

Author accepted manuscript**To be published in the *Routledge Handbook of the Political Economy of Science*****D. Tyfield, R. Lave, S. Randalls and C. Thorpe (eds) (Forthcoming, 2017)*****Introduction to the Handbook – Beyond Crisis in the Knowledge Economy*****David Tyfield, Rebecca Lave, Samuel Randalls and Charles Thorpe**Introduction

In July 2016, an article in the *Wall Street Journal* declared "Election 2016 Is Propelled by the American Economy's Failed Promises" (Hilsenrath and Davis, 2016; see also Beams, 2016). The article effectively acknowledges that the political economic orthodoxy of the day – for which the *Journal* has long been a primary proponent – is in tatters and that anger at economic dislocation is creating seismic shifts in Americans' political outlook. Among the failed promises that the article lists is that of technology in the 'knowledge economy', namely that "Technology would lead to rising incomes and broadly shared prosperity." The reality is that "Productivity and output growth have slowed and technology has been polarizing the workforce."

Technological unemployment, a notion treated as heretical, if not absurd, in the 1990s, is now increasingly taken seriously as a key factor holding down job creation, wages, living standards, and economic growth. The article further notes that in the past "those with bachelors' degrees in science seemed safe from automation-prompted layoffs—their knowledge was tough for computers to duplicate." But this is no longer the case, with a whole swathe of middle-class employment now being downgraded or eliminated: "Between 2000 and 2012... the hollowing-out of work spread to professions including librarians and engineers." These trends have contributed to the widening of income inequality. In the UK, the surprise vote for 'Brexit', with the UK quitting the EU, has been explained in similar terms of mass political and economic disenfranchisement and anger (Harris, 2016; Elliott, 2016).

It is salutary to contrast the reality of today's low growth, low productivity, and low employment economy with the rhetoric of the 'knowledge economy' not so very long ago. This was supposed to be a 'new economy' for which the old rules of boom and bust did not apply. The new economy would almost overcome economics itself, escaping materiality, since scarcity could be banished in the realm of information (Kelly, 1997; see also Thorpe, 2016, 105-6). Buying and selling knowledge meant "living on thin air" as British knowledge economy pundit Charles Leadbeater (1999) declared. The ethereal knowledge economy would be more ecologically sensitive, less demanding of resources. High-tech was also green. It also would allow for a change in the character of work itself, liberating us from the routinized, standardized world of Fordist mass production and mass consumption (cf. Clark, Foster and York, 2009; York and Rosa, 2003).

This also translated into new bold high-technology promises about research and innovation (R&I). Genetic engineering would solve world hunger, with a reduced ecological footprint, and/or cure persistent diseases, while also thereby developing whole new industries for profitable investment and rewarding, knowledge-intensive work. New digital and information communication technologies would revolutionize our capacity to understand and

skilfully manage complex problems, such as those of the environment, while also unlocking unprecedented innovation and generation of new knowledge through a new fluid, global interconnectivity. And this would seed further breakthroughs in science and technology, unleashing undreamt of progress in the human mastery of matter (e.g. nanotechnology), living systems (e.g. biotechnology) and consciousness (e.g. artificial intelligence) (Cf. Birch, et al., 2010; Cooper, 2008; Thorpe, 2013; Tyfield, 2012a: 43-62; Walker, 2016).

Just as the political turmoil of 2016 lays bare the broken shells of those economic promises, so too we find the promises regarding R&I equally battered. Indeed, the greater political and economic importance of R&I has clearly proven a double-edged sword. For instance, consider the case of genetically modified agriculture. Expectations for genetic engineering of plants have been frequently founded on ideals of public benefits whether in terms of agricultural crop disease resistance, ability to withstand environmental changes or on the economic development prospects for local communities. Yet agricultural engineering has also offered one of the most consistent arenas for contestation over the past three decades, whether about the potential for increased corporate power or fears of ‘playing God’ (Delborne, 2008; Delborne and Kinchy, 2008; Kinchy, 2012; Kleinman, 2003; Kloppenburg, 1988).

In recent years, therefore, ag-biotech has been forced to outline its public-spiritedness to ward off persistent and powerful critique. As Harrison et al. (this volume) show, however, contemporary political economic policies and practices towards R&I restrict the possibilities of change, thereby, in turn, entrenching opposition. Water efficient maize and the American chestnut are differently constituted in political-economic terms. But while both offer some pushback on commercialisation imperatives, they both also reconstitute the norms of the contemporary political economy of science through forms of regulation, economic ideals, intellectual property frameworks and profitability – even if dressed up in humanitarian terms.

It seems, therefore, that if the ardent pursuit of the ‘knowledge economy’ has produced anything in recent decades, it is not the world that was promised but the ascendancy of the political economy of science – or more appropriately, the political economy of R&I – into a key issue of contestation for contemporary society, and amongst the public at large not just the relatively small groups directly employed in these fields.

Putting the production of knowledge in question...

In a sense, it is obvious that the subject of a political economy of R&I (PERI) is the production – and inseparably, the distribution and consumption – of knowledge, and how this shapes and is shaped by (distinct) political economies. From the point of view of mainstream economics of science/knowledge, we are here studying two things – knowledge (incorporating both science and innovation) and economy – and how these fit together: knowledge, once produced, is commercialized, leading to economic development and further knowledge production. Yet profound assumptions are built into this picture; assumptions that not only have significant causal effect in the actual trajectories of contemporary socio-technical change, but also, in fact, are highly problematic.

Two of these assumptions regarding ‘knowledge’, emerge as particularly important: first, that ‘knowledge’ is a familiar beast, namely the (growing) body of factual, normatively neutral truths that enables people to serve their needs and desires; and, secondly, that it is therefore obvious and axiomatic that, when it comes to the question of the *production* of knowledge,

more knowledge always leads to economic growth and societal benefit. In short, more knowledge is always better. Let us call these joint presumptions the 'knowledge economy credo'.

