typical if pugnacious citizen of the Republic of

[28] The freedom to express ideas without any constraints was a guiding principle of the French intellectuals who organized in the early seventeenth century in the so-called Cabinet of the Dupuy brothers, an informal French academy established in Paris following the will of Jacques August de Thou (1553–1617), a noted historian and great patron of French learning, and himself one of the most respected citizens of the Republic of Letters of his age. It seems that the idea of this freedom ripened during the bloody French religious wars, which senselessly set the French against one another (Delatour, 2005a, p. 289).

[29] William Wotton, a late seventeenth-century intellectual and a great admirer of the new science as practiced in the Republic of Letters, noted pointedly that in the "Modern Methods of philosophizing as compared with the Ancient ... Des Cartes is not more believed upon his own word than is Aristotle; Matter of Fact is the only thing appealed to" (Wotton, 1694, p. 300).

Letters, wrote many essays attacking sacred cows in his life (among them Newton, Leibniz, and Jacob Bernoulli) and was unrepentant: "I very humbly beg of all whose opinions I have attacked, perhaps with too much liberty, not to take it in a bad way, since I have most often done this only to invite them to do the same to mine ... this philosophical war will likely cost a bit of ink but there will be no spilling of blood" (quoted in Feingold, 2010, p. 183). As a sixteen-year-old he had been taught by no less a figure than Leeuwenhoek himself about microscopes, but in his later work he did not hesitate to criticize and even ridicule the old man. Notwithstanding (and perhaps because of) his disputatious reputation, he was offered a number of patronage positions, including one by Czar Peter the Great (which he declined).

Voltaire, looking back at the history of the Republic of Letters in 1753 reflected that "During the Age of Louis XIV, a Republic of Letters was established, almost unnoticed, despite the wars and despite the difference in religions ... all the sciences and arts received mutual assistance this way. ... True scholars in each field drew closer the bonds of this great society of minds, spread everywhere and everywhere independent ... this institution is still with us, and is one of the great consolations for the evils that ambition and politics have spread through the earth" (Voltaire, [1751] 1785, vol. 21, p. 287).

The Republic of Letters was predominantly male, although at times women did play important roles.[30] The invisible college that emerged in the late seventeenth century in full bloom was successful precisely because it was relatively small. Cooperative behavior was encouraged, and defectors could be recognized and punished. This kind of equilibrium was more likely to emerge if the "game" is played over and over again, if the participants shared an "ethos" of cooperation and knew that others do, and if the numbers remained small enough so that opportunistic behavior could and would be detected and punished. These conditions obtained in the Republic of Letters far more than anywhere else. As David (2008, p. 77) notes, "the norm of cooperative disclosure provided the basis for repeated, reciprocal information transactions that on balance would be conducive to further enhancing the members' reputation." For those reasons, membership in the Republic of Letters was limited and not costless. The norms it set implied that one was expected to reply to letters, to disclose findings and data truthfully, and to acknowledge intellectual debts. The markets for ideas was an arena of both competition and cooperation: the suppliers and the buyers both competed with one another and competition often led to conflict.

[30] This matter is still in some dispute. For a useful summary, see Melton (2001, pp. 209–11). In some of the locations were the Republic of Letters was actually organized in concrete locations, such as the French *salons*, women played a pivotal role; elsewhere, such as in English coffeehouses, they were excluded.

Indeed, the marketplace for ideas at the time was often riven by bitter disputes, rivalries, and jealousies, a cutthroat nasty world of selfish individuals, jockeying for positions, patronage, and reputations—something that a modern academic might not regard as very alien. At the same time, its participants shared a set of underlying assumptions and had to cooperate and trust one another. There is no contradiction between the coexistence of such harmonious and competitive forces, as an analysis of any market demonstrates. Economists have understood since Adam Smith that the glory of the market system is this unique combination.

In principle, the Republic of Letters fancied itself to be egalitarian, although this was of course not always the case in practice. Yet its hierarchy was ordered quite differently from that of the rest of society: neither ancestry nor wealth were supposed to count for much. Merit, originality, achievement, and erudition determined one's place in the hierarchy and were always formally contestable. The community dealt on more or less equal footing with the very rich and aristocratic Robert Boyle and his assistant, the impecunious parvenu Robert Hooke, as well as members of the *haute bourgeois* intelligentsia such as Christiaan Huygens and René Descartes.[31] To be sure, the wealthy and socially prominent French intellectual, astronomer, and classical scholar Nicolas Claude Fabri de Peiresc (1580–1637) has been called "the prince of the Republic of Letters," but clearly this distinction was related to his intellectual power and widespread personal and correspondence networks. Of his correspondence, about 10,000 letters survive.[32] It has been argued that the lack of hierarchical organization was effective, because in scientific and technological endeavors the tasks normally delegated in a hierarchical structure "are better left undelegated" (Rosenberg and Birdzell, 1986, p. 255). The more important elements, however, were that the lack of hierarchy guaranteed contestability and that the internal pecking order of science, which was the closest that the institutional setup in Europe came

[31] Habermas (1989, p. 33) notes that in the Paris salons the nobility and the grande bourgeoisie met with intellectuals on "an equal footing" and that the sons of watchmakers and shopkeepers associated with princes and counts.

[32] Pierre Bayle, another pivot of the international intellectual community half a century after Peiresc summarized the latter's contribution as "no man ever rendered more services to the Republic of Letters than him" (Bayle, [1696–1697] 1740, pp. 638–39). Fumaroli (2015, pp. 60–61) sees in him a "figurehead" of the Republic of Letters, someone who facilitated and encouraged the work of others but produced little of lasting value himself. Miller (2000, p. 4) sees in Peiresc's celebrity status in his own lifetime the kind of activity and skills that other members of the Republic of Letters found worth celebrating. Many European intellectuals, many of them now obscure, were similar. Truly original minds were complemented and supported by other network members, who shared and distributed their knowledge and helped making access to it easier and faster. Peiresc shared and distributed knowledge and interests with his contemporaries, but he was far from unique. As Grafton notes, Europe's Republic of Letters was teeming with such intellectuals and it was their work that constituted the fabric of the Republic of Letters (Grafton, 2015, p. 65).

to a hierarchy, provided incentives for ambitious practitioners to do their best. Being a scientific superstar, then as now, was enormously desirable.

The ethos of the Republic of Letters conformed in many ways to Robert K. Merton's famous characterization of the ethos of science.[33] The most important operational rule of the community was that new knowledge should be placed in the public realm when it was generated. If one of the important characteristics of good institutions is that they define and enforce property rights, priority rights were the equivalent of ownership for intellectual innovations. The creator would earn a property right as the rightful discoverer of some natural regularity or phenomenon, or the originator of a new idea, but such priority rights did not include the right to exclude others from using it. Instead, the originator was credited by other members of the community as the original innovator. A successful intellectual innovator would have her or his name associated with the new idea so that the idea and its progenitor become a dyad as "Boyle's Law" or a "Poisson process," and thus while the progenitor does not own the new idea (in the sense of excluding others), he or she is credited with it and may therefore gain in terms of reputation. At some stage, the process became more sophisticated. In the second half of the seventeenth century procedures emerged that allowed a scientist to establish priority even before publication by depositing a paper in a sealed envelope or a device with the secretary of a learned society (Pancaldi, 2003). Credit without direct profit became the rule for intellectual property rights in the Republic of Letters—the profit had to come indirectly, from the reputation effect. Pascal was quite explicit in establishing clear and well-defined property rights in new ideas. In his *Expériences Nouvelles*, published in 1647, he noted that he owned experiences "that were proper to me" (quoted in Dear, 1995, p. 186) yet responded with horror when someone suggested that he passed on Torricelli's finding as his own (Wootton, 2015, p. 101).

