Cosmology and Society: Developing a Bourdieusian Perspective

by Peter Dickens
University of Cambridge

Sociological Research Online, 17 (2) 14
<<http://www.socresonline.org.uk/17/2/14.html>>
10.5153/sro.2613

Received: 6 Oct 2011 Accepted: 28 Feb 2012 Published: 31 May 2012

Abstract

Contemporary sociology has paid very little attention to cosmology. But, like all forms of intellectual endeavour, cosmology is a product of society. Using insights from Bourdieu's social theory, this paper shows how cosmologies are invested in by owners of economic capital seeking power and social status. There are also important dialectical relations between economic patronage and cosmology, cosmologies resonating in different ways with the economic interests patronising them. These assertions are made using three case studies: Renaissance Europe, 17th century England and 20th century U.S.A. The selection of these case studies has been based on two connected criteria. First, as Arrighi (2010) outlines, there has been 'a recurrent pattern of historical capitalism' whereby phases of stable growth based on technological innovation alternate with periods of crisis and the rise of a new economic, social and technological regime. The case-study areas examined here have been made the nodal-points of these cycles of accumulation and financial investment. Local elites, business organisations and governments have organised the expansion and restructuring of their economy and have used regional economic expansion to promote and display their power and cultural capital. This brings us to the second reason for choosing the particular case studies examined here. Advances in scientific capital (including astronomy and cosmology) have often corresponded with these macrosocial changes and investments. A macro-perspective such as that of Arrighi does little to show how 'economic capital' is used by particular people and institutions in particular regions to enhance their power and prestige. But a Bourdieusian perspective can show which elites (owners of economic, social and symbolic capital) control, and are controlled by, these global economic shocks.

Keywords: Cosmologies, Bourdieu, Patronage, Capital

Society, theory and the universe

The sociology of 'primitive' and 'cosmological' societies

1.1 Two important exceptions help prove the rule that the universe has been largely ignored by contemporary social theory. Durkheim is of course particularly well-known for giving extensive consideration to the cosmology of 'primitive' societies. (Durkheim 1915). His work showed how tribes and clans attributed sacred powers and magical qualities as totems. Durkheim demonstrated how the phratries within these societies closely integrated their members into the universe as a whole through totemic practices. Another theorist with interests in the universe was Talcott Parsons (1966). He used the term 'cosmological societies' to describe a group of early civilisations such as the Aztecs, Ancient China, Ancient Greece and Ancient Egypt where power-relations and access to resources were intimately involved in these societies' relations to the universe and to the sun in particular. The Egyptian Pharaohs, for example, represented the gods on earth.

1.2 The societies examined by Durkheim and Parsons demonstrated close, interlocking, relations between the structure and workings of society and the structure and workings of the universe. But how can the links between cosmology and more modern societies be understood?

Later developments: science, realism and the cosmos

1.3 There is now a very large literature on the relations between science, technology and society (STS) and there is insufficient space here to thoroughly engage in the often heated debates in this field (David 2005, Erickson 2005). Suffice to say here that this study is guided by a particular ontology, namely critical realism. This asserts that there is a world (and a universe) which exists independent of our thoughts about it (Benton and Craib 2001). Critical realism is opposed to the argument that all ideas are simply context-dependent and of equal worth.

1.4 The importance of a critical realist perspective is that it distances itself from what is known as 'the strong programme'. This latter seeks sociological explanations of scientific beliefs quite independent of their truth or falsity. Such a picture is at complete odds with science, including the physical and cosmological sciences discussed in this paper. Rejecting 'the strong programme' is not to imply, however, that ideas about society and cosmology emerge as completely separate from the society we inhabit. But it is to suggest that some ideas are more reliable and closer to the truth than others.

1.5 Critical realism, in contrast to the strong programme, has a strong ontological basis. It asserts that there are real causal mechanisms influencing the physical and social worlds. They combine with each other and with contingent and historical factors to produce a vast array of concrete outcomes (Benton and Craib 2001 op.cit.).

1.6 Modern cosmology, advanced during the period of the three case-studies examined here, has almost always been premised on some form of realism. Galileo was the first modern astronomer, using telescopes to observe the heavens. These empirical observations led to his support in 1613 of a Sun-centred model of the Solar System as advanced by Copernicus a century earlier. In the late 17th century Newton took Galileo's work further, establishing the modern techniques of scientific investigation and discovering the laws of gravity and motion governing the movements of the planets. In the early 20th century Einstein's model of gravity offered further explanations of detailed planetary movements and light-bending. These were an advance on Newton's work and could be assessed by observation. The picture is therefore one of increasing progress, both in terms empirical observation and of theory-making.

1.7 The three case studies of this paper do not, however, point to a relentlessly *critical* realism on the part of cosmology. There have certainly been attempts by physical scientists to resist self-criticism and to ignore how powerful social institutions guide and use scientific ideas. But, seen over the past four centuries, the development of cosmology is still a relatively coherent story about how the cosmos has slowly come to be understood and how scientific method and evidence can be developed towards this end. Seen over the long-term, each generation's stock of knowledge has been drawn on and developed in a cumulative way by later generations of scientists and cosmologists.

Bourdieu and Elias: Forms of Capital, Fields and Cosmologies

1.8 Connections between societies and forms of cosmology can be developed by using Bourdieu's work, particularly that on economic capital and 'symbolic' forms of capital, including 'social', 'scientific', 'cultural' and 'religious' capital (Bourdieu 1986a). 'Social' capital refers to membership of networks, these usually bringing increased economic and symbolic capital, the latter due to the prestige of the group in question. Scientific capital refers to books, instruments and knowledge of science, this including problem-solving techniques and the ideology that is value-free or 'objective'. Cultural capital refers to goods of different kinds (for example, books and paintings) and to forms of knowledge acquired through education and home-background. 'Religious capital' refers to the capital embodied in, for example, institutions and cosmologies. It also refers to priests and prophets (those endowed with high levels of 'religious capital') producing and reproducing ideas for a laity to 'buy into'. These ideas include notions about the nature of God and salvation. Those members of the laity adopting these ideas themselves acquire higher levels of religious capital) (Ley 2007)

1.9 Crucial to Bourdieu's analysis is the assertion that different forms of capital can be converted from one to another. Thus 'economic capital' is frequently, through patronage, converted into scientific capital. Similarly, economic elites repeatedly acquire cultural and aesthetic capital as a means of expressing their 'taste' and social power. As mentioned, religious elites attempt to increase their economic capital by producing ideas attractive to their laity. But, clearly, reverse processes also take place. Scientific capital is often, again through patronage, converted back into economic capital. As we will see, for example, Newton's laws helped stimulate industrial capitalism in Britain. Similarly, those possessing cultural capital, such as artists and architects, attempt to enhance their economic capital by producing what they believe their patrons and publics require.

