

Commercializing environmental data: seeing like a market

Abstract

Research on science and innovation frequently explores the processes, practices and politics of scientific research and its commercialization. There has been rather less attention to the ways that data infrastructures are commercialized and marketized, particularly in a geophysical science like meteorology. This chapter explores the ways in which changing governmental regulations of public service organizations such as the Met Office in the U.K., and the National Weather Service in the U.S., reflect increasingly neoliberal discourses about the value, purposes and efficiency of data collection and use. In particular, a detailed exploration of the historical development of funding and accounting regimes for the Met Office demonstrates how ideals for marketization has steered changes to the data infrastructure.

Introduction

In Scott's (1998) classic account of government, *Seeing like a state*, he argues that state power is established through an administrative vision that enables government to track, monitor and record citizens, and engineer policies to enhance economic development. Increasingly, seeing like a state means 'seeing like a market' (a term used in reference to Foucault by Tellmann, 2009 and being developed by Fourcade and Healy, 2013). Markets have become dominant ways of resolving all kinds of policy problems from CO₂ to water supply, and from energy to healthcare. More fundamentally, the general epistemic warrant given to 'the marketplace' as the best adjudicator of expertise is a core trademark of neoliberal thinking. In the 'marketplace of ideas,' the market delivers the best verified and established information, its raw information processing capacity far surpassing the ability of states or intelligent persons (Mirowski, 2011). Markets can be trusted to deliver solutions not simply because they may provide regulatory fixes for a wide range of problems, but because they have the ability to *know* better than a state could. As Mirowski (2012) somewhat bluntly states, a neoliberal agenda does not invest hope in state-funded science, but rather in the "day when all knowledge (and not just science) is comprehensively funded and coordinated by the market, which really means private corporations, and state-organized research is reduced to a pitiful insignificant remnant" (Mirowski, 2012: 306). If states see like markets, then there would be a withdrawal from state funding of science and state intervention into knowledge production. In line with this conclusion, a significant literature on the political economy of science has emerged particularly focusing on innovation, research and development as arenas in which marketization is increasing visible (and as chapters in this book demonstrate). But in Scott's (1998) account, data practices are central to seeing like a state whether through censuses, surveys or maps. Likewise in Mitchell's (2002) account of the formation of national economic management, there is a reorganization and transformation of calculative practices (property titling, surveys and maps, national statistics) that is crucial to establishing 'the economy' as an object for development. Data are equally central therefore to seeing like a market.

Debates about the commercialization and marketization of data are familiar within the context of biomedicine and pharmaceutical science, focusing on the loss of the free and open exchange of information, the data agreements that restrict further use, and the studies that are simply obscured or published with limited or misleading findings (e.g. Krinsky, 2003). Yet it is not just in the fields of biomedicine that data have become a critical site for governmental intervention in the spirit of market and neoliberal oriented reforms. As Bates (2014) has noted information policy across government is central to delivering on such neoliberal visions. In the U.K. the settlement in the 1950s-70s whereby data were funded by taxpayers for the general public good, was transformed by the cost recovery programmes of Thatcher's government in the 1980s, a settlement that is being transformed again now by open access. Government agencies have been under pressure to demonstrate and extract the economic value of the data they provide and store. This is as true with the case of environmental, particularly meteorological, data and services as it is with other areas of government remit.

This question of what government should provide has often been considered more broadly in terms of the literature on public goods. In meteorological terms, public goods are often considered to cover basic infrastructure, essential data products and some basic services such as severe weather forecasts, where lives are in imminent danger (Freebairn and Zillman, 2002). They are national public goods as their provision is non-rival and many users benefit from their consumption. But not all data or forecasts would be considered public goods. High resolution data beyond what publics would regularly use and specialist forecasts (whether more spatially specific or temporally or weather specific covering particular industry requests e.g. for frost for creating cement) would be considered to be value-added. In other words, data and services that emanate from the same infrastructure are conceived differentially as public or private goods based on the use to which they are put. As Johnson and Rampini (this volume) point out in the case of global climate models, the models are not built for one purpose or user but they are made to be relevant for purposes or users by the "institutional and financial orders governing production and distribution of data." Likewise in meteorology, I suggest, what is to be defined as a core public good part is not a settled object, but rather an emergent configuration shaped by regulations and ideals. If, as this chapter will suggest, these regulations and ideals are increasingly moulded to commercial and neoliberal ends, then this is a significant area for research within the political economy of science.