The unquestioned presumption that the goal at hand is to maximize the production of straightforward, unproblematic knowledge (research, innovation and education) is highly consequential in the *actual* political economy of R&I today, since it underpins policies and practices. Mainstream economics of science adopts this goal as both achievable and self-evidently good, and proceeds to focus on how best to maximize (quantitatively) this output, 'knowledge'. The actual interaction of knowledge production and an expressly *political* economy, however, quickly dissolves this neat picture. The example of agbiotech above demonstrates the necessity of the political legitimation of new forms of knowledge and technology in a contested public sphere and political economy, and therefore the mutual co-constitution or co-construction of knowledge, economy, culture, and politics.

While both knowledge and political economy have been the object of significant bodies of insightful work, they are not generally conceptualized together. In recent decades Science & Technology Studies (STS) has thoroughly transformed the empirical study of knowledge production by taking science not as an obvious and unproblematic production of empirical truth, but as a complex social and cultural practice requiring sociological/anthropological study. STS thus brings together a broad range of approaches from the social sciences and humanities. But political economy is conspicuous by its relative absence. This is, in part, because of the field's dominant micro-scale focus on the particularities of scientific practice in particular (academic) labs and field sites. It is also due to its foundation in heated debates about constructivist, anti-realist philosophy of science that elicited a deep-seated empiricist disposition towards anti-structural, including non-Marxist, approaches; approaches that have unquestionably proven extremely illuminating and conceptually productive. Yet the vast majority of STS work, but by no means all of it, shows little interest in, and sometimes even scant toleration of, issues of political economy (Tyfield, 2012b, 8-51; Lynch and Fuhrman, 1991, 1992; Winner, 1993; Klein and Kleinman, 2002; Mirowski, this volume).

For its part, mainstream economics of R&I shows little interest in issues of knowledge production as irreducibly cultural-political processes (Tyfield, 2012a, 13-25), while knowledge production is not generally a primary concern from political economy approaches. PERI, as pursued in this volume, therefore, seeks to draw on and continue the attention that STS scholars have given to the culturally constructed aspects of science and technology, but also to show how science is a force of production, embedded in the broader economic, political, and social institutions and relations of modern capitalism (Cf Bernal, 1939; Rose and Rose eds, 1976; Levidow and Young, 1981).

From this perspective, the 'knowledge economy' must not be understood as entirely novel and distinct from the production and distribution of material (and immaterial) goods. Instead, the marketization of scientific and technical knowledge must be understood within the overall framework of industrial capitalism, while the novelties of political economies increasingly dominated by production of knowledge(s) must also be attended to. This is the mode of understanding that has taken shape over the last 10-15 years under the rubric of PERI.

The growing PERI literature has repeatedly shown, in abstract and in concrete, how exploring the dynamic interrelations between 'knowledge' and an irreducibly political 'economy' necessarily problematize both pillars of the knowledge economy credo, viz. the common-

sense definition of knowledge and the axiomatic presumption that economic prosperity and socio-environmental well-being necessarily follow from the increase in knowledge and technology. Instead, ‘knowledge’ is revealed to be a key arena and instrument of political contestation. Meanwhile, the ‘economy’ conditioning and conditioned by this production of knowledge is itself shown to be an inherently contradictory and always deeply political sphere of human social life, characterized by specific political projects and the broad underlying systemic imperatives of continued accumulation of capital.

The mainstream approach thus attempts to explore the interaction of what it treats as two fundamentally different phenomena – namely factual knowledge (and its embodiment in new ‘technologies’) and a material economy of (possibly ‘optimal’) production and distribution. In contrast, PERI treats ‘knowledge’ and ‘economy’ as different and analytically distinguishable aspects of one and the same thing, namely systems of power/knowledge-mediated relations. PERI investigates empirical instances of how specific political economic regimes and specific practices of R&I are co-produced in self-sustaining and contested feedback loops. In the process, PERI unravels the ontological assumptions underpinning the knowledge economy credo, clearing the way toward a richer co-productionist perspective in which solutions to problems of knowledge are solutions to problems *not only* of local social orders *but also* macro-scale political-economic order (Shapin and Schaffer, 1985; Jasanoff, 2004). In this way, PERI exposes the deep fallacy that the ‘immaterial’ and ‘neutral’ thing called knowledge somehow escapes the deeper contradictions and constraints of the political and economic relations of capitalism.

... In neoliberal times

The need for this both dynamically historical and structural political-economic perspective is particularly acute given the period within which PERI has arisen and which it has immediately sought to analyze, namely the broadly neoliberal era of the past few decades. PERI work has often involved a profound engagement with analysis of the nature and trajectory of neoliberalism itself alongside the specific issue of the transformation of knowledge production that has happened in tandem (Birch and Mykhnenko, 2010; Laveet al., 2010, Tyfield, 2012c; Mirowski, 2011 and 2014).

While often unfortunately reduced to a politically progressive swear word, incorporating a contradictory multitude of positions and presumptions, ‘neoliberalism’ remains a useful – and, we would argue, essential – term for contemporary PERI work insofar as it is given a sufficiently substantive and rigorous definition (see e.g. Springer et al., 2016). For our purposes, following the discussion above about systems of power/knowledge-mediated relations, we take neoliberalism as an example or regime of such a system that has, contingently, dominated the evolution of global capitalism since the late 1970s/early 1980s (e.g. Harvey, 2005; Peck and Tickell, 2002). This regime has several key characteristics, all of which are best conceptualized as iterative processes and political projects that have proven, to date, extremely productive (in terms of creative destruction) and resilient regarding their own self-propagation. This has included: a model and political dogma of global economic liberalization and domestic privatization, unleashing and/or introducing markets to replace state provision and protection; the financialisation of the economy in terms of growing economic and political heft of the financial sector, debt and new financial products; growing corporate power, on a global scale; and the take-over and use of state power to drive forward, and clear obstacles to privatisation, marketisation, and financialisation.