1.10 Cosmology, as later elaborated, is a fusion of religious, scientific and aesthetic capital. A Bourdieusian perspective points to the relations between economic capital on the one hand and these forms of capital incorporated in cosmology. Economic elites consistently patronise cosmologies as a means of enhancing their assets, status and power. But the cosmologies they patronise usually contain a consistent feature; the division between an earthly 'chaos' and a pure, smooth-running and heavenly 'cosmos'. Discovering and sponsoring what is pure, good, and stable are all means by which economic elites have attempted to accrue social, political and religious capital.

1.11 Other features of Bourdieu's work are useful for the sociological study of cosmology. Bourdieu deploys the word 'doxa' to refer to 'a set of fundamental beliefs which does not even need to be asserted in the form of an explicit, self-conscious dogma'. (2000:16). Doxa of this type is, for example, a regular if temporary feature of those sciences engaged in scientific cosmology. Indeed the fundamental beliefs involved have been made so strong and integral to cosmologists' outlook that they are precluding consideration of radically alternative cosmologies. Examples of religious cum scientific 'doxa' are by no

means unfamiliar in the history of cosmology. This paper's case-studies offer good instances. Galileo encountered great resistance from the Pope by arguing that the Earth revolves around the Sun as Copernicus had earlier maintained. Similarly, today's 'Big Bang' cosmology has now become such an unspoken fundamental belief in mainstream cosmology that, as we will see, alternative cosmologies are having a very hard time advancing their arguments.

1.12 One of Bourdieu's most important concepts is 'field'. This is a social space in which struggles between different forms of capital take place. In our case this concerns struggles within the forms of scientific, aesthetic and religious capital surrounding cosmologies. As regards science, Bourdieu argues that the notion of field 'sweeps away the naively idealist view of the scientific world as a community of solidarity or a 'kingdom of ends' (2004:46). But, at the same time, 'it is also opposed to the no less partial view of scientific life as a 'war of all against all' that scientists themselves evoke'. (2004:46).

1.13 But the social world as a whole is constituted of overlapping and competing fields. This is 'the 'field of power' (Bourdieu 2004:35). Later we find economic capital constantly attempting to appropriate cultural and religious capital within the field of power, with large quantities of capital (economic capital, scientific capital and so forth) being struggled over. Cosmology, composed of different forms of capital, is part of 'the field of power'.

1.14 Finally, there are forms of 'commonsense' within fields which are shared by most agents within these fields. This raises Bourdieu's important concept (paralleling 'capital' and 'field') of 'habitus'. This concept is used to reconcile the unsatisfactory dichotomy between social structure and human agency (Bourdieu, 1986b, 1990). 'Habitus' encompasses the perceptions, practices and dispositions of agents, the latter referring to groups and as well as individuals. Habitus is a product of upbringing, education and everyday social practice. It shapes dispositions, outlook and behaviour.

1.15 There are strong overlaps between the work of Bourdieu and Norbert Elias here, the latter doing a great deal of historical work, tracing and explaining the forms of habitus which are now considered 'modern'. As Elias (1994) showed in detail, forms of *self* control (in, for example, eating, sexuality and body functions) were established in the post-mediaeval courts of France, England and Germany. Modern or 'civilised' behaviour within these courts was, Elias argued, the product of state-building in this era.

1.16 But how does the work of Bourdieu and Elias relate to the forms of habitus in which courtiers engaged in the 16th and 17th century city states such as Florence? And what, in Bourdieusian terms, were the forms of capital these courtiers were trying to accrue? These become important questions when considering the rise of Galileo's 'scientific' and 'economic capital'.

1.17 As Biagioli (1993) explains, the giving and receiving of 'gifts' was a central feature of these early courts, especially that of the Medici. Gifts were the key means by which power was sought by courtiers. At the same time the competition between the courtiers enhanced the Medici's own power. As outlined in detail later, Galileo made a 'gift' to Cosimo of four 'Medicean Stars' he had discovered with his new telescopes. This gift was reciprocated by Cosimo with the 'gift' of a gold medal and chain. Still more important for Galileo, he was made the Court's chief mathematician. The status of astronomy and mathematics were thereby boosted relative to that of theology, the latter then being what Biagioli calls 'the queen of the disciplines'. In hindsight, Galileo's recognition as a scientist can be seen as signalling the beginning of a slow decline in the significance of 'religious capital' relative to the scientific capital of astronomy and cosmology.

1.18 Questions of money or 'economic capital' were not explicitly raised in these early Courts. (Galileo's salary was not even discussed when he moved to the Medici Court. He just told Cosimo what he had earned in his previous employment but left Cosimo to establish the level of his 'economic capital'). Rather, 'honour' and 'status' were apparently the most important 'currency', with courtiers (working through brokers with access to Cosimo) pushing for increased status-recognition. Again with the benefit of hindsight, this can be seen as the beginning of a modern system of manners in which money (or economic capital) is not openly discussed in 'civilised' social circles. Rather, honour and status were gained through seemingly non-economic, behaviour. Explicit demands regarding 'economic capital' were avoided, even if monetary rewards surely remained a significant issue for the courtiers and indeed for Cosimo himself.

1.19 In sum, features of the later forms of 'civilisation' and 'state formation' outlined by Elias and Bourdieu can be detected in the early Renaissance city states such as Florence.

Philosophy and social power: cosmology's ancient origins

2.1 A Platonic (and to a lesser extent Aristotelian) divide between a 'pure' cosmos and an impure (chaotic) earth have been a recurring feature of cosmologies at least since the days of Ancient Greece and, as outlined shortly, the division can still be recognised in the present day. It has become a 'doxic' feature of the cosmological field. Yet the division is of course thoroughly 'manmade'. It was originally the product of dominant classes working closely with their philosophical advisers who consistently promoted the 'higher' value of philosophising and mental work as opposed to 'lower' manual labour. Here, for example, is an account of the relationship between economic and cultural capital in Ancient Greece.