It is this chapter's core claim that environmental data in the U.K. and the U.S. are increasingly treated as markets rather than as primarily public goods. Yet this is neither a straightforward process towards marketization nor one that leads to outcomes that are always welcomed by commercial actors. Commercialization and marketization are messy processes (Mirowski and van Horn, 2005) and thus seeing like a market is not simply an unfolding story of neoliberal achievement. In the case of meteorology explored here, I first outline a brief history of commercial meteorology to outline some of the market-oriented practices they have suggested, but then in more detail move on to consider how governments have translated the goals of national meteorological providers, particularly the UK Met Office, to deliver on the commercial value of meteorological data and services. This is achieved through changes in accountancy practices and regulations and policies that define public and commercial services, but which re-define their objects in new ways. It is the contention in this chapter that these have frequently paralleled neoliberal arguments, but that these have been resisted and transformed too, such that what has been developed reflects a diversity of practices. That said, the fundamental presupposition of the centrality and vitality of the

'marketplace of ideas' is central and it is therefore important to combine studies of complexity in practice as STS-scholars are so expert at doing, with a renewed attention to the political economy of science that directs analytical focus to the ways in which science is increasingly seen like a market.

Early arguments for market-oriented meteorology from industry

Meteorology as a discipline has long had a commercial component, particularly in the U.S. A surplus of war-time (WWII) trained meteorologists led to the creation of a raft of new commercially-oriented meteorological jobs within companies and an emergent consultancy sector. Commercial meteorologists made regular claims for their value and usefulness to society not least in relation to economic sectors such as agriculture, fisheries, energy, air pollution and importantly aviation. For example, Du Pont offered short range weather forecasting for construction and to predict storms and tides for plants in vulnerable coastal locations and, in 1953, established a Severe Weather Advisory Service (Collins and Evans, 1958). For Du Pont, the advantage of a private sector meteorologist was that they intimately knew the company's plant sites and could therefore understand the interactions between weather events and the specific conditions of each bay and inlet, in a way the Weather Bureau could not. As Francis Reichelderfer, Chief of the Weather Bureau, said: "The government cannot possibly handle all the applications of meteorology for aviation and industry. Is it to be left undeveloped because the Government cannot handle it?" No; after all, he continued, "Americans believe in private enterprise" (Reichelderfer, 1949: 79).

Commercial meteorology organizations were growing in number, led by people like Malone at the Travelers Insurance Company based in Hartford, Connecticut who headed up the Travelers Weather Research Centre within the company in 1954 (Janković, 2015). Malone estimated a quadrupling of private consultancy companies in the previous 10 years (but this would have been from a very low base of less than 10 in the 1940s) and noted that a new organization was needed: a meteorological equivalent of the National Bureau of Economic Research. Weather knowledge could aid economic growth and profit, not just simply act as an information service. Even university meteorologists were starting to embrace the new commercial operations. David Ludlum, Chairman of Committee on Industrial, Bureau and Applied Meteorology stated that "It is an unimaginative meteorology professor who walks on campus today without two or three consulting contracts in his pocket" (Ludlum, 1953: 125).

Commercial meteorologists however had to work hard to convince doubters of their expertise. A long-running jibe suggested that commercial meteorologists were counterfeiters in that they took public meteorological information and put their own twist or specificity on it, but did not really add anything in terms of expertise (see critiques of this in Courtney, Jr, 1979; Smith, 2002). Cheerleading for the commercial meteorologists, on the other hand, were people like Charles Pennypacker Smith, of Pacific Gas and Transmission, who argued that "active, overt, challenging, and financially rewarding competition" was the key to a thriving commercial meteorology (Smith, 1970: 97). Even individuals whose ideas might be considered crazy should be allowed expression he stated noting a forecaster in the company who believed that a severe winter storm in the English Channel would be

followed a week later by a damaging storm in California. Why should such claims simply be discarded by scientists without seeing if they work economically? The marketplace would decide what would be considered relevant expertise, not some notional scientific expert.

In part as a result of fears that 'crazy' claims might diminish the professionalization of commercial meteorology, a system of Certified Consulting Meteorologist was established by the American Meteorological Society in 1957 to enable a formal process to recognise expertise within the commercial meteorology sector and protect their reputations. A parallel, though not equivalent, marker of expertise emerged from the University of Birmingham, which established an MSc in Applied Meteorology and Climatology in 1963 to enable the development of applied and commercial meteorology (Janković, 2015). During the 1960s the American National Council of Industrial Meteorologists was organised as a professional body and about 36 companies featured in lists of applied meteorology in the Bulletin of the American Meteorological Society. In the 1970s, some research labs were outsourced (though this was not a universal change) and consultancies emerged to perform the research previously conducted by the in-house teams (see Mirowski and van Horn, 2005, for the general point). By 1971 there were 52 firms offering consultancy work listed in the Bulletin of the American Meteorological Society with 21 having at least one of their personnel trained formally as a Certified Consulting Meteorologist. The number of private meteorology companies listed in BAMS rose to 81 by 1979 and by 1990 it was over 100. Spiegler's (1996) review suggested that there were then over 2200 private meteorologists by 1996 with their companies having a business volume of \$780-1100 mn per year. In the U.S. this proliferation of firms, as compared to the U.K. (Ellig, 1989), has been said to arise from the funding structure of meteorology. To explore the different funding structures and how they have been translated into a market-oriented agenda, I next turn to the government side of this story.