Thus neoliberalism is a *dynamic* project that has evolved through different phases and in different ways in different places (Ong, 2006; Peck and Tickell, 2002) and draws on multiple sources of intellectual inspiration (Mirowski and Plehwe, 2009; Peck, 2010; Stedman Jones, 2014). But it is unified by a radical commitment to the ‘market’ as panacea and supreme decision-maker. Indeed, a clear finding from seminal PERI work in the history of economics is the deeply epistemic nature of neoliberalism (Mirowski and Plehwe, 2009; Nik Khah, this volume), with significant implications for its interaction with and dependence upon a specifically neoliberal(ized) model of R&I (Tyfield, 2016).

As Mirowski (2009) has shown, the political radicalism – and extraordinary strategic efficacy – of neoliberalism lies in large part in its synthetic rethinking of the ‘market’ and ‘knowledge’. For this political project, the fundamental – and, indeed, *fundamentalist* – truth is that the market always ‘knows best’, and certainly knows better than any limited individual or collective intelligence (see Nik-Khah, this volume). Neoliberalism, therefore, promotes the maximization of the production (and consumption) of knowledge... but where this is understood to mean the maximized subjection of human social life to markets, as the ultimate and super-human decision-maker (Mirowski, 2009; Peck, 2010; Brown, 2015). Where optimal government of society hinges on optimal decisions about the trajectory of societal development, for neoliberals it is the market that can best achieve this. Developing in parallel with and through the much-hyped emergence of the ‘knowledge economy’, therefore, neoliberalism has sponsored the knowledge economy credo and given it a particular political form as a highly dynamic, destructively creative and evangelical political patron.

This strong epistemic aspect of neoliberalism has significant repercussions for science. Neoliberals present science as best organized as a literal ‘marketplace of ideas’, for example in the increasing subjection of academic, ‘public good’ research and higher education to market forces. This reorganization of knowledge production assumes a pivotal role in the broader neoliberal project, as the talisman and/or cornerstone of the larger edifice of an optimal (since market-organized) society. As such, the strategic strength of neoliberalism has rested to a great extent upon its relatively unchallenged popular *appeal*. For it is founded in an argument about optimal socio-political order based in the optimal *organization of the production of knowledge*.

However, the definition of ‘knowledge’ that neoliberalism actually deploys is a radical and oft-overlooked departure.¹ Indeed, neoliberalism’s ambiguous use of the knowledge economy credo – as seemingly anodyne common-sense that conceals the profound radicalism of its interpretation, in a ‘double truth’ regime (Mirowski, 2012) – is an essential aspect both of the resilience and slipperiness of neoliberalism itself to date, and of how the knowledge economy credo has become so deeply entrenched, empowered and thence (self-)destructive in recent years.

So one key contribution to date of a PERI approach is to illuminate the mutually supporting, but also destructive (see below), relations between the neoliberal project and the knowledge economy credo, and the specific and problematic assumptions on which both rest. As such, insights that assist the rejection of the latter are also *de facto* political interventions against

¹ What ‘knowledge’ is and its relevance and roles regarding good government is an historical question that changes with changing social context. As Mirowski and Sent (2008) show, for instance, the neoliberal period with its ‘globalized privatization regime’ for R&I was preceded by a post-WW2 common sense in which knowledge was considered a public good best secured through generous state financing; and before that as an unownable body of truths best produced by disinterested private gentlemen.

the former. Indeed, the existing mainstream discourse of the ‘economics of science’ must itself be understood as both the product of and, reciprocally, a key element in the construction of neoliberalism’s profound changes in the institutions of science and its role in society (Mirowski, 2009). The continuing dominance of this political economic orthodoxy is thus not just an epistemic obstacle to a more productive analysis, but *itself* a key causal aspect of any comprehensive explanation of the current crises of (the political economy of) science *and* of the persistent misfiring of policy regarding research and innovation. PERI is thus directly tackling all of these issues.

But in these circumstances, the *political* economy of ‘science’ also emerges as a key issue and lens for two major reasons. On the one hand, the dominant political economic regime of the day is highly epistemic in its abstract legitimation and this translates into its intense concrete dependence on forms of knowledge production and their transformation through marketization. As a result, an interest in neoliberalism implies a focus on R&I. For instance, recent work has explored how the pharmaceutical industry has instantiated the model of a neoliberal R&I as envisaged by key neoliberal intellectuals (Nik-Khah, 2014). On the other, the multiple problematic *effects* of the current regime of knowledge production are often what initially stimulate critical and engaged scholarship in STS, driving such research towards an interest in neoliberalism and political economy more broadly. Notably, concerns about contemporary environmental or social issues, and the production and contestation of knowledge claims regarding these, have propelled many scholars to research how neoliberal organizations construct their cases and shape broader public understanding (Thorpe and Gregory, 2010; Thorpe, 2010; Welsh and Wynne, 2013; Marris, 2015).

Whether born out of enquiry seeking to understand these problematic effects of the specific regime of neoliberalism or neoliberalism’s manifestation in R&I, however, PERI offers one further, and crucial, contribution that is not limited to, and promises to lead beyond, this particular context. This is as a key source of ongoing insight (abstract and concrete) to dislodge the publicly-sedimented misunderstanding about ‘knowledge’ – as in the knowledge economy credo – as well as, thereby, a stimulus for and moment in the practical and strategic engagement in an *alternative* knowledge politics. In short, the primary purpose of the political economy of R&I, as a growing body of work, is arguably to repudiate these misleading presumptions and replace them with something that promises to mediate the emergence of better socio-technical – and political economic – futures.

As the selection of PERI work in this Handbook demonstrates, however, these better futures are desperately needed today, while the globalizing ‘knowledge’ societies and economies being built on the neoliberal-sponsored knowledge economy credo are causing ever-deeper social, political and environmental problems. In the rest of this Introduction, rather than summarize the content of all the subsequent chapters – an impossible task and one better served by the chapter abstracts in any case – we draw on some of their insights to discuss four ways in which these profound challenges to the neoliberal knowledge economy are in evidence. These are:

1. Immanent crises of the production of knowledge (innovation, research, HE) itself;
2. Extrinsic crises of R&I that are failing to serve the public purposes of dealing with grievous global risks, and possibly even compounding them, even as R&I are increasingly cast by policy as panaceas to all these challenges;
3. Changing political/social relations to the use or consumption of knowledge; and
4. Changing geographies of knowledge production and political epistemologies.