The wealthy slave-owners and landlords who welcomed to their banquets the natural philosopher and on whose patronage the latter had to rely, did not want labour-saving devices and despised craftsmanship as degrading (*banausic*) and servile. The pursuit of abstract knowledge for its own sake or as the 'greatest purification' became a consolation to the rich slave-owner who was relieved by his slaves of any need to exert himself

productively (Childe 1982:233).

2.2 Such 'purity' remained a dominant feature of feudal cosmology. Platonic and Aristotelian ideas were adopted and adapted by Christian theology to create The Great Chain of Being, a system of concentric circles in which the outer levels are those containing God and the angels and the central rings circles occupied by priests and kings (as semi-divine beings) and aristocrats. The most inner rings are occupied by, amongst others, actors, serfs, animals and inorganic nature. Here was a philosophy which of course resonated with the hierarchical society of its day, allocating an ordered place for all individuals. Inequalities within the Great Chain had been set by God in his creation of nature (Lovejoy 1960).

Cosmology, Society and Cosmic Elites: Three Case Studies.

Mercantile Capitalism, Galileo and the Cosmos

3.1 The fast-growing mercantile capitalism of the 16th and 17th centuries (particularly that in Northern Italy but rapidly spreading to other European regions) was also the form of society within which modern forms of science, astronomy and cosmology started to be developed. Much of the Platonic 'purity' of earlier cosmologies was retained. But notable too are the ways in which cosmological ideas were distorted in the process of being patronised by economic capital.

Early Capitalism and the Patronage of 'World Systems'

3.2 Economic elites of the Renaissance era ranged from the king, members of the royal family, dukes, viscounts and minor nobility. Economic capital was largely located in these people's land-holdings but the period also saw the beginnings of new forms of property-owners: holders of economic capital, based on the exploitation of labour and new international trade-patterns. Typically, resources were being bought cheap throughout the globe and sold dear in Europe.

3.3 An emergent form of cosmological science developed in this Northern region and other parts of Europe. But the geographical scale of the new science grew rapidly. It developed in small centres such as Florence and Rome. Another example was the Island of Hven in Denmark where Tycho Brahe measured the positions of the stars and movements of the planets, his 'economic capital' being provided by King Frederick II of Denmark (Mosley 2007). Galileo, Brahe, Kepler (who used Brahe's observations) were amongst the most important examples of individuals in a rapidly expanding network of personal contacts enabling the development of early scientific capital (Harris 2006).

3.4 Cosmologies once more took the form (again following the precepts of Plato) of 'pure' circular and uniform shapes. These early theories again had aesthetic as well as a scientific inspiration. And, in line with Bourdieu's perspective on the attempted 'purity' of science, mathematics was made the *lingua franca* of this scientific culture. This was the main discourse used to describe these pure forms but, though 'universal', it was of course a language left inaccessible to subordinated people.

3.5 Economic and scientific forms of capital, and their associated fields, were now being interchanged in a 'Bourdiesian' fashion, with wealthy patrons financing the work of the astronomers. These investments were clearly not instances of scientific capital being purchased by economic elites for their exchange value. Patronage of astronomers, cosmologists, their 'universal' ideas and associated books and instruments were invested in by economic elites as a means of demonstrating and further enhancing their status and power.

3.6 Perhaps most importantly as regards subsequent cosmological forms, kings and holders of economic capital were in competition for the power and prestige associated with distinguished astronomers, cosmologists and their instruments (Westfall 1985; Biagioli 1993 op.cit.; Jardine 1998). While, for example, the King of Denmark patronised Tycho Brahe, the Imperial Emperor Rudolph II was delivering economic capital to Kepler. Such patronage had a distinctly competitive edge and this eventually led to competing observation-based descriptions of what were then termed 'world systems', these being no less than 'a physically grounded model of the cosmos' (Jardine 1998 op.cit.:58). Tycho's cosmology had the Earth fixed at the centre of the world. Around the Earth circulated the Moon and the Sun and around the Sun orbited the five then-known planets. Kepler, however, argued for a compromise, one in which the Sun orbits around the Earth while all other planets orbit the Sun in an elliptical fashion. Galileo followed Copernicus (who as early as the 1510s had advanced the idea of a heliocentric universe) with all the planets circulating the Sun. It was of course the 'world system' of Copernicus and Galileo which prevailed, Newton's laws of gravity later being used to account for the elliptical orbits. But without the competitive patronage of astronomy and cosmology by economic elites the relative speed of cosmological theory-making would surely have been greatly held back.

Cosmic Patronage and Court Etiquettes.

3.7 Particularly important and well-known relations between forms of capital within their linked fields of science and cosmology were those created in Northern Italy (Biagioli 1993 op.cit.). Central were the Medicis. They were a large banking family based in Florence. Its origins stemmed from the feudal era and they remained extremely active in developing the new mercantile form of capitalism. From the 13th century onwards they acquired enormous quantities of economic capital. In the 16th century they moved out of deteriorating trade conditions in Italy and made themselves the bankers of the government of Imperial Spain (Arrighi 2010 op.cit.).

3.8 The Medici family invested massive amounts of economic capital into art, science and architecture. These, in Bourdieu's terms, were early acts of what Bourdieu calls 'symbolic violence', one in which power is exerted not by physical repression but by the creation and reproduction of supposedly 'universal' and 'superior' ideas and ideals. (Bourdieu 1993: 121) The Medicis, in patronising and classifying art and architecture as possessing supposed 'universal' beauty, were exercising forms of cultural and political authority over their social subordinates. The Medicis' economic capital was also invested in Galileo. He is rightly best known for his excellent telescopes, his telescopic observations and, as outlined above, his resulting public support of the sun-centred universe earlier advanced by Copernicus. His use of telescopes to make systematic observations of the universe were later to have far-reaching influences on the development of science and scientific method and the further making of what Bourdieu calls 'scientific capital'.