For intellectual innovation to be an effective force for cultural change among the literate elite, diffusion mechanisms were crucial. It is indeed worth keeping in mind that right below the intellectual superstars such as Bacon, Spinoza, and Newton, the market for ideas depended on learned polymaths such as Browne, Campanella, Hartlib, and Peiresc, who transmitted and tweaked the products of the great minds. Less prominent intellectuals, many of them now obscure, supported this endeavor. Truly original minds were complemented and supported by other network members, who shared and distributed their knowledge, making access to it easier and faster. As Grafton notes, Europe's Republic of Letters was teeming with

[33] Merton (1973) notes four basic characteristics: universalism (knowledge is not specific to a single group); communism (the knowledge is shared by placing it in the public domain and it thus becomes a "commons problem"); disinterestedness (researchers and philosophers search for a truth, to be policed and verified by their peers); and organized skepticism (the unwillingness of those in search of knowledge to be constrained by preconceptions).

such intellectuals and it was their work that constituted the fabric of the Republic of Letters (Grafton, 2015, p. 65).

Although the idea of open science explicitly eschewed the notion of excludability and secrecy in the intellectual marketplace, the implicit notion of "credit without profit" did not exclude notions of intellectual property rights. There was growing recognition that new ideas and the reputation that came with them were assets and that the sanctity of property rights applied to them. Queen Anne's Law (1710) established a rather rudimentary form of copyright in Britain, and similar arrangements emerged elsewhere in the eighteenth century. The patent system was a very different idea, since it explicitly excluded others from using the new knowledge without permission, though the knowledge itself was placed in the public domain. In the realm of propositional knowledge, however, in principle priority established some kind of one-to-one relationship between the idea and its originator.

This system did not work perfectly, as the many priority disputes between scientists attest.[34] It is significant that the person who received credit for an idea was not always the person who was historically the first to discover or enunciate it, but was often the one who managed to sell it most effectively in the market for ideas.[35] But as a means of simultaneously ensuring the openness of science and intellectual discourse, and as a means of ensuring adequate incentives to creative and original minds to generate intellectual innovations, it was a resounding success (Dasgupta and David, 1994, pp. 499–500). If the Republic of Letters was the institution that made the market for ideas work, it is important to realize how it enforced these rules, as it had little coercive power and no formal structure. One answer in institutional analysis is that legitimacy—a shared set of beliefs—reduces enforcement costs for any institution. It is this growing legitimacy of the Republic of Letters that made it successful in imposing its rules. These rules, as noted, included contestability, transnationality, independence from authority, and openness.

The incentive structure that drove the market for ideas depended on reputations and the Republic of Letters set the criteria by which repu-

[34] The earliest priority fights are found in the sixteenth century, such as that between the astronomers Tycho Brahe and Nicolaus Reimers ("Ursus") Baer. Of the many others, the dispute between Leibniz and Newton over the invention of differential calculus is the most famous, but that between Newton and Hooke over optics and between Hooke and Huygens over the invention of the spiral-spring balance in watches are well documented. Equally nasty, if more obscure, is the fight between two Dutch scientists, Jan Swammerdam and Reinier de Graaf, over the discovery of a technique to study female reproductive organs ca.1665. According to an unsubstantiated account, De Graaf died as a result of the exhaustion caused by the priority dispute.

[35] This was pointed out by Stephen Stigler, and is known as "Stigler's Law." Appropriately enough, Stigler has attributed its original discovery to Robert K. Merton. See Stigler (1999, pp. 277–90).

tations were established. Reputations required openness. Besides the obvious importance of establishing a reputation, openness was in part driven by an ideology regarding the moral duties of scientists in their societies. As Descartes noted, "I believed that I could not keep them [my notions concerning physics] concealed without greatly sinning against the law which obliges us to procure... the general good of mankind. For they caused me to see that it is possible to attain knowledge which is very useful in life... and thus render ourselves the master and possessor of nature" (Descartes, [1641] 2005, p. 50). But an economist tends to suspect that besides morality and ideology, there may also have been material or other selfish motives.[36]

As Richard Westfall (1985), Roger Hahn (1990), and Paul David (2004, 2008) have pointed out, the incentives that drove this system were part of a reputation game that had patronage jobs as its payoffs (although in some cases publishing a successful book could be remunerative). Peer assessment was especially important because unlike artistic and literary genius, the real quality of scholarship and original ideas was hard to establish for outsiders with fat purses.[37] The members of the Republic of Letters thus set up mechanisms that sent out signals about the quality of their peers (David, 2008). Reputations were based on achievement and merit, measured by the quality and originality of the scholarship. With some exaggeration, Hahn (1990, p. 11) states that the "invention of the merit yardstick" as a measure of intellectual worth was a radical innovation. Moreover, merit was global, not local, and was judged by a transnational community in which social connections counted for relatively little.[38] As such it amplified the incentives: a global reputation clearly provided advantages

[36] It is telling that even such a wealthy scientist as Robert Boyle eventually became annoyed by people using his work without attribution and instructed Henry Oldenburg to produce a catalog of his writings to secure his intellectual property rights in this research (Shapin, 1994, p. 183; Hunter, 2009, p. 190). At the same time, however, he remained very generous with awarding credit where it was due—as befitted a gentleman. In Boyle (1682, preface) he gives ample credit to his assistant, the French Huguenot refugee and itinerant experimental philosopher Denis Papin, the first to construct a workable model of an atmospheric engine.

[37] Dasgupta and David (1994) and David (2008) make the important point that in many areas of natural philosophy and mathematics, it was impossible for the outsiders who mattered—potential patrons—to evaluate the work themselves, and so reputation *within* the community of scholars determined the reputation one enjoyed vis-à-vis the outside world. In that regard, the Republic of Letters differed from, say, the kind of patronage awarded to painters and musicians, whose work the patrons mostly judged themselves.

[38] Daston puts it well: "the avowed foundation of the ... diffuse and often quarrelsome Republic of Letters ... was *merit* ... and many Enlightenment intellectuals came to believe that foreigners were more trustworthy judges of merit than compatriots" (Daston, 1991, p. 379, emphasis added and slightly rearranged).

in bargaining power for anyone who acquired one.[39] It bears repeating that such reputations required the creation of original knowledge, not just erudition and the interpretation of existing texts.

Princes and kings competed to provide patronage and protection to the most successful and best-known artists and scientists. They bid high for the services of such superstars as the painter Anthonie van Dyck, the composer Jean-Baptiste Lully, and the astronomer Tycho Brahe in a competition for being able to attract the most glorious and talented of Europe's citizens. Prestige, vanity, and a need to demonstrate the ruler's wealth and power in a highly competitive world were motives that drove dukes and kings to try to attract the best and the brightest. It was common for rulers to employ gifted and mathematically trained people in a variety of technical advisory positions. Princes needed mathematicians, architects, map-makers, engineers, and experts in ballistics, fortifications, and metallurgy.[40] The age of mercantilism expected trained mathematicians and engineers to help improve navigation, ship-design, and the technical aspects of warfare. Princes and nobles also often provided patronage to their personal physicians who could use the position to engage in scientific writing. An example is the astronomer and physician Jean Fernel (1497–1558) who served as the king's personal physician at the court of Henry II. In the sixteenth century, the great naturalist Conrad Gesner (1516–1565), referred to as "the Swiss Pliny," made his living by becoming chief physician of Zurich, as well as professor at the local Carolinum University. The French physician and polymath Pierre Michon Bourdelot (1610–1685) served as the personal physician of Queen Christina of Sweden and later became both the personal physician and protegé of the rich and powerful French general the Prince de Condé. Francesco Redi served as the court physician of the

[39] Jan Jonston, the Polish physician, who enjoyed the patronage of a Polish prince, built a reputation sufficient to generate offers of professorships at a number of Dutch and German universities (which he declined). To build up that reputation, he published textbooks on medicine and natural history, as well as (tellingly enough) a guidebook for the tutors of the children of noble patrons (Margóczy, 2014b). Or consider the case of the distinguished Florentine mathematician Vincenzo Viviani (1622–1703), the aging Galileo's student and protegé. In 1666 his reputation was such that he was offered lucrative positions by both Louis XIV and John II Casimir of Poland, whereupon Grand Duke Ferdinand de Medici made him a counteroffer and appointed him court mathematician.