Government interest in the commercial value of meteorology

As meteorology embraced numerical modelling that required ever-faster computing power, the cost to government increased rapidly, leading to much concern to economically justify investment in meteorology especially for publicly funded offices (Janković, 2015). An economic rationale, however, was not uniformly implemented and it is worth briefly contrasting the regulatory cases of the U.S. and the U.K.

In the U.S., the progenitor of the National Weather Service was founded in 1870 under the title of 'The Division of Telegrams and Reports for the Benefit of Commerce' (Fleming, 1990). Concerned with a disciplined telegraph system, it was established under the Department of War, but was renamed the Weather Bureau and transferred to the Department of Agriculture in 1890 where it was sited until transfer to the Department of Commerce in 1940 (Daipha, 2015). The name was changed from the Weather Bureau to the National Weather Service (NWS) in 1970 as it moved under the administration of the National Oceanic and Atmospheric Administration. Except for a brief foray into charging for data in the late 1940s (Spiegler, 1996), the NWS provided data for free enabling companies to use this to create and tailor forecasts and services to their own needs. This

was central to government policy to only provide essential public services and basic infrastructure – what Freebairn and Zillman (2002) classified as public goods - while leaving the rest to commercial operators. As re-iterated in a 1991 government policy statement, the NWS focus was to protect life and property (e.g. severe weather alerts) and, for all else, to provide freely accessible meteorological data which private meteorologists could use to construct their own products (Daipha, 2015; Spiegler, 1996).

While the NWS continued to issue regular forecasts through into the 1990s, they lost out to competition: in media, from television news stations and particularly the Weather Channel for public weather forecasts, especially once news stations acquired their own weather radars from the 1980s; and for specialist forecasts, to commercial weather forecasters e.g. in 1995 the NWS passed on its agricultural and non-wildfire fire weather services to commercial operators (Daipha, 2015). Private weather companies were establishing “new weather information display techniques, private weather data networks and uses of computer managed databases that rival those being created in the government and, at times, surpassing the capabilities of the federal weather service” (Pearl and Henz, 1980: 280). The NWS’ role was to set this market free.

In the U.K. on the other hand, there was a rather different regulatory set-up. Historically, the UK Met Office started out in the 19th century within the Board of Trade, but was transferred to defence in the First World War, and remained in the Ministry of Defence until coming round full circle with the transfer to Business, Innovation and Skills in 2011 (Hall, 2015; Walker, 2012). While the Met Office provides public information and forecasts from its own data as with the NWS, it can openly compete with commercial companies in selling more specialised weather services and products too. This has led some private meteorologists to claim that the Met Office can act as a monopoly competitor that forces competition out by inflating data prices and cross-subsidising its commercial operation from its public expertise (see for example Ellig, 1989). Ironically, therefore, the need to generate a market-oriented meteorology in the U.K. has established a framework in which the monopoly provider is widely criticised for blocking the emergence of competitors i.e. being anti-market at some level. Commercial meteorology was much slower to emerge and generate significant investment, at least in part because of the Met Office’s dominant position in the marketplace (Ellig, 1989).

The structure of the government agency for meteorology plays an important role in shaping the prospects for commercial meteorology. As Ellig (1989: 14) puts it, “The British policy attempts to make a government bureau function more like a private business, while the US policy restrains a government bureau so that private businesses can enter the field.” While the U.S. approach enabled the NWS to support a market in commercial meteorology, in the U.K., the same organisation that provided the public goods (the Met Office) would equally be encouraged to sell commercial services to maximise cost recovery. The arguments in the U.K. and U.S. have strong family resemblances, not least in their desire for marketization, but they are institutionalized and regulated in contrasting ways; what might usefully be termed ‘variegated neoliberalism’ (Brenner, Peck and Theodore, 2010). Both were based on an interpretation of the arguments about public goods.

Public goods, for economists, are non-rival and non-excludable, benefiting all and their use by one does not affect their use by another. Meteorological data and forecasts might seem to sit fairly neatly within this definition, except that it prompts a further question – whether the same level of quality and quantity of data and forecasts provided are needed for all users? In other words, do all users benefit equally from enhancements in meteorological capacity? For the U.S. the answer was that only basic data was a public good. The pitfall of this system, for marketeers, was that there was arguably little incentive to improve the quality of basic data if the agency responsible for its construction had no commercial stake in the value that this data received in the marketplace. The challenge with charging for basic data, however, was that there was a monopoly supplier (the national meteorological service) and if that supplier was also competing with value-added suppliers then there was an inequitable competition basis. This prompted a more complex debate in the U.K. about the boundary between public and private goods. This played out through shifting regulatory and accounting environments for the Met Office and it is useful to turn to these next to explore the contradictory dynamics of commercialization.