Cosmic 'gifts' and astrological capital

3.9 However, as contemporary sociologists of science are now pointing out, Galileo's *presentation* of his science in court actually did *not* take the form of a 'pure science' describing the Copernican world system (Westfall 1985 op.cit., Westman 1990, Biagioli 1993 op.cit., Jardine 1998 op.cit.). Indeed, Galileo's relations with his patrons often took a distinctly '*unscientific*', even astrological, form. This seems surprising until we recognise the delicate exchanges of gifts and etiquette characteristic of court life. On the one hand his patrons demanded that Galileo, like other courtiers, should obey court etiquette. On the other hand, Galileo seems to have remained comfortable with such expectations. Here was another form of interdependent relationship between economic capital and science, one perhaps less recognisable in our own era. In his 1610 text, *Sidereus Nuncius* (Fig.1), Galileo announced his discovery of four new stars. He dedicated the four satellites of Jupiter he believed he had discovered to Cosimo Medici, naming them 'The Medicean Stars'. (See Fig.1)

Figure 1. Scientific capital seeks the support of economic capital: Galileo's *Sidereus Nuncius* (or 'Starry Messenger') published in 1610.

3.10 Fate, Galileo suggested, had meant that these stars had *always* and *inevitably* belonged to the Medici family. Fate had also led the Medicis to employ Galileo earlier as their mathematics teacher and as their astronomer and cosmologist. The fact that the stars were 'Medicean' was, according to Galileo, therefore predetermined by the stars themselves.

3.11 Galileo assured the Medicis that their 'ownership' of the stars was also a product of fate. Furthermore, he had noted that the stars had been circling around Jupiter (Cosimo's adopted planet) at precisely the time of the Prince's birth. Jupiter had been near the horizon at the time of this birth. All this gave, Galileo argued, special significance to the connection between the Prince and Jupiter. It also

meant, again according to Galileo, that the high and excellent virtues of the founder of the Medici dynasty had been passed on to the Prince. Furthermore, it was no accident that there were four stars since this was exactly the same number as Cosimo II and his three brothers (Biagioli 1993 op.cit.:129).

3.12 This somewhat contorted and distinctly '*un*scientific' form of astrological logic resulted in Galileo being granted a privileged position in Cosimo's court. As mentioned earlier, having made these stars as 'gifts' or 'novelties' to his potential patrons Galileo was shortly afterwards made the court's chief mathematician and philosopher. And this was shortly *before* he made his famous claim that the Copernican heliocentric world-system is correct. So, although economic patronage of cosmologists did eventually result in the creation of alternative 'world systems', this was by no means a straightforward case of economic capital being invested in already-formed visions of the universe. Etiquette and status also surrounded the rise, and later the fall, of Galileo's Papal patronage. (Bourdieu 1993 op.cit.:37-8). Galileo publish his views in favour of a sun-centred cosmos in *A Dialogue Concerning the Two Chief World Systems*. (A supposedly dispassionate assessment, though clearly favouring the heliocentric model). The permission for this publication had come from a Father Riccardi, an individual close to Galileo's first patrons, the Medicis. The Pope, however, viewed this permission as challenging his authority.

3.13 Galileo's support of the heliocentric universe in *The Dialogue Concerning the Two Chief World Systems* was condemned not for being 'wrong' in either scientific or theological terms. It was deemed 'wrong' because it had threatened the Pope's religious, political and social capital. The Pope could never have been seen as personally in error. If an event had occurred, such as the unauthorised printing of Galileo's book, the culprit had to be someone other than the Pope himself. Court etiquette, issues of status and authority therefore led to Galileo losing his patronage and another courtier taking his place.

3.14 A Bourdieusian analysis of Galileo's relations with the Pope is therefore useful for showing that whether Copernican sun-centred cosmology was correct (or had 'high' or 'low' levels of scientific capital) was not at the time the main issue. Much more significant were the delicate relationships between Galileo's science and the economic and religious forms of capital on which he depended. Galileo well appreciated the formalised etiquettes surrounding patronage. Indeed, he was apparently very adept at forestalling and manipulating court etiquettes. In Bourdieusian terms he was an expert at establishing his 'social capital'. Biagioli detects 'a systematic pattern' whereby:

Galileo invested in a patron who was destined to become powerful and then carefully improved his connection with him by relying on a series of powerful brokers located closer and closer to him'. (1993 op.cit.24)

3.15 So at this stage of early capitalism we find the 'pure' science or 'scientific capital' for which the era is now justifiably famous being the product of what now seem quite trivial issues of etiquette and 'honour'. Yet these issues were by no means trivial. As Elias's 'pre-Bourdieuian' or 'pre-Biagiolian' work on Louis XIV's court clearly shows, etiquette and honour were the central means by which the complex power-relations of the Court were sustained. They allowed a ruler, in the French case *Le Roi Soleil*, to maintain and increase his power (Elias 1983).

Newton and Early Modern Cosmology

4.1 The late 17th century saw further considerable development of 'scientific capital', this now combining with the economic capital being invested into industry. The most dominant 'field of power' was now shifting to Britain and its emergent empire.

Keeping space for God

4.2 But first note that older forms of distinctly 'non-scientific' practice were widely continued, albeit now in highly concealed ways. Newton, like many other eminent scientists such as Robert Boyle, read alchemical texts and conducted meetings with alchemists and hermeticists. Newton was examining alchemy as part of his search for the basic structures of matter. But to admit to such meetings and practices would have clearly undermined the quality of the scientific capital associated with this iconic figure. Astrology now had to be suppressed as 'non scientific'.

4.3 Also note that important remnants of the old Platonic vision of the cosmos were retained. Newton (as President of the Royal Society) continued to insist on the idea of a pure and Godly 'heaven' within his scientifically-defined assertion of an infinite universe. As Wertheim puts it, 'The Royal Society stood on the side of reason, but it also allied itself with the state, the King and God' (2000:73). Though some scientists did shortly afterwards consider supplanting religion with science, Newton found a space for heaven by asserting that outer space was God's *sensorium*. It was a substrate through which God sees all, feels all and knows all. Again, this commended Newtonianism to those with high levels of religious capital, these including not only clerics and royalty but Britain's landed and industrial classes (Porter 2000). God was envisaged by Newton as an occasionally intervening Creator, starting up the cosmos but applying only light-touch regulation to its motions.

4.4 Newton's assiduously promoted his image of a 'gentleman' scientist, one working in a disinterested way to assess the truth or falsity of theories with the aid of evidence. He did not allow the practical applications of his theories to be part of his public image or his working-methods. He was of course *the* pre-eminent member of the new 'scientific field'. His science was central to the scientific capital and practices of London's Royal Society, a small group containing a number of notable scientists (or 'natural philosophers') including Robert Hooke and Robert Boyle. The Royal Society (See Fig.2) offered extensive 'social capital' for those achieving membership. It was to become 'the catalyst for the scientific revolution'

(Gribbin 2006; xi). Indeed, much of what is now seen as modern science and scientific method was at the time encapsulated in the Society.