[40] Galileo, while working in Padua, freelanced for the Venetian arsenal and invented his famous geometric and military compass (used for gunnery) as well as other militarily useful devices. Similarly, Giovanni Domenico Cassini, one of the most eminent astronomers of the second half of the seventeenth century, while professor of astronomy at Bologna in the 1650s, was employed by Pope Alexander VII to investigate the hydraulics of the Po river and the means to avoid flooding, as well as to consult on military matters (he was appointed superintendent of fortifications in Perugia). Prince Maurice of Nassau retained the services of the engineer Simon Stevin, who tutored him in mathematics, served as his quartermaster general, and revamped the prince's finances using new methods of bookkeeping.

Medicis in Florence, as well as secretary and supervisor of their pharmacy and foundry.

Another kind of learning in demand by courts concerned geography, driven by patriotic and colonial motives by some princes. The young British Crown Prince Henry Frederick, prince of Wales, who died in 1612 at age nineteen, assembled an impressive collection of geographers around him, motivated by a "burgeoning patriotism" (Cormack, 1991, p. 81). But in addition to those direct services, patronage involved image and reputation. The concept of "the wise prince," combining learning with power, was laid out by Machiavelli, projecting the image of a Platonic philosopher-king, and thus providing legitimacy for many local Italian rulers in Florence, Milan, and Mantua, many of whom were little more than warlords (Eamon, 1991, p. 33). German princes likewise were involved in practical matters or scientific pursuits (Moran, 1991b, p. 169). Newton was made warden and later master of the English mint in London and conducted a merciless campaign against counterfeiters. The eighteenth-century German physicist and mathematician Franz Aepinus (1724–1802), who enjoyed the patronage of the Czarina Catherine the Great, was appointed head of her cryptographic services. John T. Desaguliers enjoyed the patronage of the Duke of Chandos, whom he advised on a variety of technical projects. At the same time he was engaged by Queen Caroline (King George II's spouse), who had deep scientific interests to instruct her on a variety of scientific subjects.[41]

Patronage provided more than material incentives. Biagioli (1990) has made this a central argument in his "new view" of patronage, in which he explicitly tried to minimize economic motives by scientists. Instead he, as well as Moran (1991a, p. 3), have argued that being associated with the mighty and rich elite provided scientists with "social and intellectual legitimacy." Patronage in this view was a means to an end. By carrying out their work in high-prestige locales, at the courts of people at the social pinnacle, experimentalists would put a "seal of good housekeeping" on their results and gain credibility. Patronage, as Biagioli has argued, helped natural philosophers acquire social status. Whether social status was the password to cognitive legitimization, as he argues remains to be seen. His assertion that the reputations earned by men like Galileo, Kepler, and Clavius were not the result of the quality of their scientific work but only of the social status and the patrons associated with them seems so over the top that it may have been made tongue-in-cheek (Biagioli, 1990, pp. 5, 28). If we take Biagioli's views too literally, we should observe that court philosophers would have

[41] The art of fawning and groveling before people in power that intellectuals at the time sometimes had to engage in is illustrated by Desaguliers's allegorical poem "The Newtonian System" written in 1728 for the ascension of King George II, in an attempt to ensure the continuation of the queen's support, in which he compared Newtonian astronomical certitude with Hanoverian stability (Fara, 2004).

worked for free or perhaps even paid their patrons for the right to be at their court and enjoy their protection.[42] Biagioli's interpretation of patronage contains an important truth, but there is no denying (nor any need to deny) that for many scientists patronage provided income and security and such patronage depended on the legitimization by peers who were best positioned to evaluate the contribution, as Westfall (1985) has argued.

Patronage could take different forms. Much of it was handed out by the princes and kings of Europe who collected intellectuals at their courts in part just for prestige reasons. The otherwise rather inept Habsburg Emperor Rudolf II (ruled 1572–1612) collected a large number of scientists and artists at his court in Prague (at that time the Imperial capital). The astronomers Tycho Brahe and Johannes Kepler were both members of the Habsburg court, as was Carolus Clusius, né Charles de l'Écluse (1526–1609). Clusius, one of the founders of modern botany, was by all accounts a paradigmatic member of the sixteenth-century Republic of Letters: cosmopolitan, widely traveled, extremely well connected, he worked for both Rudolf II and Rudolf's father Maximilian II (Evans, 1973, pp. 119–20).[43] Galileo was perhaps the most famous case: in 1610 he was appointed as court mathematician and philosopher by Grand Duke Cosimo II of Florence, and as such he was free to pursue his research (as long as it did not conflict too much with religious doctrine—but that is another story). As Westfall (1985) has shown, Galileo lobbied seriously for this position and in fact to some extent may have directed his research to increase his chances of obtaining the coveted court position. But other academic superstars found remunerative appointments based on their reputation as well. The Dutch mathematician Christiaan Huygens and the Italian astronomer Giovanni-Domenico Cassini were appointed to the French Royal academy in the

[42] Nor can one accept literally Biagioli's (1990, p. 5) claim that "patronage was a voluntary act only in the sense that by not engaging in it one would commit social suicide." For one thing, some of the leading scientists of the seventeenth century were sufficiently financially independent to not need patronage in the narrow sense of the word, yet no one seriously questioned the legitimacy of Spinoza or Newton. Reputations were built on intellectual achievement, and their relation with patronage was a two-way street. Moreover, Biagioli fails to recognize fully the voluntary nature of exchange in a competitive market with many actors on both the supply and the demand side, in which the action of exchange between two agents is consensual and welfare-improving even if participating in the market itself may be inevitable.

[43] The politics of patronage could be complex and as a source of income it could be fickle, as rulers could be capricious, or be replaced by others with different tastes. Rudolf II employed a Czech court physician named Tadeás Hajek (Hagecius, 1525–1600) who was well-connected and known throughout Europe and had the emperor's ear. It was through his influence that Brahe settled in Prague in 1599. Hajek's knowledge of astronomy, like many scientists at this time, was driven by a deep commitment to astrology much in demand at the Habsburg court (Evans, 1973, p. 152).

1660s at annual salaries of 6,000 and 9,000 livres, respectively. But much patronage was also handed out by rich nobles and merchants.[44]

Tutoring the children of the rich and noble was another common service rendered by intellectuals in search of a secure and peaceful existence: Thomas Hobbes was originally hired by the Cavendish family to teach their children, as was the mathematician William Oughtred, who was a member of the household of the earl of Arundel. Isaac Casaubon (1559–1614), a prodigiously learned French scholar who found refuge in England, was frequently summoned to one of the lodges of King James to entertain his majesty and his retainers with learned conversation. René Descartes was hired by the Queen of Sweden to tutor her children. The Biagioli theory that patronage served above all as a form of legitimization is clearly incomplete: a complex and multifaceted exchange of services between patron and scientist took place.

Patronage was both complex and adaptable. Courtly patronage provided intellectuals with an alternative to the often intellectually stifling environment of universities (Moran, 1991b, p. 169). At other times, they provided them with some measure of political protection against their intellectual (and personal) enemies. The aforementioned Tommaso Campanella could survive and accomplish much of his work because the Emperor Rudolf, Duke Maximilian of Bavaria, and other Catholic notables were exerting influence to protect him. Galileo relied on the powerful princes of Florence to protect him from his intellectual foes, although he may have overestimated their power in the end. Moreover, not all scientists were motivated and incentivized by patronage. Then, as now, scientific research and intellectual innovation were motivated by a combination of financial incentives, personal curiosity, a search for recognition and respect from one's peers, a moral commitment to revealing what was felt to be true, and a feeling of responsibility toward a collective entity such as one's country or humankind in general. Robert Boyle was a wealthy landowner and a dispenser rather than a recipient of patronage. Antonie van Leeuwenhoek was a well-to-do merchant in his native city of Delft and despite peppering the Royal Society with his observations using his improved microscope, there is no evidence that he sought anything in return except recognition. Spinoza, his famous contemporary, made his income from lens grinding

[44] There are many well-known examples of patrons who were not heads of state. One of the best known was the Prince de Condé, the famous French rebel and later successful general (1621–1686), whose intellectual tastes were quite eclectic: he engaged at his court the authors Molière and Racine, the rather radical theologian Isaac La Peyrère (1596–1676), who served as his secretary, as well as conservative mainstream Catholic intellectuals such as Bishop Bossuet. Cardinal Mazarin hired the bibliophile physician Gabriel Naudé (1600–1653) as his personal librarian and book-collector. Pierre Gassendi, a peasant's son, enjoyed the protection ofthe wealthy intellectual Peiresc (and for years lived in his house), and after the latter's death he acquired the patronage of Louis Emmanuel de Valois, governor of Provence.

and instrument making (and some tutoring and gifts from friends). He never accepted a patronage position despite his reputation. René Descartes lived comfortably, if not extravagantly, off assets that he inherited.[45] Marin Mersenne was a friar in the order of the Minims and was supported by his fellow monks. Pierre Bayle, the publisher of the *News from the Republic of Letters,* had the only patron he needed, namely, his Rotterdam publisher Reiner Leers and the existence of a large audience all over Europe (Eisenstein, 1979, p. 138).