Making meteorology a commercial activity for government

The Met Office was perceived to be a prime candidate for emerging Trading Fund legislation in the 1970s. Trading Funds would set up a new efficient management for government offices that served public and (potential) commercial goals. The advantages of the Trading Fund designation were seen to be greater accountability for staff, clearer internal management, better cost recovery and a clear demarcation between services that would be provided on a commercial basis and services that needed to be provided on a public basis. Within trading funds, internal accountancy changes would enable better cost recovery through charging end-users for data and services, while maintaining an ideal of public service too. For environmental data, this legislation implies treating science as another kind of bureaucratic concern to deliver on economic goals.

But if the Trading Fund legislation is clear in what it sets out to achieve, in practice it did not simply roll out easily. There were competing arguments about the legislation including concerns about what might happen to data or products which might not attract sufficient commercial value but would still be societally important. Trading Funds did not necessarily mean that services in the public interest would be abandoned where there was no substitute or where they failed to pay their way (Earl of Lauderdale, 1973, from Hansard documents), but rather that the designation of Trading Funds would establish an economic rationale for recovering the costs of taxpayer funded work. Users would be central and enable the marketplace of users to shape the nature of future government work rather than experts always defining what should be provided. But there were concerns:

the Government are inclined to regard the trading fund device as essentially a managerial device which does not necessarily affect policy, that it ... is really only another way of running the Ordnance Survey... I am concerned, as indeed are many people who use maps, that the availability and cost of these maps is likely to be determined much more by a commercial approach (Earl of Lauderdale, 1973, from Hansard documents).

The Earl's angst here was that, for maps, for example, given that the main users would be other public bodies, in essence one part of the government would be trying to extract revenue from another part of government. The 'customer-contractor principle' would mean that information users would pay the relevant cost of access to the information they required. This legislative change needed to be accompanied by an accounting change within organizations like the Ordnance Survey and the Met Office to distinguish public and commercial services.

The key accounting change was from a public service approach to a cost recovery system. As Broadbent and Guthrie (1992: 3) have suggested, public sector accountancy moved from a concern with "probity, compliance and control..." to one where "the emphasis now is on changing the character of the discourse and technologies to promote what is characterized as efficiency, effectiveness, cost savings and streamlining – managerialism in the public sector" (see also Robins and Webster, 1988). By exploring the full cost of providing public services, management hoped to achieve greater efficiencies within the public sector (Ellwood and Newberry, 2007). Indeed in the case of the Met Office, which was not formally instituted as a trading fund until 1996, these accountancy changes in the 1980s shaped the organisation to behave in a commercially-oriented way that steered the organization towards Trading Fund status.

The National Audit Office, which was set up in 1983 with the National Audit Act to aid with privatisation programmes (McEldowney, 1991), made two key arguments for a better cost recovery of services. First they suggested that Met Office free services restricted growth; that is they prevented the development of a marketized meteorology. Second, drawing from the work of consultants, they concluded that the Met Office activities were under-priced which meant that government was not recovering as much money as they could do (National Audit Office, 1986). Cost recovery accountancy, on the other hand, would enable a clearer structure in which the Met Office could become more economically efficient. In practice, cost recovery sent the budget deficit down as private users were charged for information on a commercial basis, but with accountancy changes the expenditure on free services went up as the percentage of overheads attributed to the public services was increased significantly between 1983-5 (Table 1).

| | 1983-4 | 1984-5 |
|-------------------------------------|--------|--------|
| Budget deficit | £8mn | £0.8mn |
| Expenditure on free public services | 10% | 28% |
| Attribution of central overheads: | | |
| Armed forces | 46% | 40% |
| Free public services | 10% | 32.5% |
| Civil aviation | 22.5% | 22.5% |
| General repayment | 21.5% | 5% |

Table 1. Changes in annual report for cost attribution between 1983-5 (data from Sharp and Hansford, as synthesized in Wood, 1997).

The Met Office needed to generate further revenue. The 1985 Sharp and Hansford report's answer was that data would not be available free of charge since it was not in the public (taxpayers) interest (Sharp and Hansford, 1985) and charging at commercial rates would prove the value of meteorology

to government. Equally, prices could not be too high or else customers would rely on that basic, free public weather information and thus not pay for enhanced data or forecasts (National Audit Office, 1986). Charging for data would maximize the public value from taxpayer investment as it would focus attention on those services the 'users' actually wanted. Data would be treated as a market good. The taxpayer would only indirectly reap any benefits from meteorology as the public would not have free access to all the enhanced data or products.