Figure 2. London's Royal Society. Scientific capital finds economic and political capital.

4.5 Gresham College (above) was later to become The Royal Society. In 1662 it was patronised by King James II, this giving the Society legal status and the ability to accept economic capital in the form of donations. Such patronage also brought status political capital to the King. The Civil War had just ended and the Monarchy was in the early stages of its restoration.

4.6 But while Newton's religious commitment remained intact, other features of Newton's religious thoughts and practice remained concealed. He made sure, for example, that his belief in Arianism (the heretical doctrine that Jesus was not a fully divine being) did not form part his public image. In Bourdieusian terms this would surely have thoroughly undermined his social, cultural and even his economic capital.

From scientific to economic capital

4.7 It was in this era that Newton's scientific capital started being transformed into economic capital in the early stages of the Industrial Revolution. One commonly-held view is that there was little or no relation between the science of this time (including Newton's science) and manufacturing capital. Technological take-up was conducted simply by practical amateurs with little or no knowledge of Newton's science (Matthias 1983). Similarly, it is sometimes argued that Newton had little idea of how his science might be transformed into economic capital. (Jacob and Stewart 2004). Yet this is an over-simple picture.

4.8 Science and Technology Studies have so far made rather little impact on relations between cosmology and society. But the idea that Newton's science had only marginal relations with his society can be countered by Boris Hessen's pioneering historical materialist analysis of Newton's *Principia*. Hessen demonstrated as early as the 1930s that Newton's research did distinctly resonate with dominant economic interests and especially with the rapidly-growing requirements of industrialising capitalism and emergent forms of colonisation. (Hessen 1946)

4.9 The two Civil Wars had broken the hold of the Royalists and those attempting to turn Britain back to feudalism. These wars 'cleared the ground for the development of a society based on market relations and capitalist forms of exploitation' (Harman 2008: 217). Landowners were increasingly forced to mechanise if they were to survive in the new competitive, market-based, society. Industrial innovation also started to grow, this forming the basis of the industrial revolution, a new form of master-slave society and new global trading systems originating in Britain in the mid 18th century.

4.10 How did these changes relate to scientific developments in physics and in particular to Newton's theories? Newton's *Principia* is best known for setting out the laws of gravity and motion; these describing the attraction between masses and the motion of objects throughout the Universe. But, as Hessen

argued, his insights were swiftly taken up by leading representatives of capitalist industry. And Newton's new and improved telescopes had clear economic value for a new era of global colonisation.

4.11 Similarly, Newton's insights into 'hydrostatics' (the pressures exerted by fluids at rest) and into the flotation of physical bodies all fed directly into the emerging requirements of industry and the creation of a new global empire. The design and construction of water pumps, ventilation systems, ships, canals and fortifications were all to benefit from Newton's science. Furthermore, part of *Principia* was devoted to the movement of the Moon and the planets. Newton's astronomical theories later assisted in the development of East-West navigation across seas, rather than navigating close to distant coasts. Newton's scientific innovations, in short, aided the great extension of economic capital, with Britain becoming the centre of a powerful empire.

4.12 There is evidence that Newton had at least some idea of how his 'scientific capital' could be converted in 'Bourdieuian' fashion into economic capital. A colleague at Trinity College wrote to Newton in 1669 saying that he was shortly travelling abroad and asking whether he had advice as to how he should use his time during his travels. Newton made a number of suggestions, the first reflecting his continuing (but still strictly suppressed) interest in alchemy (Turnbull ed. 1959).

'Observe the products of nature in severall places especially in mines with ye circumstances of mining & of extracting metallis and minerals out of their oare and refining them and if you meet with any transmutation out of one species into another.'

4.13 Other suggestions included:

- The examination of fortifications. Those encountered should be examined for 'their fashion, strength and advantages for defence; and other military affairs as are considerable'.
- The means of maritime trade should be examined. As Newton put it: 'Observe ye Mechanisme and manner of guiding ships'.
- Methods of keeping ships in good repair should also be observed, as should means of navigation. The Dutch maritimers should undergo especially close observation. 'You may inform your selfe whither ye Dutch have any tricks to keep their ships from being all worme eaten in the voyages to ye Indys. Whether pendulum clocks doe any service in finding out ye longitude etc.'

Transformations between economic, scientific and cultural capital.

4.14 In Bourdieusian terms, comparatively little economic capital was necessary to set up the Royal Society as the contemporary hub of scientific capital. The Society was 'utterly dependent on its membership fees, these being one shilling per week.' These fees were paid by 'rich amateur scientists' who also acted as trustworthy witnesses of experiments being held in the Society. 'Economic capital' in the form of Newton's legacy and his Trinity College Fellowship was also very small. In 17th century England, at least, cosmological research therefore did not receive massive amounts of economic capital. The Newtonian episode shows, as does that of Renaissance, that the science of 'world systems' could be developed relatively independent of major economic capital.

4.15 Similarly, science did not need immediate application to the economy for it to thrive. But a Bourdieusian focus also alerts us to other new and very important developments in this era. Newtonian scientific capital now started to benefit emergent forms of *cultural* and *social* capital, particularly the new disciplines of politics and economics. For example, John Locke and others made far-fetched extrapolations from Newton's science to the political realm, arguing that a form of politics appropriate to the post Civil War era would be one in which individuals should move peaceably about a Sun-like ruler and, obey simple, quasi-Newtonian, 'laws'. Such extrapolations were of course the origins of the model of parliamentary democracy which remain so widely prevalent today.

4.16 Similarly, Adam Smith's economics was directly inspired by Newton's physics. A God-like state should, as far as possible, stand aside from an economic world in which individuals simply sold goods and services for money. Like the solar system itself, the 'free market' should be envisaged as a harmonious entity requiring little or no outside intervention (Dickens 2011),

4.17 In these ways the transfer of the new scientific capital to the social sciences was used in an attempt to enhance the cultural and social capital of philosophers and theorists such as Locke and Smith. But applying Newtonian concepts in these ways has, as Elias (1956, 2007) has argued, been highly problematic. A 'Newtonian' politics or economics has the immediate effect of detaching the social scientist or policy-maker from the human beings being described. Avoiding an active involvement and understanding of peoples' lives and attempting to transfer 'scientific capital' to these non-scientific areas has since led to much social mayhem and unhappiness.