The relationship between intellectuals and their political environment was complex, and more was at stake for patronage than display and amusement. The competition to attract the best minds of Europe to one's court reflected the belief that highly intelligent and well-read individuals could prove useful to the state, because their insights provided rulers with sage advice and helped guide policies. Their intelligence and expertise could come in handy in affairs of state. Indeed, many of the prominent scientists of the time were active as diplomats or advisors. Leibniz, an intellectual superstar, was hired in 1676 by the Duke of Brunswick-Lüneburg (after 1692 elector of Hanover), whom he served for the rest of his life in a variety of capacities.

The Republic of Letters, then, functioned as a competitive market for ideas. Like all well-working markets, it would settle on a single equilibrium best-practice idea if the knowledge was tight enough. However, because it was a market for ideas, it was subject to what economists call "network externalities." What one intellectual accepted as truth could affect the demand for the ideas of others. Many of the cultural evolution biases in chapter 5 were operative, and both direct bias (accepting the opinions of others because of their reputation) and frequency-dependent bias (joining a growing consensus) suggest that in many cases, the competitive process would settle on a dominant view even if it took many decades, as was the case with the Copernican Revolution, and even if eventually it would be judged as mistaken (such as the phlogiston theory of combustion, proposed by German natural philosophers in the seventeenth century). Much like many markets for goods with network externalities, the market for ideas

[45] According to Project Galileo, "Descartes asserted that he had received enough property from his family that he was free to choose where and how he would live. And he did. Note that in 1633 he withdrew *Le Monde* [a manuscript written between 1629 and 1633] from publication lest it compromise his freedom and leisure. The decision makes it clear that he felt no need to establish a name for himself." See http://galileo.rice.edu/Catalog/NewFiles/descarts.html (accessed Aug. 18, 2013). The additional point made by Richard Westfall (the compiler of project Galileo) regarding the essay that Descartes dedicated the *Principles* to Princess Elizabeth of Bohemia. "The whole relation with the Princess is surely revealing of the patronage system. She had no monetary rewards to give, just the prestige of a royal name" seems far-fetched; the princess was an exile from her native Bohemia and an accomplished intellectual. She spent the last twenty years of her life as abbess of a Lutheran convent in Germany. It is hard to see how much legitimization her royal name could convey.

normally settled on an equilibrium in which one doctrine became predominant. This depended on how tight the knowledge was. Everything was contestable, but if a proposition was tight enough and could be verified at a reasonable level of certainty, the system tended toward it as an equilibrium cultural variant, making it "conventional wisdom." If it was untight, that is, if prevailing best-practice scientific methods were inadequate to decide between competing views, such a convergence would not occur. Even when it did, however, the market environment was rarely sufficiently stringent to rule out many niches occupied by non-conformists and crackpots insisting on cultural variants that most people had abandoned (such as a belief that all answers about the history of life are in the book of Genesis). This, perhaps, is desirable, since a small fraction of such crackpot beliefs may end up generating ideas that turn out after all to be scientifically important—though that outcome is unlikely to emerge from the creationist museum in Petersburg, Kentucky.

The discourses that took place in the Republic of Letters were not just about content but also about the methods and means of acquiring knowledge that were more trustworthy and accurate. Better experiments, more careful calculations, and exact observations all became part of the scientific discourse. As noted earlier, in the Republic of Letters, between 1500 and 1700, a number of scientific debates took place that illustrate the effectiveness of the market for ideas to arbitrate and decide disputes. These debates were a form of *persuasion*, that is, various biases in cultural evolution. At least some of those disputes were decided by content bias: those with the best evidence and logic won out. In other words, when the accumulating evidence for a particular belief was sufficiently strong so that no attempt to falsify it had succeeded, it became increasingly accepted and thus could be considered tight knowledge. Such competitions could, of course, take decades and even centuries to be decided. Some have not been decided to the present day. Precisely because many issues were insufficiently tight to be thus decided, the market for ideas depended on other biases, especially direct bias. But direct bias was especially important because it saved information costs. Difficult mathematical proofs were accepted, because it was assumed that those who had vetted the theorems had checked them. Experimental results, as we have seen above, were often accepted and not reproduced because the buyers in the market for idea "trusted" those who had carried them out.[46]

[46] Shapin and Schaffer (1985, pp. 55–67) describe in detail the steps taken by Boyle to establish the trustworthiness of his experiments. Boyle's descriptions were also described in extreme detail in order to facilitate replication, to convince readers that the experiments could be trusted, and to offer the possibility of "virtual witnessing." Moreover, to further establish his trustworthiness, Boyle reported even failed experiments, wrote modestly, and ensured that his statements did not overreach.

The competition in the market for ideas and the importance of knowledge tightness and content bias is well illustrated by the rise and fall of a mystical religious movement known as Hermeticism, which counted as its followers such notable intellectuals as Giordano Bruno and John Dee. It was widely condemned as heretical and based on black magic, but for a while it competed seriously in the European market for ideas. The core of Hermetic beliefs was based on a set of ancient writings attributed to a mythical writer named Hermes, consisting of a mix of religious doctrines, astrology, and occult practices, such as talismans with great powers and the virtues of certain plants and stones (Yates, 1964, p. 2). Its followers believed that the writings attributed to Hermes were Egyptian in origin and predated the books of Moses, and their alleged antiquity gave them an aura of sacredness. The Hermetic books were part of a larger body of what was known as *prisca theologia*, books believed to be by ancient sages antedating both the Hebrew Bible and the earliest Greek sages and containing a body of knowledge that reflected the pure ur-religion from which all later wisdom originated. The rules of evidence and persuasion of the Republic of Letters and the principle of contestability did not spare this movement, however. In 1614 the Huguenot classical scholar Isaac Casaubon published a devastating analysis of the Hermetical writings. He established beyond serious doubt that they dated from the second or third centuries AD and were a Greek pastiche of ancient and biblical texts rather than a divinely inspired book by a much more ancient Egyptian writer (Grafton, 1983).[47] As Yates and others have pointed out, the strong belief in mystical and occult powers was widely shared in early modern Europe among learned people, from the Neapolitan philosopher and experimentalist Giambattista della Porta (1535–1615) to Isaac Newton himself.[48] Subsequent generations, embarrassed by what they regarded to be the superstitions of their predecessors, tried to minimize this element: intellectual history, too, is written by the winners.

The belief in magic and the occult was not necessarily retrograde: they constituted in Yates's words another illustration of the growing conviction that whereas "in the Middle Ages ... the true end of man was contemplation," the occult and magic of the Renaissance changed the purpose of intellectual activity. It now was "religious and not contrary to the will of God that man, the great miracle, should exert his powers" (Yates, 1964, p. 156). Many scholars have pointed out that these attitudes constituted a

[47] Yates (1964, p. 398) goes as far as seeing Casaubon's book as a watershed event, separating the Renaissance world from the modern one.