Crises and changes in production of knowledge

Surveying knowledge production around the world today we find four fundamental beliefs (or dogmas), all elaborations of the knowledge production credo, that are both widely accepted and manifest in R&I policy and strategy, but also increasingly threadbare when confronted with the empirical record of deepening problems with the production of research and innovation. These are that:

- Dogma 1: science (R&I) contributes substantially to economic growth, and that funding of R&I is best legitimated in such terms; hence
- Dogma 2: R&I may be best explained and arranged in terms of a ‘marketplace of ideas’; hence
- Dogma 3: domination by corporate and speculative entrepreneurial investment ensures a unique dynamism and productivity in R&I, presumptively to the maximized benefit of all (especially as consumers and investors); and
- Dogma 4: such R&I can be expected, given time and investment, to resolve (or at least optimally to tackle) all social challenges with which it is tasked.

We turn to the last of these four in the next section. As regards the first three, though, it is increasingly clear that none of them stands up to scrutiny, while acting as if they are true serves only to compound the evidence to the contrary and the stagnation of socio-economically productive innovation thus organized.

First, as regards dogma 1, current literature shows, at best, significant ignorance still regarding any relationship between R&I (let alone ‘science’, and especially academic or ‘basic’ science as the term is often understood) and economic growth and, at worst, arguably an inverse relationship (see Edgerton, this volume). But what are the effects of this dogma and of basing legitimation of (public) funding of R&I upon it?

As Pagano & Rossi (this volume) show, the specific regime of R&I funding today, which supports R&I primarily to the extent it promises swift translation into profitable commercial impact, is conditioning a generalized stagnation of innovation and private sector R&I investment, which has historically been the dominant site of R&I (Edgerton, this volume). This has involved the propagation of an overly-proprietary model of innovation that locks up knowledge-intensive products of innovation and research into an increasingly impenetrable thicket of mutually exclusive claims of ownership. This has produced not only an ‘anti-commons’ (Heller & Eisenberg, 1998), in which the share commons of ‘ideas’ upon which the generation further ideas are premised, are increasingly inaccessible. But it also has generated a deepening ‘investment strike’ (Pagano & Rossi, 2009), in which private ownership of knowledge ironically disincentivizes investment in its generation in the first place, even as strong intellectual property rights are advocated for precisely the opposite reason. Meanwhile, such innovation as does occur is increasingly the parasitic mobilization of existing assets, perhaps via online platforms, by a new class of rentiers (Birch, this volume).

This, in turn, substantially underlies the crisis of productivity and stagnation of the broader political economy that culminated in the Great Financial Crash of 2007/8. Nor does this account seem merely historical despite being nearly a decade down the road, with an ongoing and deepening crisis in productivity growth across the global economy for similar reasons of stalled business investment. For not only has little changed in the global North where these dynamics were strongest and most efficacious, but they now seem to be reaching similar

crisis-inducing proportions in the global South as well, which has been the effective engine of global economic growth since the beginning of the century.

This discussion, however, immediately leads to dogma 2, regarding knowledge production as a marketplace of ideas (MoI). For it is precisely the untrammelled expansion of markets of contending *private* ownership of knowledge and the systematic shrinking of a legitimate discourse and institutional capacity of *public* knowledge production (notwithstanding a ‘stealth industrial policy’ in the US throughout the neoliberal period (Block, 2008)) that has sown this cannibalistic trajectory. This self-defeating logic is arguably intrinsic, there from the outset, to the entire conception and project of the ‘marketplace of ideas’, even as this has indeed become the dominant public framing for thinking about R&I. For instance, as Nik-Khah (this volume) shows, the successful political propagation of this concept was built upon a radical commitment to academic freedom, in an open marketplace not an arena of scholarly debate, together with an equally foundational determination that the course of knowledge production should be guided by a specific elite committed to the superiority of the market. While apparently contradictory, these twin commitments have afforded the productive ‘double truth’ regime discussed above. This has then driven a deepening acceptance and empowerment of a knowledge production regime that, in both these commitments, is essentially committed to the destruction of any space for public reasoning (i.e. reasoning *about* matters of public interest and *in* the public sphere with *a view to* shaping the public good) by its subsumption in an ever-growing, all-knowing market. And in practice, this ‘market’ is actually powerful corporations and wealthy individuals (Crouch, 2011).

This concrete manifestation of the MoI is captured in dogma 3. Again, though, far from yielding unprecedented productivity and advances in R&I, Lazonick et al. (this volume) set out the multiple negative effects that are increasingly apparent from organizing innovation as a financialized market, based on a model of maximizing shareholder value (MSV). They illustrate this focusing on the pivotal case of the pharmaceutical biotech industry.

Both Lazonick et al. and Pagano and Rossi (both this volume) thus explain a political economic model of R&I that generates ‘profits without prosperity’ (Lazonick, 2014), and hence that demonstrably contravenes this key dogma of neoliberal political economy. Indeed, the combination of dominant neoliberal models of innovation and financialisation even subverts the key figure of the entrepreneur. Instead of the creator of new markets and commodities, s/he becomes its antithesis, the rentier, developing new technoscientific interventions that aim to exploit the (positive externalities associated with) monopolization of *existing* stocks of assets (Birch, this volume; Zeller, 2008).

But this model is also culpably constraining production of the various forms of ‘knowledge’ seemingly most dependent on this model of innovation. This is the case whether in terms of (possibly hi-tech) innovation within industries dependent upon regular, proprietary breakthroughs (with pharmaceuticals again archetypal (see chapters by Sismondo, Lazonick et al.)) or even of the production of ‘basic’ knowledge and ‘knowledgeable’ people through the institutions of academic research and higher education (Tyfield, 2013; see also Muellerleile, this volume).