Cosmology and Economic Capital in Current Times

5.1 Our third case study switches to the modern United States. Here we find still more 'Bourdieuian' transfers between forms of capital. Now, however, there is a major undermining of the idea that science is a 'pure', socially-detached, entity.

5.2 In the years leading up to the Second World War about half the economic capital for astronomy and cosmology came from publicly-funded institutions and the remainder from wealthy philanthropists profiting from the new era of great US wealth (Miller 1970). But now the fields of astronomy and cosmology were being changed and this brought new and increased demands for economic capital.

Traditional astronomical research mapped the sky, this being a step towards understanding all celestial phenomena in relation to Newton's laws.

New cosmologies, old forms of economic patronage

5.3 Increasingly, however, the main function of the new astronomy now was to gather stellar light. This was used in attempts to discover the physical and chemical composition of celestial objects and the age of the universe (Miller 1970 op.cit.). The older telescopes gave mediocre results when applied to the demands of the new astronomy. The field of science associated with outer space now demanded very expensive instruments enabling measurements of light from the cosmos at different frequencies. These techniques required much higher levels of funding and astronomers in the United States increasingly relied on high levels of private patronage.

5.4 New kinds of astronomical observatory were increasingly invested in. And these investments were very often used in 'Bourdieuian' fashion, with exceptionally wealthy individuals using these observatories to further enhance their social and cultural capital. Observatories were large monuments highly visible to the public. They were symbols of 'progress' and, particularly of *American* progress competing with that of Western Europe.

5.5 Economic investments to improve social status were therefore being extended to enhance the status of a whole nation. But they could still bring high levels of cultural capital to patrons with high levels of economic capital. James Lick, for example, was a multimillionaire who funded an observatory near San Francisco later bearing his name. He was a benefactor with considerable economic capital but he was also a senior member of what Bourdieu calls 'the religious laity'. Lick was 'deistically inclined' comments Miller (1970:101). He presumably hoped his investment in an expensive telescope would bring enhanced religious capital and, in due course, a secure place in the heavens.

Big Science, the Military-Industrial Complex and Big Bang

5.6 But relations between economic, scientific and political capital started to fundamentally change around the Second World War. Links between the economic, scientific and cultural now underwent major transformation. Cosmology was now subject to the USA as 'the field of power', one dominated by large corporations, military institutions, the nation state and conservative think-tanks such as the American Enterprise Institute founded in 1943 (Tremblay 2006). Membership of this network, and particularly of the think tanks, resulted in an increased 'social capital' shared by business and government leaders. And this of course could help rise further levels of economic capital, especially for the fast-emerging armaments and space industries.

5.7 The United States emerged as by far the most economically and politically powerful economic nation. President Eisenhower's much-cited 'military industrial complex' was at the centre of the new, dominant, 'field of power'. It was, and very much still is, a formidable combination of economic, social, scientific, and cultural capital. It even retained, as Eisenhower himself suggested, elements of 'spiritual' or 'religious' capital. This is confirmed by Eisenhower's speech which signalled his retirement from the U.S. presidency/ (see www.youtube.com/watch?v=8y06NSBBRtY)

5.8 Furthermore, the postwar period, especially in the U.S.A., was the era of 'Big Science', one incorporating the major American universities now being incorporated into the new field of power. 'Scientific capital' in most American universities was now increasingly reduced to those forms of practically-oriented endeavour able to secure funding from the military-industrial complex. (Leslie 1993 op.cit., Ledbetter 2011, Smith 1993)

The 'golden triangle' of military agencies, the high technology industry, and research universities therefore created a new kind of postwar science, one that blurred traditional distinctions between theory and practice, science and engineering, civilian and military, and classified and unclassified, one that owed its character as well as its contracts to the national security state.(Leslie 1993 op.cit.:2)

5.9 Such was also the setting for the next major stage in the development of astronomy and cosmology. Astronomy and cosmology were now developing another new focus. In 1922 Georges Lemaitre, a Belgian priest, astronomer and physicist, had advanced the idea of the Big Bang. Postwar cosmologists continued developing and assessing the theory, supporting it with speculations about 'Black Holes' and 'Dark Matter'. These concepts generated new cosmological questions. How much time has elapsed since the Big Bang? What is the nature of 'black holes'? These holes cannot, it was argued, be seen directly but might be deduced from observations and measurements of light being subjected to the gravitational pull of black holes and disappearing into them. Evidence for The Big Bang, it was believed, can be established through examining 'redshifts' of light indicating the earliest stages of galactic evolution and its continuing expansion.(Hawking 2005)

Security, state capital and the space telescope

5.10 A new combination of economic and scientific capitals was now centred on making a telescope to be launched into outer space. It would be designed, *inter alia*, to track the evolution of the universe from its origins. New forms of cosmology or 'scientific capital' associated with Big Bang would thereby be developed. Tracking the early evolution of the universe could, it was argued, be provided by a sophisticated telescope whose images were not obscured by the Earth's atmosphere. But even

supposedly 'pure' form of science designed to answer the big questions of cosmic evolution were now fused with demands to improve national security under Cold War conditions. It is not often recognised that the space telescope, in the earliest stages of its development, was promoted as an asset to secure national defence. (Von Braun 1952:44). In addition to observing the depths of the cosmos, it could be turned by the United States back towards Earth, forming a God-like observer of Russian and other enemies.

5.11 Professional astronomers and cosmologists with high levels of 'scientific capital' were to the fore in these developments. The Hubble Telescope, as it was later called, was designed and produced by many thousands of different groups of people throughout the United States and Europe, these including hardware and software managers, administrators and engineers. But economic capital in the shape of Lockheed Martin, a multinational aerospace corporation already designing and building weaponry, was the main economic beneficiary of government patronage. The rocket-launcher technologies already developed by this company for military purposes were now used in 'peaceful' applications such as placing the Hubble Telescope into orbit.