[48] Many Renaissance intellectuals were fascinated by the mystical numerology, known as *Kabbalah* or *Cabala* practiced by Jewish scholars since the publication of the *Zohar* book in thirteenth-century Spain. Among the writers fascinated by Cabalism were the fifteenth-century humanist scholar Giovanni Pico della Mirandola (1463–1494), the French classical scholar and astronomer Guillaume Postel (1510–1581), Athanasius Kircher, and Giordano Bruno.

novel bridge between the theoretical and the practical, but these bridges could take many forms. The gap between magic and science in early modern Europe was not nearly as wide as it became during the Enlightenment. Occult, mysticism, and magic coexisted and intersected with experimental methodology and empirical testing. It often employed advanced mathematics. Very slowly, what we call today modern science gained the upper hand and led to the Industrial Enlightenment, but the victory was never final and complete (Tambiah, 1990). All the same, by the second quarter of the eighteenth century, the occultist tradition had lost its intellectual respectability and contemporaries, much as they adulated Isaac Newton, avoided mentioning his occultist interests (Copenhaver, 1978, p. 34).

The market for ideas was the arena in which philosophical doctrines battled one another for acceptance. By the early eighteenth century the scientific world of the Continent had trifurcated into a Newtonian, a Cartesian, and a Leibnizian camp, which battled one another over important points. By the second half of the century the Newtonians had for all intents and purposes won this battle. It was a battle fought, at least north of the Alps, with only minimal intervention by the authorities, secular or religious. Instead, the weapons were persuasion, evidence, logic, political arm-twisting, and academic haggling on a playing ground that was at least reasonably level.[49]

Within the larger European context, the competition within the market for ideas was between conservative forces and the *nuova scienza.* Conservative forces did all they could to stop what they considered heretical views that contradicted the scriptures and other authorities. In the vanguard of the forces of reaction stood the Inquisition and the Jesuit order, the tormentors of the aging Galileo and the fierce opponents of heliocentrism, corpuscularianism, and infinitesimals. The fate of the Jesuits is especially telling. In many ways their best scientific minds considered themselves bona fide members of the Republic of Letters. They were torn between the formal rules of the order and their formidable intellectual abilities, which often created a contradiction between the scriptures and their scientific insights. Some Jesuits, for instance Christoph Grienberger, Clavius's successor as the professor of mathematics at the Collegio Romano, may have secretly

[49] An illustrative example is the late seventeenth-century dispute between the Newtonians and Cartesians on the shape of the earth. Johann Bernoulli had shown that Newtonian theory suggested an oblate (flattened at the poles) shape as opposed to the prolate (oblong) theory of the Cartesians. The great mathematician and Enlightenment genius Pierre Louis Maupertuis and his mathematician colleague Alexis-Claude Clairaut went to Lapland in 1736 to make the appropriate measurements (comparing the length of the meridian degree in Lapland with that in Paris), finding the evidence in favor of Newton's theory. Some minor anomalies remained, and new mathematical and geodesic tools were applied to the question until the matter of the degree of flattening was settled by the early nineteenth century. The point is, however, that these measurements settled the matter.

sympathized with Galileo's work, but the order's discipline to which the Jesuits were committed demanded deference to its theological principles (Castellano, 2004, pp. 10–11, 20). Rodrigo Arriaga, a Spanish Jesuit scientist, who taught in Prague for much of his life, published in 1632 a widely read textbook, *Cursus Philosophicus*, which had sympathetic passages about both the new astronomy and the new infinitesimal mathematics (Grant, 2003; Alexander, 2014, pp. 139–41). It was prohibited by the Jesuit's Board of Revisors led by the very conservative Jesuit General Muzio Vitelleschi. Within the Catholic world, many astronomers and mathematicians were sympathetic to Copernicus, Galileo, and other exponents of the heretical cosmology, such as Diego de Zuñiga's (1536–1598), who argued that texts in the Bible actually supported heliocentrism, but their works found themselves on the Index of prohibited books.

Not all reactionaries were Catholic: Descartes complained in 1642 about conservative Dutch Calvinist professors who rejected the new philosophy because it was opposed to and had undermined the traditional doctrines that universities had taught hitherto and because it was "in conflict with other disciplines and faculties and above all with orthodox theology" (Descartes, 2000, p. xiv).[50] Many of the great thinkers of the era, including Descartes himself, were concerned that their work might be misinterpreted as potentially atheistic and cause them to get into serious trouble. In the Paris of the 1620s, where there was little Jesuit influence and no Inquisition, too blatant an attack on approved thinkers could lead to the threat of capital punishment (MacLean 2006, p. 272). An opinion that clearly threatened to devalue existing dogma could bring with it serious risks. As a result, the most heterodox thinkers needed to keep a clear path to retract their views or had to find powerful protectors, or else they could find themselves on trial, in jail, or worse.

The market for ideas decided not only which ideas were to be accepted but also engaged in meta-arguments about the legitimate criteria and tools through which disputes among competing cultural variants were to be decided. As noted in chapter 5, the rise of the concept of experiment, so ardently advocated by the Baconians, was a major breakthrough. The commitment to experimentation as a tool to settle disputes and create the

[50] A case in point is his clash with the orthodox Calvinist theologian Voetius, who forced the University of Utrecht, where he was rector, to condemn Descartes's work and to enforce its nothing-but-Aristotle teaching policy. In Leyden, too, a demand was made in 1642 to stop teaching Descartes's works, on account of accusations of blasphemy and atheism. The pugnacious Descartes and his acolytes fought these limitations tooth and nail. Philosophers were instructed to stay clear of theology which in practice meant a serious limitation on what they could teach (Stewart, 1994, p. 41). In the long term, however, the competitive nature of the Republic of Letters left these intellectuals no choice: by the 1670s Cartesian science had become quite influential in Leyden, which was becoming the most prominent scientific center on the Continent (Jacob, 1988, p. 68).

kind of content bias that would make others change their mind emerged in full bloom in the seventeenth century. In England the work of Harvey and Gilbert, in Italy that of Galileo and Torricelli, and in France in a variety of circles and groups, all exchanged notes and results. To repeat, experiments were not an entirely new phenomenon, and experiments were conducted in antiquity and in the Middle Ages. But, as Wootton (2015, p. 346) has stressed, what was new was a scientific community that recognized the experimental method and the replication of experimental results as a powerful means of persuasion.

There were others important debates in this competitive marketplace. One of these was the dispute about the role of mathematics in the growth of propositional knowledge. Such Renaissance scholars as Erasmus and Juan Luis Vives counseled against the study of mathematics, fearing that it would withdraw the mind from the practical concerns of life. The many followers of Paracelsus, one of the most rebellious intellectuals of his age, condemned mathematical abstraction in the study of natural phenomena and favored a more inductive and observational method such as practiced in the chemistry and alchemy of the age (Debus, 1978, p. 21). Francis Bacon, as already noted, failed to see the opportunities that mathematics offered to natural sciences (Gaukroger, 2001, pp. 21–27). In contrast, Galileo, Descartes, and Huygens clearly realized that experiment and formal analysis complemented one another, and with Newton's work this faction resoundingly triumphed in the marketplace for ideas. But early in the seventeenth century there was also a debate about what one should use mathematics for: should it be used to study specific phenomena such as motion and force, as Galileo suggested, or should it be confined to a more ambitious study of the universe as a whole?[51] Here, too, the competitive process did its work: over time mystical and occultist approaches to natural philosophy, still very much in play by 1650, fell into disrepute, though their continued demise—to become a niche phenomenon, never quite disappearing—was an eighteenth century phenomenon. The market for ideas also had to determine what the agenda of research would be: should topics be picked because of their inherent metaphysical importance? Or were practical and economic considerations to be front and center?

Economics suggests that competitive and integrated markets breed global superstars, and some of those superstars can become cultural entrepreneurs. Such superstars can arise especially when the product of an individual is convex in output, and when production costs do not rise with the size of the market (Rosen, 1981). These conditions were satisfied in the Republic of Letters: convexity implies that the addition to knowledge by one

[51] A case in point is the English physician, occult philosopher, and mathematician Robert Fludd (1574–1637), who suggested that mathematics could be used to decipher the mystical harmonies of the universe (Debus, 1978, p. 12).