With the promise of more independence for an organization like the Met Office came the unambiguous message that the price of this freedom was an orientation to commercial activity. "The Met Office is in practice a business activity and not a government organization in the usual sense and therefore it should adopt a commercial approach in all its dealings" (Sharp and Hansford, 1985: 14). Internally, the Met Office would have to account for the division of all of its activities: those that served a clear commercial purpose with products that would be priced at a level the market would bear, and those that were essential for public services such as emergency weather forecast alerts. Met Office staff were less than comfortable with this division not least as it enforced artificial separation between forecasters work and frustrated managers confessed that some parts of the operation paid too little regard to business targets with the National Audit Office (1995) commenting that managers had resisted changes to traditional ways of working amidst claims that new ways of measuring performance were inadequate. In the 1990-1995 period the Met Office was placed under clear efficiency targets, including stronger engagement in performance management, reduction of costs, and a 6% increase in uptake in services across both the public and commercial sectors with commercial service revenue to increase by 10% (Walker, 2012). This led the Met Office to adopt new commercial activities though many private meteorological companies complained that the Met Office had an unfair advantage based on its ownership and pricing of the datasets that only the Met Office had the power to collect.

The Met Office was finally established as trading fund on 1st April 1996 and faced immediate targets to further enhance efficiency, customer satisfaction, model accuracy and a value-for-money index to judge the quality of its services (Walker, 2012). Further bureaucratic performance management measures were enacted to improve efficiency and effectiveness in the new commercial era. Yet, if the trading fund legislation was to encourage competition, there has been a conspicuous lack of serious competition in British meteorology. As Mirowski (2011: 268) notes, "once data provision becomes privatized, it usually follows that a form of oligopolistic competition sets in." Despite some high profile casualties such as the Met Office losing prestige weather forecast contracts such as for the BBC, ironically because the BBC was forced to seek out the best value for money (BBC, 2015), the Met Office accounts show that it still receives some 80% of its funding from government sources. So while the Met Office has been made to see the provision of meteorology as like a market, through accounting, legislation and internal targets, the state remains its biggest market.

That said, after the Met Office officially became a Trading Fund, its then Chief Executive Prof. Julian Hunt argued that the new commercial-like operation would present "great opportunities to be competitive in the growing markets for meteorology and environmental services" (Cited in Walker, 2012: 429). One of its flagship interventions was the 2001 establishment of the company weatherXchange, a joint partnership with a financial brokerage company. WeatherXchange was

formed to provide services (data and forecasts) to the emerging weather futures market, an industry that by its very nature transformed meteorological information into a market (Randalls, 2010). It was to enormous embarrassment that weatherXchange went bankrupt with the loss of about £1.5mn of public funds and to even greater discomfort when called out at a parliamentary hearing in 2006 after Met Office executives publicly stated that they had deliberately undercut their joint venture to achieve a greater share of the market and profits themselves (see Randalls, 2010). They had demonstrated in this one incident just how much the Met Office could see like a market. By 2013-14, the Met Office was making an operating profit of £11.2mn (Hall, 2015). But there was a new challenge ahead: increasing pressure to free, open access to government data, a campaign that potentially imperilled the cost recovery settlement developed from the 1970s.

Towards open data

In the 2000s, movements for open access data including *The Guardian's* 'Free our Data' campaign put pressure on the U.K. government to release more data to public (and commercial) access. The UK's Department for the Environment, Food and Rural Affairs (hereafter Defra) was set a target to deliver 8000 open datasets by June 2016 for everything from long-term ecological monitoring and environmental quality, through to ecological survey data, the national food survey and agricultural statistics (Coley and Newman, 2016; Ross, 2016). Central to this was a concern to put users first and consider how open data might be taken up in productive ways. In principle what this meant was that data are to be adjudicated and valued by the marketplace of users while data providers compete (or in the case of government departments enhance quality provision) to meet user demands (see the Defra Digital blog e.g. Kavanagh, 2016). Indeed data releases have been described as being on a 'use it or lose it' basis because government cannot afford to keep producing open data for only a few end-users (personal communication). Data that are of limited user value, but not demonstrably in the public interest, may simply be removed as the new strictures on quality and availability of data restrict the possibility of maintaining everything.