For instance, a massive shift in the global political economy of higher education is afoot (chapters by Best and Rich; Xu and Ye). Dependence on ballooning and largely national-based student debt is clashing with increasingly global market ‘competition’ between universities for students and research funding, now reconfigured as ‘services’ and

‘consumers’ respectively. Not only is this drawing a deepening split into top and lower tier ‘providers’. It is also shaping a system of higher education that is financially unstable (if not unsustainable) and for *all* parties – increasingly part-time staff and heavily-indebted students *and* universities themselves, building new attractive campuses – even as there are arguably diminishing (financial) returns regarding the ‘product’ of (even a high-quality, if not globally elite) higher education.

Crucially, this is not just a phenomenon of the ‘core’ of the Global North, as Xu and Ye (this volume) show, regarding the key example of China, as possible global ‘leader’ or hegemon in the coming century. For here the compound effect of exposure to global competition and rankings and of determination by the central government to create a handful of globally-leading institutions is creating a particularly steep hierarchy of HE institutions. This is thereby transforming HE – and *with* significant state support and oversight – into a key mediation of cycles not of socioeconomic mobility and knowledge-based meritocracy but of deepening inequality and political economic dysfunction regarding the national goal of building a broad-based ‘moderately well-off’ (*xiaokang*) knowledge economy in China.

Here, then, we have analyses that challenge not just the claim of a unique dynamism from this model of R&I but also its seeding *qualitatively* optimal trajectories. In similar vein, Schiller and Yeo (this volume) show how instrumental state funding has continued to be in what dynamism *is* evident – albeit wedded to a specifically neoliberal imaginary –, but also how the combined effect of the conditioning by (US) state and capital is producing a qualitatively specific and problematic trajectory of innovation in information communication technologies.

Moreover, once we are prepared to explore the cycles of co-production of knowledges as specific political technologies and equally specific political economic regimes, the forms of knowledge relevant to the concerns of a PERI are not just those of the R&I but also those enabling, constraining and framing that process. This includes, in particular, policy knowledges, not least of ‘science’ or ‘innovation’ policy. And, indeed, these forms of knowledge have also been profoundly exposed to neoliberal conditioning and marketization in recent decades, with profound impact on the political economy of R&I.

Neoliberal R&I policies frequently lead to a crisis in the production of knowledge and its corollary, a deepening crisis of policy legitimacy. For instance, the reformulation of public data provision or modelling creates conflicting economic priorities that do not necessarily translate into better policy, let alone more competitive, efficient knowledge production (see chapters by Johnson and Rampini; Randalls; Ransom et al; Suttmeier). Policies to enable a wider diversity of actors to engage in knowledge production equally open up spaces in which think-tanks and lobbyists can play central roles in both claiming expertise and simultaneously powerfully disclaiming expertise (as we show later; Fernández Pinto, this volume). There is thus a crisis of legitimacy that, perhaps ironically, further substantiates a claimed need for more and deeper neoliberalisation of science and science policy as the ‘depoliticized’ solution currently to hand.

In short, then, at the level of *policy* and political knowledges, a political economy of R&I perspective reveals a similar crisis of production of knowledge as is visible in R&I itself. Treading the boundary of power/knowledge, therefore, this crisis of *production* of knowledge verges into a crisis of the *productivity* or *usefulness* of what knowledge *is* produced: the

present neoliberal conjunction of unprecedented global challenges and R&I as supposed panacea that is dogma 4, to which we now turn.

Crises and changes in the productivity of knowledge

The funding of science, whether by public/state or private/market sources, inevitably calls upon arguments for legitimization of spending money in that way and not on some other priority. Fundamental to the arguments discussed above therefore is the final dogma of this progress narrative of ‘knowledge’ and its economics: that science, or R&I, should be funded (to *this* extent and in *these* ways) so that it can grow and thereby provide (profitable) solutions to the world’s many ills. Indeed, discourses of how research and innovation promise to tackle and eliminate the multiple problems of the present – e.g. squaring ‘green’ and ‘growth’, or Big Pharma profits and global public health, or ... – have arguably reached new heights in recent years, manifesting almost a fetishism of innovation (and preferably of the high-technology, privately-owned and research-intensive kind) (Godin, 2006; Tyfield, 2012c).

It is thus a deepening problem for this perspective that current R&I seems unable to deal with, let alone resolve, what appear to be deepening systemic problems and new global risks; while, conversely, R&I is intimately implicated in the emergence of these very problems, as key enablers of both clear and present dangers and new, threatening socio-technical (and socio-natural) futures. Far from delivering on the promise of greater human capacities, mastery and spontaneous order, therefore, ‘more knowledge’ seems to be delivering precisely the opposite. This thus presents a fundamental challenge to the productivity and usefulness of knowledge that underpins the knowledge economy credo. And, again, this is increasingly evident in multiple forms.

First, consider R&I that deals with contemporary challenges in relation to health and well-being, environments, resources and consumption around the world. To those concerned with ‘planetary boundaries’ (Rockstrom et al., 2015), these global problems require a significant investment in R&I. Yet, surveying the current landscape of such innovation seems to reveal a depressing vista of politically locked-in systems of planetary destruction and stalled transitions (e.g. Hess and McKane, this volume), not to mention the limitations to transitions imposed by neoliberalism-framed international trade agreements, already in force and/or under negotiation. This also plays out in terms of the contemporary fortunes of disciplines and fields of research enquiry relevant to these global challenges (see chapters by Harrison et al.; Johnson and Rampini; Lave and Robertson; Lohmann; Robinson). Attuned to profit as much as public benefits, scholars have demonstrated that current political economic drivers play an important role in shaping the kinds of science produced and the ends to which it is produced (e.g. chapters by Harrison et al.; Johnson and Rampini; Lohmann). This stagnation of precisely the R&I that is urgently needed is inseparable from the specific political economic model that currently dominates these processes.