Galileo was larger than twice the contributions of two mediocre scientists, and the marginal costs of spreading new knowledge (that is, the costs incurred by adding one more person to the body of people already familiar with the new knowledge) were negligible thanks to the printing press and a large number of intelligencers, translators, and acolytes. In Europe, "superstar" intellectuals—from Erasmus, Paracelsus, and Luther in the early sixteenth century to Descartes, Newton, and Leibniz in the seventeenth—were famous throughout the Continent. And while they too only catered to an educated elite, they could access their audiences throughout the Continent and try to persuade scholars in different countries, thus not only selling books but also hopefully finding a powerful and rich sponsor who would underwrite their careers and provide a patronage appointment. Much like stellar sports figures and musicians today, a fairly small number of truly world-famous intellectuals attracted a disproportionate amount of the fame and patronage of the time. But the effect of the concentration of the payoffs among superstars had enormous externalities, because it demonstrated to young and ambitious intellectuals the rewards of winning this lottery. As with all superstars, those of science created a large cadre of would-be imitators, most of whom would never attain stardom. Society, however, would still benefit from their work, even if it amounted to little more than "normal science." In that sense, the superstars were the source of considerable model-based bias in cultural change: their fame and success made intellectual innovation respectable, even desirable.

The Republic of Letters, as MacLean (2008, p. 17) points out, could be seen from many different angles: a community of scholars, the content of the ideas they fostered, the means of disseminating them, the intellectual norms that set standards of persuasion (adequacy of proof, reproducibility of experiment), attitudes toward collaboration and disclosure, and so forth. Joining it meant that one had to accept a scientific ethic of sharing and communicating. For my purposes here, it can also be seen as a community that set incentives through social norms and informal rules, that is an institution. It was this institution that turned out to be one of the taproots of European technological change. In this regard the Republic of Letters should be regarded as the missing link that connects the growing literature that views institutions as the core difference between successful economies and less successful ones, and the literature that stresses the importance of technology and innovation in the origins of the Industrial Revolution and the generation of sustainable economic growth.

The institutionalists maintain, quite rightly, that one of the main ways that institutions fostered economic growth was by supporting markets. The Republic of Letters and its daughter, the eighteenth- and nineteenth-century Republic of Science, provided the institutional underpinning of a well-functioning market for ideas. It was in many ways a unique phenomenon: other civilizations made scientific advances and had functioning markets for ideas, but they always eventually ran into diminishing returns

and eventually into a dead-end. There were built-in mechanisms that protected the status quo and resisted further innovation. In Europe that resistance was overcome, if not easily, rapidly, and universally. The result was a set of scientific and technological breakthroughs that was self-reinforcing and to date shows no signs of abating. Whether they merit the term "scientific revolution" or not is a moot point. It is the main explanation why ultimately Europe succeeded where no other society did, to break out of the Malthusian state of subsistence economies through the relentless power of accumulated useful knowledge.[52]

To repeat: the key to Europe's success was its fortunate condition that combined political fragmentation with cultural unity. If it had had one without the other, the end result would in all likelihood have been profoundly different. Political fragmentation in a poorly integrated intellectual world implied that no cultural entrepreneur would have been able to cover the fixed cost catering to a "market" (or audience) of a few thousand local people. Nor would there have been networks of people from whom scientists could learn and on whose shoulders they could stand. Even a well-integrated and large market for ideas in which there is little competition and limited entry will eventually not be able to generate enough innovation and change, because incumbents would find ways to suppress challenges to their cultural positions.

This is not to argue that the Republic of Letters came into being or persisted because it was fulfilled this task. Such functionalism would be ahistorical. Originally it was no more than a network set up by intellectuals who wanted to share and test out new ideas on like-minded colleagues, persuade them of the merits of their insights (thus "making a sale" in the market for ideas) to enhance their reputations, and who wanted to find out what others were up to (so as to make sure they were up to date on other people's work). Its impact on the long-run cultural development of the European intellectual elite and the economic transformation of the European world was an unintended consequence of these needs. But whatever brought it about, it turned out eventually to be an institution unique in human history and a key to the understanding where the long road that led to modern economic growth began. If one believes in the importance of institutions as drivers of economic growth, one cannot fail to recognize the importance of the Republic of Letters. Small as it may be, it illustrates how in evolutionary change that takes place in tiny minorities can have cascading consequences for the population at large. It is the paradigmatic

[52] As a comparison, we may look at India, which was very far from being the scientific desert that European visitors described it to be. Historians of India, however, have pointed to the "usual secretiveness" of Indian scholars in the eighteenth century, and to the fact that when the validity of knowledge was put to the test, "the sacred texts were always the standard measure" (Dharampal, 1971, p. 5; Kumar, 2003, p. 687).

illustration of the pivotal role of Hooke's "Cortesian army" or upper-tail human capital.

Between 1500 and 1700, Europe thus experienced an accelerated rate of cultural development. It discovered Protestantism, the structure of the solar system, the circulation of blood, the atmosphere, calculus, the laws driving the motion of heavenly and earthly bodies, biblical textual criticism, and many things in between. The greatest and most fateful outcome of a well-functioning market for ideas, however, was a set of beliefs we refer to as the Enlightenment. I have elsewhere (Mokyr, 2002, 2009a) made an argument about the central role of the Enlightenment in the economic history of Europe. The Enlightenment was the final stage in the cultural evolution that eventually led to the Industrial Revolution and modern economic growth in Europe. It stressed the two elements needed for the material progress of the nation and society. One consisted of the growth of useful knowledge, and the interaction between theory and practice; the other of improving the political institutions that governed the rules of the economic game and how resources were allocated and income distributed.

Can the concepts of cultural evolution put forward in chapters 3–5 help us understand the role of the Republic of Letters in the triumph of Enlightenment ideas in eighteenth-century Europe? At first blush the answer is obvious: it lubricated the market for ideas and greatly speeded up changing beliefs among the European literate elite. The epistolary and publication networks facilitated horizontal transmission of beliefs and ideas. After all, for **content bias** (that is, persuasion) to be effective in shaping people's minds, they need above all to be exposed to the ideas of others. Access was the one thing that the Republic of Letters provided with increasing abundance. But content bias itself can be seen as subject to evolutionary forces. Shapiro (2000) and Poovey (1998) and more recently Wootton (2015, pp. 251–309) have argued that early modern Europe witnessed a growing respect for the concept of fact and its counterpart, verification. Perhaps the central phenomenon in the cultural evolution of the era was the transformation of how content bias in natural philosophy worked, that is, what was admissible as evidence. In the scientific community of early modern Europe, what counted as persuasive evidence was evolving itself: it became accepted to treat facts the way the legal system had always done, namely to infer facts logically from indirect observations even when the fact itself could not be seen directly (Shapiro, 2000). In Wootton's felicitous phrase, this was the age in which scientists began to "handle evidence in the way that lawyers and theologians had been handling it for many years" (Wootton, 2015, p. 407). Moreover, knowledge was always contestable and subject to challenge. If new and more persuasive evidence was brought to bear on an issue, useful knowledge would be revised. It became increasingly accepted that science was not a search for the Truth but a never-ending road advancing toward more plausible and effective ways of understanding the natural world.

This type of reasoning changed the way the Republic of Letters worked and how it handled content bias. While none of the new forms of persuasion was wholly new, the discourse changed. Experimental data became increasingly credible as a way of persuading skeptics. Mathematization and precise computation slowly became a way of defending new propositions, and where precision was hard, empirical regularities could be discerned through the collection of facts and specimens and their organization and cataloging. And finally, new tools and instruments, as noted, created new facts that were increasingly indisputable.