As government agencies are to account for and recover costs from their data and services, yet increasingly be open access, there are real challenges, particularly where a significant data infrastructure is required (Edwards, 2010). Within remote sensing, there has been considerable discussion of the possibilities and pitfalls of open vs commercial satellite system data. Johnston and Cordes (2003) discussed the Landsat satellite system where new laws in the 1980s were enacted to privatize the operation of weather satellites and the commercialization of remote sensing capabilities. This was intended as a 10-year experiment, but lasted a little less than that and was repealed in 1992 as the commercialization had not been successful. As a result of this Landsat data became freely provided with no restrictions on commercial use (Harris and Baumann, 2015). The Iraq war further emphasized the value of government-owned Landsat data and there were few signs that Landsat had the capability to operate as a commercial-only entity (Johnston and Cordes, 2003). That, however, did not prevent debates about whether its data were all essential for providing other public goods and, in an era of cost recovery, whether other government agencies would pay for that data. By 2001 there were competing remote sensing systems generating data for diverse users with

commercial systems providing high spatial resolutions. There was concomitantly a significant expansion in private or licensed data.

In the case of satellite data, a series of riders were placed on what kinds of data should be provided free of charge, including exemptions if data were affected by issues of security, law, IP, commercial confidentiality, statistical confidentiality, proprietary interests, availability of resources and so on (Harris and Baumann, 2015). In practice that could cover nearly everything in principle leaving “both data providers and data users with large uncertainty with regard to individual data sets” (Harris and Baumann, 2015: 53) not knowing if they would be maintained, or access would be continued. For the Met Office, likewise, there were similar problems if taxpayer-funded data was released when users were quite prepared to pay a charge for those services enabling the Met Office to recover its costs (Hall, 2015). Commitments to open data were couched within the economic language of preceding approaches (cost recovery), but as Harris and Baumann (2015: 52) put it “The supply of data free of charge requires continuing assured long-term public funding,” precisely what governments did not want to commit to without seeing direct economic returns. The challenge of opening up access to government data had to be squared with the need to maintain arguments about economic efficiency, recovery of costs and marketplace superiority (see Bates, 2014, and Mullerleile, this volume).

Open access may create alternative possibilities too, but it is important to diagnose the continuing neoliberal rhetoric at the heart of this political economy of science when it comes to seeing like a market for environmental data provision. While commercialization and economization are not specifically new (Berman, 2014; Hall, 2015), there are neoliberal resonances in much of the debate about meteorological data. It is not simply about extracting efficient economic value from government services. It is about opening up that data infrastructure to be reorganized as a market in which the marketplace delivers an assessment of the value of the kinds of data produced. It is the marketplace that should reign supreme in deciding on data, not some notional experts or governments. Government agencies are to be taught to see like a market. The example of open data hints at how determinations of the value of data through the marketplace could have significant consequences on what kinds of data are produced and maintained. If only what is used and valued now is maintained in the marketplace of data, then this has all kinds of consequences for the availability of data that might have been useful for other projects in years to come. “*Après moi le déluge!* is the watchword of every capitalist and capitalist nation” (Marx, 2008: 155).

To return to the example of weatherXchange and the weather futures market, traders are much more concerned with accurate, timely data than with improvements in modelled cleaning of data for the long-term records. This is because weather future contracts pay out on the data provided at a specific meteorological station at a specific time and if data are wrong or an instrument is moved without much notice, there is nothing that can be done about it financially (Randalls, 2010). Correcting historical records after the fact is irrelevant. This is just one commercial interest of course and others might compete to have historical smoothing at the heart of Met Office policy. The general point though is that if particular users commercially direct the data providers to create data for the market, there could be overt or subtle shifts in the kinds of data infrastructures created and maintained, less along scientific lines and more along commercial ones.

Conclusions

Data infrastructures do not exist merely to support commercial ends (Benson, 2012); rather they can support multiple, sometimes competing interests (Edwards, 2010). Even if there is a broadly neoliberal policy infrastructure it does not translate that all users will have neoliberal motivations; witness the clamouring by private meteorologists against the increasingly market-oriented Met Office. But neither does this disprove the argument that these data infrastructures are increasingly organised around market-oriented ideas. The regulatory framework that instructs the Met Office to enhance cost recovery, to increase its revenues, to manage the resources in line with the Thatcherite principles underpinning the auditing of government services from the 1980s; all of this comes to shape the collection, use and accessibility of data. Within the political economy of science it is crucial to focus on what are sometimes seemingly banal, but important accounting principles and procedures that enable the formation of a marketized (and neoliberal) approach to data. Data in other words have to be central to considerations of the political economy of science.

At one level, this is intuitive territory for science and technology studies scholars. Scientists do not simply go out and collect 'neutral' data on everything without a reason. On the other hand, it seems uncomfortable to reflect on the ways in which a logic of the marketplace of ideas has informed the changing practices of data collection, collation and use. The economics of information underpinning this has been clearly identified by Mlrowski (2011): that science's organization, structure and regulation should be supplied through market-oriented tools such that science is treated as per any other commodity. The Met Office is geared to delivering on the foundations of economic growth and efficiency in public services, hoping to both continue the day-to-day income generating activities while looking to capture market share in meteorological services. Science (often of very high quality) performs a supporting role to administrative economic reason.