Similarly, if from the other end of the spectrum, currently powerful imaginaries about future advances in many spheres of R&I themselves elicit profound, even ontological, anxiety for many, just as they seem irresistibly enticing and enabling to others; or, indeed, both, as Fisher (2016) shows regarding leading scientists in nanotechnology. Examples of these essentially contested – if also currently stuttering – horizons of hi-tech innovation abound, including synthetic biology, new biotech and GM agriculture (chapters by Rossi; Delfanti; and Harrison et al. respectively), information capitalism (Schiller and Yeo, this volume), smart mobility

and smart cities (Tyfield, this volume), geoengineering and the Anthropocene, Artificial Intelligence and nanotechnology. But it is the specific dominant *form* of each of these fields of innovation as sponsored by neoliberalism that is arguably the greatest source of this unease and controversy.

More generally, and returning to the issue of *policy* knowledges, these heightened concerns about R&I's trajectories and their broader effects have underpinned new calls for a 'responsible' R&I (RRI) (Stilgoe et al., 2013). Yet a major lacuna in the current dominant policy framing of RRI is attention to different *political economies* of R&I as a key aspect of its 'responsiveness' to the demands and concerns of a specific relevant public. This is a significant gap since RRI at its best promises to move beyond experiments with 'upstream public engagement' in R&I, that were often desultory exercises in seeking legitimation of policies already settled upon, towards a more concerted involvement of publics in the very constitution of R&I politics (Irwin, 2006). Here, then, PERI not only problematizes current policies and practices of R&I, sponsoring calls for RRI in the first place, but could also assist in its realization.

Yet significant challenges remain for RRI. For instance, confronted with enterprises and institutions of R&I that are increasingly remote from and unaccountable to public scrutiny, this raises difficult questions about what such a politics – as a *democratic* politics – could look like. At the very least, we are once again confronted with the problematic presumption of a central and essentially benign role of *knowledge*; here in terms of the supposedly pivotal role (at least in principle) of reasoned debate, in the public sphere, in a functioning democratic politics as against a pragmatic and power/knowledge relational contestation of actual technoscientific developments. Here, then, we see deepening challenges, increasingly apparent even to 'common-sense', to the key ideas that knowledge is always enlightening, and hence the more knowledge is produced and consumed, the better. And this leads to the next issue.

Crises and changes in the consumption, and definition, of knowledge

As 'knowledge' and its production and consumption has become increasingly central to contemporary political economic life, the roles it plays and our relations to it have also demonstrably and noticeably changed. This is progressively changing even the lay public understanding of 'knowledge' – what it is, what it does, its capacities, limits and limitations – in ways that are disintegrating the knowledge economy credo from within, just as the preceding two sections have discussed its assault from without. There are multiple tendencies at work here, and these range across a spectrum of the extent to which they are conceptually challenging to the identification of (more and better) knowledge with a social and personal progressive Enlightenment.

At the least challenging end of this spectrum is the simple dawning realization of the reality of the problems of information overload and the concomitant challenge of superficial skimming and diminishing intervals of concentration and 'deep' thought. Here knowledge – produced in a marketplace of ideas that, via the echo-chamber of social media, privileges self-projection over reflection, speaking and shouting not listening – is increasingly reduced to readily consumable information, or even infotainment, rather than the deepening strategic wisdom arguably necessary to tackle the unprecedented global challenges just discussed. The bountiful quantity of 'knowledge' thus often appears to be directly in inverse proportion to quality: of the knowledge itself, of its material manifestation (in 'innovation'), or of the lives

it shapes and (supposedly) enriches (Cf Schiller and Yeo, this volume, on information capitalism).

But such reflections quickly lead on to the growing acknowledgement of the extent to which dominant trajectories of R&I and socio-technical change are shaped – and have been historically, with profound effects on the contours and texture of everyday lives (and around the world) – by forces that are not only isolated from public accountability, but also very difficult even to analyse and trace. Take, for instance, the utter domination of medicines by a small number of highly proprietary transnational corporations. Not only do these companies claim exclusive rights (what Drahos and Braithwaite (2002) call ‘intellectual monopoly privileges’, not ‘intellectual property rights’) over key medicines – often developed with significant public investment. But they also assert commercial confidentiality over their data, including the data establishing the efficacy and safety of the drugs. As Sismondo (this volume) documents, the ‘science’ of clinical trials and medical journal articles are entirely ghost managed by the pharmaceutical industry.

Similarly, and more high-profile still, is the shaping of ICT and web 2.0 technologies by deliberately clandestine interventions from corporate and state surveillance, and in the US as much as in a clearly authoritarian regime such as China’s (Schiller and Yeo, this volume). Yet this points to an even bigger arena of R&I that is all but impossible to hold up to public scrutiny, even as it is – and has long been (chapters by Thorpe; and Edgerton) – pivotal in the broader co-evolution of techno-science and political systems: the military. New, specifically neoliberal, combinations of these two forces of state (military) and corporate initiatives, however, seem to make these innovation processes even *more* in need of oversight, as in the growing possibility of lethal (micro)drones, cyber-attacks or bio-warfare being first developed and then slipping out of government hands (Langley and Parkinson, this volume). ‘Knowledge economies’ were not supposed to be so dark.

Yet the current confounding of the given concept of knowledge goes way beyond this too. In particular, sponsored by the ‘double truth’ regime of neoliberalism and its active cultivation of ‘truthiness’, a new regime of knowledge production has emerged: agnotology (Oreskes and Conway, 2011; Fernández Pinto, this volume). Here ‘knowledge’ is deliberately treated as, first and foremost, a tool in political or commercial strategic projects; a device, moreover, whose effectiveness is parasitic upon the ‘scientific’ status and epistemic (and hence *political*, not least amidst widespread acceptance of the knowledge economy credo) authority of such claims in winning high-stakes contests in the public sphere.