5.12 But now, somewhat abstract and universal ideals of scientific and social 'progress' were advanced as a means of justifying the required state economic patronage. For example, In 1975 James Fletcher (a senior NASA administrator) even summoned up the ghosts of Galileo, Copernicus and Einstein to argue that investment of economic capital into the new cosmic sciences would eventually result in untold economic and cultural advances. Fletcher assured a US Congress Subcommittee that:

'The benefit from Galileo's experiments was literally the Industrial Revolution. How can you put a value on that? We are on the edge of extremely important discoveries in astronomy. Astronomy is starting to blossom in much in the same way as in the days of Galileo and Copernicus. If you ask the two areas the astronomers are most interested in, one would be the quasars, enormous energy sources coming of those objects, second, the nature of our universe.... Is it expanding without end? How did it begin? Is it going to contract again? Understanding those processes will contribute to our fundamental knowledge of science. There could be brand new energy sources downstream, just as nuclear energy came out of Einstein's investigations. By the way, that was astronomy, too. The whole idea of relativity came out of astronomy'. (Cited by Smith 1993 op.cit.:157).

5.13 This appeal for greater economic capital to secure increased scientific capital and further 'progress' is understandable. But some rewriting of history was happening here. The theory of relativity was advanced by Einstein well before the advent of an astronomy able to test the theory. And, as was the case with Galileo and Newton, massive economic investment was clearly not needed by Einstein for the development of his ideas.

5.14 This final case study illustrates a third phase in the relation between scientific and other forms of Bourdieusian 'capital'. Scientific capital could certainly still be converted into economic capital and its combination with the Military Industrial Complex. But in doing so it had now lost its 'purity' and its claims to bringing a universal progress and one without risk.

Big Bang and the inflation of religious capital

5.15 It should also not be forgotten that the mathematically defined 'Big Bang' universe also contains lingering traces of much earlier descriptions of the cosmos. Bourdieu's 'religious' and 'cultural' capital, have remained relatively alive and well in these debates over cosmology, even if they are not as dominant as in Galileo's day.

5.16 As Lerner (1991) shows, Big Bang theory has been deemed 'right' largely because it is mathematically and aesthetically beautiful. Observation is hardly needed. It is true because it is scientifically and aesthetically pleasing. Again, modern cosmology still strongly smacks of a Platonic attitude towards a 'pure' cosmos.

5.17 Close links between religion and the new cosmology also continue. Ever since its invention by Lemaitre, Big Bang theory has been deployed in varying ways to enhance the 'religious capital' of individuals and institutions. Proof of Big Bang has often been considered proof of Divine Creation (Collins 2011). Support for the Big Bang has come from the Catholic Church, most recently from the current Pope Benedict XVI. In 2011 Sir Martin Rees, an enthusiastic proponent of Big Bang and Newton's successor as President of the Royal Society, received the £1m Templeton Prize. This is 'given to a person who has tried to comprehend the many and diverse manifestations of the Divine'(Sample 2011). Somewhat curiously, however, Rees states he is a non-believer in the Divine.

5.18 Big Bang remains the dominant paradigm of contemporary cosmology. Alternatives are strongly contested within the cosmological 'field'. The Hubble Telescope has done much to promote Big Bang, with most cosmologists still seeing definite proof of Big Bang through the observations of 'redshift' light waves offered by the Hubble Telescope. But a subversive minority see these waves as by no means offering proof. And they argue that alternative forms of cosmology (including, for example, the idea that the universe is composed of massive plasmas of gas, electric currents and magnetic fields) are the main features of outer space (Alfvén 1977, Lerner 1991, Frankl 2003, Scott 2006, Ashmore 2006.) But the very considerable scientific, economic and even quasi-religious capital invested by physical science into Big Bang thinking is so far preventing these alternative cosmologies being seriously countenanced or tested. Those attempting to pursue these alternative forms of cosmology have a great deal of difficulty in securing economic capital in the form of research-funds. Bourdieusian 'doxa' remains very much evidence

Conclusion: critical realism and Bourdieu revisited

6.1 In theoretical terms this paper has been largely based on parts of Bourdieu's work, particularly the relations between economic and other forms of capital, especially social, religious, scientific and aesthetic capital. More valuable work could be done by taking Bourdieu's concepts still further. For example, what of the 'habitus' now informing relations between cosmologists and astronomers on the one hand and economic institutions (including research bodies, companies and governments) on the other? What are the (often tacit) etiquettes, 'manners', rituals and practices adopted by those with scientific capital and seeking support from those with economic capital?

6.2 As suggested in the paper's introduction, Bourdieu's work could be taken further still by linking it to historical materialist accounts of social change (Arrighi 2010 op.cit.). Bourdieu's work nowhere seriously suggests how systems of social reproduction are, or could be, fundamentally changed. It is a 'conservative' theory insofar as it largely concentrates on how patterns of domination are 'reproduced' (Calhoun 1993). This problem could start being addressed by properly recognising the dynamism and causal mechanisms of a globalising capitalism over the past four centuries.

6.3 The obvious link between Bourdieusian sociology and these wider process is 'economic capital'. Bourdieu insists that economic capital dominates other forms of capital. But historical materialism, with its focus on modes of production, class relations and recurrent economic crisis, pinpoints how and why economic capital remains dominant over other forms of capital. Forms of cultural and social capital come and go but, as this paper has suggested, economic capital (one based on property-ownership and the exploitation of labour) has remained a fairly constant feature of Western societies over the last four centuries.

6.4 In summary, what Bourdieu calls his 'thinking tools' can and should be combined with macrosociology of the kind offered by Arrighi. And, while still focussing on Bourdieu, we can see the value of older forms of sociology, particularly that of Norbert Elias. But such fusions could easily become chaotic without some guiding ontology. This is where a critical realist focus (one applicable to the social as well as the natural and physical sciences) is important.

6.5 The major social and political issue surrounding science and society now, and one of immediate interest to critical realists, is that originally spelt out by Adorno and Horkheimer in *Dialectic of Enlightenment* (1994). The physical sciences have been making a steady somewhat stately progress but in the meantime they have been applied and (mis)used by the powerful to enhance their economic, political and social capital. Yet, as Adorno and Horkheimer also remind us, it has been precisely Enlightenment ideals which allow the socially-powerful to be challenged and held to account as to their uses. An historical focus of the kind offered by this paper shows how cosmological science, has been made. But it also shows, particularly in Case Study 3, how such science has been used and, in our own time, perverted and limited the insights of science. Critical realist sociologists and scientists alike need to constantly challenge such perversions and subversions.

Acknowledgements

Thanks to James Ormrod and two anonymous referees for comments on earlier versions of this paper.