In contrasting ways, the U.K. and the U.S. cases demonstrate how to create a market from and in meteorology. Changes in regulations, accounting techniques and auditing regimes are the banal but significant players training scientists and organizations to see like a market. Marketized logics do not simply represent unfolding neoliberalism; they are also an experimentation in governance too (Law and Williams, 2014). They are a situated and variegated assembling of components (from computers to thermometers, and from accounts to staff audit protocols) that unfold in practice in sometimes contradictory ways to unlock the market potential of meteorology. in sometimes coherent and sometimes confusing ways even as they appear to aim at unlocking the market potential of meteorology.

There is, therefore, a family resemblance to core neoliberal principles. Scientists or government experts are not to know what is best; rather, the marketplace of ideas defines the relevant, useful and efficient information required. While commentators like Morss and Hooke (2005) imply that commercialization can be better regulated or managed to ensure that meteorology does not follow

the pitfalls of biomedicine, they neglect the foundational economics of information that underpins the enacting of the marketplace as an ideal bar none. If science is to be seen like a market and to see (work) like a market, then for all the variegation and contextual-specificity outlined in this chapter, there is a fundamental (attempt at) marketization of data infrastructures. That is not to say that all users or uses are neoliberal, but rather that a guiding principle is to unlock the market value of meteorological services for the knowledge economy. For research in the political economy of science, scholarship needs to be aware of these kinds of broader philosophies while still remaining alive to the fact that these are in formation rather than already settled. This kind of work might be considered an awkward encounter between political economy and the diverse sites of science in action, but this Handbook suggests that it is a worthwhile goal.

References:

Bates, J. 2014. The strategic importance of information policy for the contemporary neoliberal state: The case of Open Government Data in the United Kingdom, *Government Information Quarterly*, 31(3): 388-395.

BBC, 2015. Met Office loses BBC weather forecasting contract, <http://www.bbc.co.uk/news/uk-34031785> (Last accessed 23rd June 2016).

Berman, E.P. 2014. Not just neoliberalism: Economization in US science and technology policy, *Science, Technology and Human Values*, 39(3): 397-431.

Brenner, N., Peck, J. and Theodore, N. 2010. Variegated neoliberalization: geographies, modalities, pathways, *Global Networks*, 10(2): 182-222.

Broadbent, J. and Guthrie, J. 1992. Changes in the public sector: A review of recent 'alternative' accounting research, *Accounting, Auditing and Accountability Journal*, 5(2): 3-31.

Coley, A. and Newman, A. 2016. Let's make Defra data driven, Available from: <https://defradigital.blog.gov.uk/2016/02/01/lets-make-defra-data-driven/> (Last accessed: 23/06/2016)

Collins, C.A. and Evans, G.F. 1958. Du Pont Tide and Storm Warning Service, In: *Proceedings of the First National Conference on Applied Meteorology*, Boston: American Meteorological Society, A8-A18.

Courtney, F.E. Jr. 1978. Trends in industrial meteorology, In: *Conference on climate and energy: Climatological aspects and industrial operations of the American Meteorological Society*, Boston, MA: American Meteorological Society, 150-152.

Daipha, P. 2015. *Masters of uncertainty: Weather forecasters and the quest for ground truth*, Chicago, IL: University of Chicago Press.

Edwards, P.N. 2010. *A vast machine: Computer models, climate data, and the politics of global warming*, Cambridge, MA: MIT Press.

Ellig, J.R. 1989. *Set fair: A gradualist proposal for privatising weather forecasting*, London: Social Affairs Unit.

Ellwood, S. and Newberry, S. 2007. Public sector accrual accounting: institutionalising neo-liberal principles?, *Accounting, Auditing and Accountability Journal*, 20(4): 549-573.