As Margóczy (2014b) notes, in some areas of knowledge, authentication was crucial; in others, such as natural history, less so. But, he notes, authentication itself could be unreliable if the evidence could be faked. Hence, experts were needed to confirm the reliability of the facts and the evidence. Hence the role of direct bias. By designating certain people as trustworthy experts, the Republic of Letters designated authorities who judged other ideas on the basis of logic and evidence and declared them valid. Peer review—far from perfect—is still the best method we have to determine the validity of intellectual innovations. Above all, what matters, is how exactly direct bias worked in different institutional settings. Until ca.1500 the classics had been the ultimate authorities and in cases of doubt they were consulted. What made them authoritative is a consensus that rested on a conservative ideology enforced by the Church. But these rules could change, and when they did, intellectual innovation could occur. They changed when the old authorities were increasingly undermined by better data, better observations, and better instruments to gather and analyze them. At times, the entire concept of authority was doubted: Pascal noted that in matters subject to reason and the senses authority was useless and he bewailed the blindness of those who in such matters relied on authority alone (Pascal, [1651] 2007, p. 446). But of course in a world of increasing specialization and a growing body of knowledge, specialization and a "division of knowledge" (akin to a division of labor) were indispensable. This required trust in *some* authority. But who was to become an authority? Who appointed them? And who was to appoint the appointers?

Yet the scholars of the age clearly were committed to the idea of the power to persuade through **rhetorical bias**. Bacon himself, in a remarkable pasage in Book two of *The Advancement of Learning* noted that the art of eloquence, while in true value inferior to wisdom, "with people it is the more mighty" and that "profoundness of wisdom will help a man to a name or admiration, but that it is eloquence that prevaileth in an active life." The duty of Rhetoric, he felt, was to apply reason to imagination (Bacon, [1605] 1996, pp. 237–38). The Republic of Letters, argues Schoeck, was based on a common foundation of rhetoric which "made possible free movement of ideas, genres and books" (Schoeck, 1982, p. 303). Eloquence was the means by which members of the Republic of Letters communicated and persuaded one another. Yet rhetorical bias had its limits: erudite and brilliant conver-

sation taking place in the *salons* and coffeehouses of the Republic of Letters in the age of Enlightenment started to look pedantic to contemporaries, and were easy to make fun of, especially when taken on by a master-satirist like Jonathan Swift.

The Republic of Letters anointed a new set of experts whose knowledge required more that just familiarity with an existing canon but also with the methods by which *novel* knowledge was to be validated. To become an expert, one had to have made an important original contribution; only those with proven creativity could judge that of others. One had to innovate to become an authority, and becoming an authority conveyed both patronage and power over others precisely because of the dependence of the system on reputation among peers. The imprimatur of expertise was no longer awarded solely by rulers, priests, and the establishment. The Republic of Letters itself increasingly asserted the right to decide who were the authorities who declared knowledge to be valid.

In that way **direct bias** was responsible for the continuous development of useful knowledge under the umbrella of the Republic of Letters. Broman (2012, p. 192) points to the Enlightenment as the era in which the ideology "that scientific knowledge had to make itself useful for social improvement" emerged, so that a well-organized society that depended on this knowledge placed a great deal of authority in the hands of these experts. The concept of direct bias bestows new importance on the influence of Bacon: while not much of an authority on science himself, his work helped set the metabeliefs underlying the mechanisms that appointed some scholars as experts and judges on the validity of ideas and helped establish the reputation mechanism that propelled the system forward. Direct bias was used not only in persuading people to accept what was right, but also to rid the intellectual community of false knowledge. David Wootton (2015, p. 304) has pointed to many books published in this period that were compilations of past errors that now could be dismissed as nonsense. Whether that demonstrates a kind of Gresham's Law in reverse in which good facts drive out bad facts, as Wootton argues, depends on how tight the knowledge was. False facts and hypotheses that could not be readily refuted with the tools of the time survived for a long time.

Paradoxically, precisely because the writings of the superstars themselves were always subject to verifiability and contestability, they gained credibility, since the audience at large could assume that ideas had been vetted and examined by experts. The Republic of Letters did not produce an unassailable gospel, like the Jewish Bible or the Chinese Four Books, works that were subject to exegesis but did not permit doubt and did not allow for a real concept of heresy. Some writers were regarded as authorities, but as the case of Newton attests, only insofar as their views had withstood every possible critique.

A model of cultural evolution also supports an inclusive view regarding the value of patronage. The Biagioli view of legitimization

through social status, appropriately shorn of its more extreme expressions, is consistent with direct bias (in which the patron becomes the authority adjudicating which scientific work is meritorious). Moreover, it serves as a prime example of model-based bias (in which the prince sets the tone for his subjects of what is right and just and what is not). Precisely because so much science was sponsored and protected by royal and aristocratic patrons, legitimization of science meant that some arguments were deemed by many to be valid because a person of high social status had blessed them. Moreover, patronage of science by a high-ranking member of society meant that useful knowledge and experimental philosophy themselves became higher-prestige activities. Many books of science and learning of the time displayed groveling dedications to nobles, who were not even remotely capable of understanding their contents. It is in this light that we should see not only the activities of patrons like Emperor Rudolf II and Duke Federico Cesi, the founder of the Accademia dei Lincei, as well as the young crown Prince Henry Frederick.

Other forms of "bias" in cultural evolution, too, can be seen to have affected the market for ideas. The rather sudden realization in the late fifteenth and early sixteenth centuries that the planet looked quite different from what everyone had believed, as we have seen, led to a serious reexamination of truths previously thought to be unassailable. A century and a half later the catastrophic bloodshed during the Thirty Years War convinced more and more people of the merits of tolerance and pluralism. Both can be seen as examples of salient event bias. The age, of course, also had its share of coercion bias, of which the "cuius regio eius religio" rule serves as an example. But the Republic of Letters also serves as a powerful demonstration that in the competitive environment of a politically fragmented world, progress cannot be blocked by the coercion of a few reactionary powers. Finally, rhetorical bias influenced readers when content alone was insufficient. It helped to have the sharp pen of Voltaire on one's side.

To return to the important work of Henrich (2009), the Republic of Letters underscores the critical importance of interconnectedness and access. The increasingly efficient and dense networks created communications among scholars slaving away on problems in mathematics, anatomy, astronomy, and botany, and allowed them to compare notes, avoid duplication, recombine different ideas into new ones, and argue from analogy and contrast with the work of others. In many other ways the existence of the scholarly network in the Republic of Letters stimulated intellectual innovations in ways that created a monstrously large synergy, in which the output of the intellectual community was far larger than the sum of the individual components had they all worked on their own.

The logic of cultural evolution suggests that contingency and chance played an important role in bringing about this outcome precisely because there was a highly competitive marketplace for ideas and because much of the innovation led to knowledge that was rather untight. When it

was hard to prove a particular supposition beyond reasonable doubt, it was possible for "bad knowledge" to drive out "good knowledge" or for the two to coexist for generations. In medicine, chemistry, and biology, for instance, incompatible and competing views survived for centuries. We do not have a very good model to predict which idea will prevail in such markets any more than we have a good tool to predict in advance which biological variants will become fixed in the population or which operating system will end up dominating personal computers. A lot may have depended on the beliefs and abilities of a few key cultural entrepreneurs and on their rhetorically powerful disciples, who persuaded large numbers of people of the master's message, sometimes in modified form. Success was never assured. Cohen (2012, p. 150) states perceptively that there is "no inherent reason whatever for why the Renaissance-European upswing should in the end have escaped the destiny of every previous, large-scale endeavor to attain knowledge of nature ... and come to a standstill at some point." In 1600, it was indeed hard to foresee what the Republic of Letters and the competitive market for ideas it supported would lead to.

All the same, the model proposed here is that when knowledge becomes tighter, content bias and direct bias mean that certain beliefs will prevail in the market for ideas. Once the tools become available to test alternatives, the members of the Republic of Science would choose Lavoisier over phlogiston, Newton's cosmology over Descartes's, and Pasteur over miasmatic theories. The remarkable thing is not that such developments took a long time—it is that they happened at all. By the second half of the eighteenth century, magical and mystical doctrines and practices were vanishing from the intellectual discourse. The first edition of the *Encyclopaedia Britannica,* which appeared in 1771, gave only 132 lines, less than a full page, to articles on such topics as astrology, alchemy, Cabala, demons, divination, the word "occult," and witchcraft. In contrast, astronomy occupied 67 pages, and chemistry 115 (Copenhaver, 1978, p. 32).[53] But what was true for biology and astronomy was not true for other cultural variants: one cannot prove by experiment or mathematics that social progress is likely to continue, or that an inclusive, open, and democratic society is more likely to prosper than an extractive, autocratic one, much less metaphysical beliefs about the purpose of the universe.