References

- ADORNO, T. and Horkheimer, M. (1979) *Dialectic of Enlightenment*. London, Verso.
- ALFVEN, H (1977) Cosmology: Myth or Science? in Yourgau, P and Breck Allen. *Cosmology, History and Theology*. New York, Plenum Press. [doi://dx.doi.org/10.1007/978-1-4615-8780-4_1]
- ARRIGHI, G (2010) *The Long Twentieth Century*. London, Verso.
- ASHMORE, L (2006) *Big Bang Blasted*. London, Booksurge.
- BENTON, T., Craib, I. (2001) *Philosophy of Social Science*. Basingstoke, Palgrave.
- BIAGIOLI, M. (1993) *Galileo Courtier*. Chicago University Press.
- BOURDIEU, P (1986a) 'The Forms of Capital'. In Richardson J (ed) *Handbook of Theory and Research for the Sociology of Education*. New York, Greenwood.
- BOURDIEU, P (1986b) *Distinction*. London, Routledge.
- BOURDIEU, P (1990) *The Logic of Practice*. Stanford University Press, California.
- BOURDIEU, P (1993) *The Field of Cultural Production*. Cambridge, Polity.
- BOURDIEU, P (2000) *Pascalian Meditations*. Cambridge, Polity.
- BOURDIEU, P (2004) *Science of Science and Reflexivity*. Cambridge, Polity.

- CALHOUN, C (1993) 'Habitus, Field and Capital: The Question of Historical Specificity'. In Calhoun C., LiPuma, E, Postone, M. (1993) *Bourdieu. Critical Perspectives*. Cambridge, Polity.
- CHILDE, G (1982) *What Happened in History?* Harmondsworth, Penguin.
- COLLINS, H (2011) 'God Behind the Big Bang, Pope Says' <<http://www.aolnews.com/2011/01/07/god-behind-the-big-bang-pope-benedict-xvi-says/>> (Accessed 7 Sept. 2011).
- DAVID, M.(2005) *Science in Society*. Basingstoke, Palgrave.
- DICKENS (2004) *Society and Nature*. Cambridge, Polity Press.
- DICKENS, P, Ormrod, James (2007) *Cosmic Society. Towards a Sociology of the Universe*. London, Routledge.
- DICKENS, P (2011) 'Society, Subjectivity and the Cosmos', *Journal of Critical Realism* 10.1 pp.5-35.
- DURKHEIM, E (1915) *The Elementary Forms of the Religious Life*. London, Allen and Unwin.
- ELIAS, N (1983) *The Court Society*. New York, Pantheon.
- ELIAS, N (1994) *The Civilizing Process*. Oxford, Blackwell. (Revised Edition).
- ELIAS, N. (1956) 'Problems of Involvement and Detachment' *The British Journal of Sociology*. 7,3 pp.226-252.
- ELIAS, N.(2007) *Involvement and Detachment*. (Vol.1, Collected Works.) University College Dublin Press.
- ERICKSON, M. (2005) *Science, Culture and Society*. Cambridge, Polity.
- FRANKL, H. (2003) *Out of This World*. Cardiff, Cardiff Academic Press.
- GRIBBIN, J (2006) *The Fellowship*. London, Penguin.
- HARMAN, C (2008) *A People's History of the World*. London, Verso.
- HARRIS, S (2006) 'Networks of Travel, Correspondence and Exchange' in Park, K, Daston, L (eds) *The Cambridge History of Science. Vol.3*. Cambridge University Press.
- HAWKING, S (2005) *A Briefer History of Time*. London, Bantam.
- HESSEN, B (1946) *The Social and Economic Roots of Newton's Principia*. Sydney, Current Book Distributors. See also http://webfiles.mpiwg-berlin.mpg.de/readingClassics/Hessen.pdf/V1_Hessen.pdf.
- JACOB, M, Stewart, L (2004) *Practical Matter*. Cambridge MA, Harvard.
- JARDINE, N (1998) The Places of Astronomy in Early Modern Culture *Journal for the History of Astronomy* xxxix, pp.49-62
- LEDBETTER, J (2011) *Unwarranted Influence*. New Haven, Yale University Press.
- LERNER, E (1991) *The Big Bang Never Happened*. New York, Vintage.
- LESLIE, S. (1993) *The Cold War and American Science*. New York, Columbia University Press.
- MATTHIAS, P. (1983) *The First Industrial Nation*. London, Methuen.
- MILLER, H. (1970) *Dollars for Research*. Seattle, University of Washington Press.
- MOSLEY, A. (2007) *Bearing the Heavens*. Cambridge University Press.
- PARSONS, T (1966) *Societies: evolutionary and comparative perspectives*. Englewood Cliffs, NJ, Prentice Hall.
- PORTER, R (2000) *Enlightenment*. London, Penguin.
- REES, M (2003) *Our Cosmic Habitat*. London, Phoenix.
- SAMPLE, I. (2011) 'Martin Rees wins controversial £1m Templeton Prize'. <<http://www.guardian.co.uk/science/2011/apr/06/martin-rees-templeton-prize>> (Accessed 7th Sept. 2011).
- SCOTT, D (2006) *The Electric Sky*. Portland, Mikamar.
- SMITH, A (1970) (1776) *The Wealth of Nations*. Harmondsworth, Penguin.

SMITH, R (1993) *The Space Telescope*. Cambridge University Press.

TREMBLAY, R (2006) 'The Five Pillars of the U.S. Military-Industrial Complex.'
<<http://www.thenewamericanempire.com/tremblay=1038htm>> (Accessed 03.10.11).

TURNBULL, H (1959) *The Correspondence of Newton. Vol.1, 1661-75*. Cambridge University Press.

VON BRAUN, W (1952) 'Prelude to Space Travel'. In Ryan, C (ed) *Across the Space Frontier*. London, Sidgwick and Jackson.

WERTHEIM, Margaret, (2010) Lost in Space: the Spiritual Crisis of Newtonian Cosmology. In Bryson, B. *Seeing Further*. London, Royal Society.

WESTFALL, R (1985) 'Science and Patronage; Galileo and the Telescope'. *Isis*, 76,1, pp.11-30.
[doi:dx.doi.org/10.1086/353735]

WESTMAN, R. (1990) 'Proof, poetics, and Patronage' Lindberg, D and Westman, R. (eds) *Reappraisals of the Scientific Revolution*. Cambridge University Press.