A key element of this process is the production of *ignorance*, and of three kinds:

- as obstacles to (conventional) ‘science’ that is politically disadvantageous to specific and (R&I-) empowered interests (e.g. quintessentially regarding tobacco, nutrition or climate change);
- its converse of ‘science-as-PR’, not science-as-truth, where the primary goal of the knowledge work is to secure some credibility for a particular strategic project, not to establish actual knowledge (e.g. as described above regarding medicines); and
- ignorance regarding a systematically unaccountable scientific process (e.g. again pharmaceuticals).

Indeed, the last of these is crucial and arguably the most self-destructive of the three. For the epistemic authority of science actually reposes upon a foundation of broad-based and generally unquestioned public trust in the (supposedly) open, sceptical and unaligned *process*

of its production. We suppose we *can* hold ‘science’ to account, even if we personally do not do so in every (or perhaps, any) particular instance. A dawning cynicism, if not rejection, regarding that trust thus threatens this key pillar of the elevated political status of knowledge – and killing the host, would destroy the agnotology parasite with it.

A key element of this process is the politicization of science, where this is the unintended consequence of the neoliberal attempt – true to its epistemic and anti-political fundamentalism – to depoliticise *politics* with science. This ‘scientification’ of politics involves the attempt to minimize the inevitable political challenges to growing governance by the market by transferring the forum of their legitimate contestation: from a restive and unruly public sphere, to ‘sound’ scientific expertise... which is, in turn, increasingly subject to market discipline (Levidow et al. 2007; see also chapters by Delfanti; Harrison et al.; Johnson and Rampini; Lohmann; Ottinger; Ransom et al.; Rossi). The actual effect of this process, however, has been precisely the opposite, as political controversy has leached in the other direction, ever-deeper into the science itself, as regarding GM agriculture or climate change. To the extent this penetrates to issues that remain essentially undecided and uncertain as being towards the forefront of scientific advance, this also can then pollute and frustrate the whole enterprise since, caught up in political suspicion and recrimination, reasoned argument becomes practically impossible.

Moreover, this process is also observable again regarding policy knowledges. For instance, judgement over such growing public concerns about R&I is increasingly handed to ‘expert’ ethics committees. As Pellizzoni (this volume) describes, this is in many respects a subversion of a *politics* of knowledge production through ‘ethicization’ of the research process. This calls on governance by a form of knowledge (i.e. ethics) that may also largely be ignored when confronted with powerful political considerations, perhaps precisely because, agnotologically, it can be dismissed as a suspicious ‘expert’ judgement. Here, in other words, neoliberalism constructs an imposing castle front, guarding innovation under the banner of ‘ethics’, while the backdoor is systematically open to precisely those interests currently most empowered and most in need of policing. This process also tragically pits a politics and an ethics of R&I against each other, to the strategic weakness of them both.

Overall, then, in these concerns we see how neoliberalism’s extraordinary success regarding the apotheosis of knowledge – where ‘knowledge’ is specifically conceived, at its weakest, as a commodity and, at its strongest, as itself a market – achieves the exact opposite: a progressive evisceration of the very concept of ‘knowledge’ as an essential tool and source of human insight and capacity for normatively-appealing action and change. Beset by disintegration from within and uncontrollable overflow from without, then, the political economy of R&I – and the twin pillars of the knowledge economy credo – are currently subject to rapid and profound change. But we can no more do without or transcend ‘knowledge’ than we can voluntaristically repudiate or move beyond ‘knowledge societies’.

So where next? Perhaps a key pointer for future directions is to take this question quite literally and look at *where* (globally-significant) knowledge production is happening and how this is changing. And changing it undoubtedly is.

Crises and changes in the geography of knowledge

The preceding sections have all revealed conditions of the incumbent regime of knowledge production (and its knowledge economy credo) that it has also systematically denied and

destroyed: a vibrant public realm of knowledge production *not* produced in search of immediate profit; R&I directed to significant contemporary social challenges, not just the (re-) fashioning of consumer desires; and a scientific process that is at least *trusted* to be publicly accountable and actively cultivates that trust. What all these have in common is that they highlight and illustrate the irreducibly concrete and located nature of the production of (perhaps, presumptively universal) R&I, just as STS has been showing for some time. A PERI, however, also brings out the key and co-produced political economic aspects of these conditions that STS often neglects.

A key aspect of this locatedness that has received far too little attention to date, however, is the (political, economic) geographies of knowledge. There are obvious reasons that this gap has persisted for so long. These include the evident dominance of R&I – and of *study* of it, in STS – in the Euro-American global North. For this allows even comparative work across these contexts to take for granted the overwhelming similarity of their political economies, if not their political cultures or ‘civic epistemologies’ (Jasanoff 2005), as all wealthy, highly techno-economically developed and capitalist. But looking to the future of the political economy of R&I, as both a reality and the work that studies it, it is clear that the geographical aspects will become increasingly central.

There are two primary, and interacting, reasons for this growing importance. On the one hand, that ‘evident dominance’ just described is progressively eroding, and in two ways. First, with the surge of economic growth, including in R&I, in the Global South (and especially its most massive and populous countries, such as China, India, Brazil, Indonesia etc...) since 2000 (Mason 2015: 94-104), the geographical global centre of R&I and the sites of greatest global influence are shifting demonstrably away from the trans-Atlantic (plus north east Asian) axis of the 20th century.

Secondly, though, is the ongoing emergence of a qualitatively unprecedented novelty in the continuing construction of a ‘global’ geography of knowledge, via globalized and globalizing networks (Ernst and Kim, 2002). This plays out through (also currently changing, if specific) forms and process of globalization and cosmopolitization (Beck et al., 2013; Zhang, 2012) that problematize the crude conception of a ‘shift’ from ‘West’ to ‘East’, ‘North’ to ‘South’. Instead we see qualitative changes, mediated by compression and distancing through novel connections, in which, for instance, leading global mega-cities and their R&I clusters and campuses are more closely connected to each other than with the rural or peri-urban and co-national cities in their hinterland. The ongoing emergence of ‘global’ R&I, therefore, raises *new questions* about the *specific* substantive form it will take, (newly) benefitting and burdening whom, from where and how (e.g. chapters by Pfotenhauer and Jasanoff; Delvenne and Kreimer).