It is thus important to stress that the victory of the beliefs we associate with the Enlightenment in the market for ideas was anything but foreordained. Neither the form nor the content of the European Enlightenment were inevitable. The contingent outcomes of wars may have played a role: had Spain prevailed in its struggle with the rebellious Dutch and the

[53] Copenhaver (1978, p. 31) adds that by the time of Newton's death (1727), "the occultist tradition, with all its claims about the powers of magic, alchemy, divination, witchcraft, Cabala, and the other secret arts, no longer demanded a serious response from serious thinkers."

recalcitrant English, had Jesuits and other Catholic conservatives been able to monopolize education and intellectual discourse, there may have been no Enlightenment, or perhaps a dramatically different one. Had the intellectual status quo succeeded in rejecting the novel ideas that constituted the core of the Enlightenment, the Industrial Revolution would probably have fizzled out as another ephemeral efflorescence. But whatever the Enlightenment was, it happened. Powerful minds used a combination of logic, evidence, and rhetoric to change the beliefs and values of the intellectual elite. Almost all the biases of cultural evolution came into play in this victory. They did not operate uniformly over time or across space. There were many different versions of the Enlightenment, to the point where some historians in desperation have questioned the usefulness of the concept altogether, although the belief in the power of knowledge and reasoning to improve life and society remains one of the most important common denominators of all its versions. What this exactly meant and how to bring it about were a different matter.

With hindsight, however, it is possible to see how Enlightenment ideas prevailed in Europe. By the middle of the seventeenth century, useful knowledge was increasingly recognized as a potentially powerful force for economic change, becoming a source of social optimism and a force for progress even if it had not come close to its full potential. The triumphs of experimental science and observations aided by new instruments were an illustration of human agency in nature. They supported the basic Enlightenment idea of an agenda to bring about economic improvement through an aggressive manipulation of natural forces made possible by useful knowledge. These ideas, in some form, had been around since the Middle Ages, but what counted was their triumph over what progressive intellectuals regarded as obscurantism and superstition. Religious warfare had been shown to have been a rather futile and destructive endeavor, and a growing number of people were advocating the need for religious tolerance rather than pious conformity. By the late seventeenth century such political philosophers as Locke were starting to lay out the parameters of a set of political institutions that could make their world a better and more prosperous place.

Beyond institutions, what mattered in the long run was the willingness and ability to harness nature to human material needs. Whatever its exact sources, more than ever the insights of natural philosophy and history confirmed the beliefs of a mechanistic, understandable universe and a controllable environment that could and should be manipulated for the material benefit of humankind. The Republic of Letters of the seventeenth century, then, prepared the ground for the Industrial Enlightenment by offering to the market for ideas the metaconcept that people's relationship with the environment was based on intelligibility and instrumentality (Dear, 2006). Instrumentality basically meant that at some level the metaphysics of the essence of a phenomenon mattered less than its full and detailed description, its modus operandi, and how it could be harnessed. Understanding its

deep causes (or, as an economist might call it, its "microfoundations") may have been a fruitless endeavor.[54] Intelligibility, above all, depended on a mechanistic and deterministic view of the world.

These two trends, institutional improvement and technological progress, were the product of the thought and labors of many people, some famous, most obscure. What accounted for the success was the institution within which these intellectuals and scholars worked and which set the incentives that drove them and the constraints that disciplined them. That institution was the sixteenth- and seventeenth-century Republic of Letters.

The Republic of Letters that began to emerge in Europe around the time of the great voyages and reached a crescendo in the age of Enlightenment is the most significant institutional development that explains the technology-led quantum leap in economic performance heralded by the Industrial Revolution. But other institutions mattered as well. Britain in the eighteenth century has been dubbed the "Associational Society" by its leading historian (Clark, 2000). Many of these associations, of course, had little to do with the dissemination of useful knowledge but were social gatherings, eating and (mostly) drinking clubs, sports and musical organizations, and so on. The significance of these associations is in the creation of a civil economy, in which economic agents behaved in an honorable manner and thus minimized the need for third party (that is, the state) enforcement of contracts. Yet a surprising number of them were devoted to the useful arts and this led to the rise of "public science" in Britain, in which useful knowledge was made available to those who could make best use of it (Stewart, 1992, 1998). Some of these tales have been well told, especially that of the most famous one, the Birmingham Lunar Society. But the Lunar Society was the culmination, not the start of the rise of public science in Britain. By 1700 there were already 2,000 coffeehouses in London, many of which were sites of literary activity, discussions about natural philosophy, and political debates (Cowan, 2005). Coffeehouses remained important centers for the dissemination of knowledge and beliefs throughout the eighteenth century. Perhaps the most famous of these coffeehouse societies was the London Chapter Coffee House, the favorite of the fellows of the Royal Society, whose membership resembled (and overlapped with) the Birmingham Lunar Society.[55] Masonic lodges, too, proved a locus for the exchange of scientific and technological information, even if that was not

[54] Thus, when William Harvey was asked by the German physician Caspar Hofmann what the "final cause" (in an Aristotelian sense, that is, the ultimate purpose) of the circulation of the blood was, he replied that as he was a very bad philosopher, he was first and foremost keen on establishing that the phenomenon actually existed and then perhaps later would worry about the final cause (Wright, 2012, p. 202).

[55] See Levere and Turner (2002). Its membership reads like a veritable list of the "Who's who" of the British Industrial Enlightenment of the 1780s.

their primary mission.[56] Public lectures on scientific and engineering subjects attracted a surprising number of attendants. Lecturers performed entertaining public experiments, in which electricity and magnetism played roles disproportionate to their economic significance, and their direct impact on the techniques in use at the time is questionable.[57]

What matters, however, is not whether there was any direct and immediate link from these cultural developments to economic change and the Industrial Revolution. What mattered was that the cultural developments in the values and beliefs of the European economic elite toward a more growth-friendly culture began to spread and affect more and more people, and especially practical people who could make a difference to economic conditions. The Industrial Enlightenment was a Western European phenomenon, and it was especially successful in Britain, where the environment was especially susceptible to the idea of progress under the term of "improvement" (Slack, 2015), though eventually these notions took firm root almost everywhere else in the North Atlantic region. Improvement meant, among many things, the application of natural philosophy to anything from agriculture and medicine to navigation. It was not the highbrow science of Newton, perhaps, that made the difference in the eighteenth century, but the lowbrow concepts of approaching the study of nature through careful measurement, precise formulation, well-designed experiments, empirical testing, mathematization, and above all the belief that such activities were virtuous, respectable, and could lead to economic and social rewards.

The significance of the cultural and technological developments in Europe in enhancing interconnectivity has been discussed at great length, even if the terminology is not always the same. The emergence of a "public sphere," a term coined by philosopher Jürgen Habermas, has caught the eye of historians. It is often equated with the Republic of Letters, and many authors have stressed how it differed as a public space from the territorial state (Goodman, 1994, pp. 14–15, 49). Such scholars as Jacob (1997, 2000b) and Stewart (1992, 1998, 2004) have made much of the emergence of a culture of public science, in which science was discussed and studied, in the hope—remote, perhaps, in most cases—that one day it could be put to good

[56] On the significance of Masonic lodges, see Jacob (1991) and Im Hoff (1994, pp. 139–45).

[57] Many of these lecturers structured their lectures around topics that had no immediate or even remote applicability, presented theories that were bogus even by the standards of the time, and at times they showed a bias toward the flashy and dramatic experiment over the strictly useful (Schaffer, 1983). John Desaguliers, who made a name for himself as a lecturer explaining the new physics to general audiences, admitted that "a great many persons get a considerable knowledge of Natural Philosophy by way of amusement" (cited by Schaffer, 1994, p. 159). But as Stewart (2004, p. 8) remarks, "a sense of practical consequence was not immediately excluded by the spectacular."

use. Meanwhile, it was to be enjoyed and its practice conveyed a certain social prestige. With some luck and a lot of patience and persistence, public science could eventually be transformed into technological progress and economic progress.