- Fleming, J.R. 1990. *Meteorology in America, 1800-1870*, Baltimore, MA: Johns Hopkins University Press.
- Fourcade, M. and Healy, K. 2013. Classification situations: Life-chances in the neoliberal era, *Accounting, Organizations and Society*, 38: 559-572.
- Freebairn, J.W. and Zillman, J.W. 2002. Funding meteorological services, *Meteorological Applications*, 9(1): 45-54.
- Hall, A. 2015. From the airfield to the high street: The Met Office's role in the emergence of commercial weather services, *Weather, Climate, and Society*, 7: 211-223.
- Harris, R. and Baumann, I. 2015. Open data policies and satellite Earth observation, *Space Policy*, 32: 44-53.
- Janković, V. 2015. Working with weather: Atmospheric resources, climate variability and the rise of industrial meteorology, 1950-2010, *History of Meteorology*, 7: 98-111.
- Johnson, L. and Rampini, C. This volume. Are climate models global public goods?
- Johnston, S. and Cordes, J. 2003. Public good or commercial opportunity? Case studies in remote sensing commercialization, *Space Policy*, 19: 32-31.
- Kavanagh, M. 2016. Data Programme Board: putting the user first, <https://defradigital.blog.gov.uk/2016/04/27/data-programme-board-putting-the-user-first/> (Last accessed, 23/06/2016).
- Krimsky, S. 2004. *Science in the private interest: Has the lure of profits corrupted biomedical research?*, Lanham, MA: Rowman and Littlefield.
- Law, J. and Williams, K. 2014. A state of unlearning? Government as experiment, *CRESC Working Paper 134*, <http://www.cresc.ac.uk/medialibrary/workingpapers/wp134.pdf> (Last accessed: 29/06/2016).
- Marx, K. 2008. Edited by Elster, J. *Karl Marx: A reader*, Cambridge: Cambridge University Press.
- McEldowney, J.F. 1991. The National Audit Office and privatisation, *The Modern Law Review*, 54(6): 933-955.
- Mirowski, P. 2011. *Science-Mart: Privatizing American science*, Cambridge, MA: Harvard University Press.
- Mirowski, P. 2012. The modern commercialization of science is a passel of Ponzi schemes, *Social Epistemology*, 26, 3-4, 285-310.
- Mirowski, P. 2013. *Never let a serious crisis go to waste: How neoliberalism survived the financial meltdown*, London: Verso.
- Mirowski, P. and van Horn, R. 2005. The Contract Research Organization and the commercialization of scientific research, *Social Studies of Science*, 35(4): 503-548.
- Mitchell, T. 2002. *Rule of experts: Egypt, techno-politics, modernity*, Berkeley, CA: University of California Press.

- Morss, R.E. and Hooke, W.H. 2005. The outlook for U.S. meteorological research in a commercializing world: Fair early, but clouds moving in?, *Bulletin of the American Meteorological Society*, 86(7): 921-936.
- Mullerleile, C. This volume. Open access panacea: Scarcity, abundance, and information enclosure in the new economy of academic knowledge production.
- National Audit Office, 1986. *Ministry of Defence: Financial arrangements for the provision of meteorological services*, London: HMSO.
- National Audit Office, 1995. *The Meteorological Office Executive Agency: Evaluation of performance*, London: HMSO.
- Pearl, E.W. and Henz, J.F. 1980. On the role of private meteorologists in operational meteorology, In: *8th Conference on weather forecasting and analysis, Denver, CO*, Boston: American Meteorological Society, 278-281.
- Randalls, S. 2010. Weather profits: Weather derivatives and the commercialization of meteorology, *Social Studies of Science*, 40(5): 705-730.
- Reichelderfer, F.W. 1949. Policy with respect to private practice of meteorology, In: *Conference of Weather Bureau forecasters*, Washington, DC: Weather Bureau, 79-80.
- Robins, K. and Webster, F. 1988. Cybernetic capitalism: Information, technology, everyday life, In: Mosco, V. and Wasko, J. (eds) *The Political Economy of Information*, The University of Wisconsin Press: Madison, WI, 44-75.
- Ross, H. 2016. Natural England hits its target early, Available from: <https://defradigital.blog.gov.uk/2016/03/29/natural-england-hits-its-target-early/> (Last accessed 23/06/2016)
- Scott, J.C. 1998. *Seeing like a state: How certain schemes to improve the human condition have failed*, New Haven, CT: Yale University Press.
- Sharp, K.J. and Hansford, J. 1985. *The Meteorological Office: Financial management*, Bracknell: Meteorological Office.
- Smith, C.P. 1970. Expanding the usefulness of meteorology in the private sector, In: Caskey, J.E. (ed). *A century of progress: A collection of addresses presented at a joint symposium commemorating the centennial of the U.S. Weather Service and the golden anniversary of the American Meteorological Society.*, Boston, MA: American Meteorological Society, 95-99.
- Smith, M.R. 2002. Five myths of commercial meteorology, *Bulletin of the American Meteorological Society*, 83(7): 993-996.
- Spiegler, D.B. 1996. A history of private sector meteorology, In: Fleming, J.R. (ed) *Historical Essays on Meteorology, 1919-1995*, Boston, MA: American Meteorological Society, 417-441.
- Tellmann, U. 2009. Foucault and the invisible economy, *Foucault Studies*, 6, 5-24.
- Walker, J.M. 2012. *History of the Meteorological Office*, New York, NY: Cambridge University Press.
- Wood, A.C.M. 1997. *The Meteorological Office: Trading Fund and beyond*, MSc Dissertation, School of Defence Management, Cranfield University.