But, on the other hand, the combined effect of the ‘Rise of the Rest’ (Amsden, 2001) and global integration brings into stark relief the specific political and economic geography presupposed, to date at least, by the success of the neoliberal project over the past few decades. Certainly, there seems little doubt that neoliberalism is an overwhelmingly (Euro-) American project, even as it has (and/or has conditioned) powerful variants around the world. But whether regarding the history of the intellectual-political project behind its formulation (see Nik-Khah, this volume), or its most graphic implementation (e.g. Harvey, 2005), or the political-cultural milieu to which it most directly speaks (as in Jasanoff’s (2005) apt characterization of the US as a *Wissenschaftstaat*, a ‘science state’, the acme product of the 18th century Enlightenment), or its presupposed power base (of briefly unrivalled global

dominance with the ‘End of History’ in the 1990s) for global roll-out (e.g. Sell, 2003; Harvey, 2005).... All of these are clearly and uniquely American.

Combined with the fast-changing geography of knowledge just described, however, and we confront a fascinating and unstable conjunction. For, notwithstanding the profound influence of a neoliberal globalization on *domestic* politics across the global South, including even in ‘Communist’ China (Harvey, 2005; Nonini, 2008) or neo-Bolivarian Latin America (Burchardt and Dietz, 2014), there remain significant and enduring differences in cultural, political and socio-economic processes, practices and tacit knowledges that underpin and enable political regimes and their co-production with R&I across the world. Again, therefore, this is to raise new and globally significant questions about how these processes will interact: of a changing and emerging *global* geography of knowledge and an incumbent global regime heavily dependent on a *geographically-specific* understanding of ‘knowledge’.

These questions call for attention across the issues and changes discussed. Hence, on the one hand, greater understanding of the actual trajectories of R&I in China, say, – away from the headlines of fear or triumph about China ‘ruling’ the world or not – is obviously crucial (chapters by Suttmeier; Tyfield; Xu and Ye). But China no more exhausts the emerging global world than the global North does the passing one. Research is also needed, therefore, on the diverse political economics of R&I elsewhere across the world and their emerging positionality in the global networks of capital, ideas, stuff and people (whether as ‘global talent’ or ‘migrants’).

Moreover, amidst deepening global risks, such as climate change, which appear most immediately threatening to hot, ‘developing’ countries, the extent to which R&I is (or is not) addressing these challenges calls for significant attention to the less spectacular stories than China’s in the majority of geographical locations (countries, regions) that have no imminent prospect of global hegemony (chapters by Delvenne and Kreimer; Peloquin; Vessuri). Together, then, a new focus on understanding the changing and unfamiliar role of knowledge in both ascendant (non-Euro-American) global powers and continuing ‘subaltern’ societies in the global system may furnish the kinds of critical, but also positive and promising, insights regarding the shape of both emergent futures *and* their strategic openings and limitations that are necessary for, and as part of, construction of alternatives.

Conclusion

Forging these positive alternatives is never just intellectual work. Insights, exemplars and new approaches are unquestionably needed, however, and *these* a PERI can, and must, help provide. But which (political economic) perspectives do we use to reach these insights? Responding to the diverse pressures on incumbent understandings about knowledge here discussed, this Handbook presents for the first time a broad collection of the growing body of literature that is constructing a compelling, wide-ranging and synthetic replacement for a mainstream ‘economics of science’ and an economically-uninterested STS.

As the subsequent chapters demonstrate, this is work that not only rigorously and critically exposes misunderstanding and misconceptions about economies of knowledge and their negative societal effects, but also highlights more insightful approaches and more promising and credible initiatives. Indeed, this work is now of sufficient scope, depth, and breadth that it deserves – demands – the concerted attention of all scholars, policymakers and stakeholders concerned with the roles of research and innovation in future societies.

Yet this work is definitely *not* unified by a single approach. There *is* no single definitive way to conduct a political economy of R&I, just as there is, in reality and in principle, no single ‘economics of science’. Instead, multiple approaches and perspectives are used, including diverse disciplinary and geographically-located lenses, and even many conceptions of ‘political economy’ itself, in a varied and vital ecology of contending heterodoxy: Marxian, post-Keynesian, Schumpeterian, World Systems Theory, Foucauldian, Institutional, Evolutionary, etc...

The pioneering PERI work presented here thus draws upon a wide array of disciplines including: history of economic thought and economic philosophy; (international) political economy; economic sociology; science & technology studies; economic geography; innovation studies; economic history; (international) law; and social scientific studies of specific scientific-technological fields such as medicine, agriculture, environment, education, energy and mobility.

Across all these, however, is convergence on calls for a research agenda that seeks to broaden current understanding of the ‘economics of science’ in at least four directions, as an empirical project that:

- 1) On the one hand, demands attention to the concrete sociotechnical diversity of particular *knowledge practices* and in particular *places*, hence engendering analysis of a political and economic geography of R&I against the tendency to evoke a generic ‘science’ and a single ‘economics of science’;
- 2) While, on the other, embeds analysis of the quantitative and qualitative contributions of R&I within a (possibly global) analysis of socio-technical *systems* and their transformation.

And where such a systemic analysis must also include two dimensions usually overlooked by purely economistic analysis, namely:

- 3) Attention to the irreducible *political* economic dimensions of funding scientific research and its relation to regimes of capital accumulation; and
- 4) Incorporation of the *cultural and discursive* dimensions of such policies, including the power of (some) visions and future imaginaries to shape the trajectories of both science funding and research itself (as in a ‘cultural’ political economy (Jessop & Sum, 2006; Best and Paterson, 2008)).

These four demands shape the following chapters. And we hope they will also stimulate a new generation of PERI work making formative contributions towards articulating and instantiating positive visions of better ‘knowledge economies’.

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