The steel plant as assemblage

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ABSTRACT

In this paper I examine what economic geographies of the steel industry might learn from cultural economy and what cultural economy might learn from manufacturing industries. In particular, I draw on the concept of assemblage to outline a performative economic geography that emphasises the importance of material encounters, process, and working with, and containing, lively matter. My account argues that production complexes like steel plants are constantly made and unmade through material practices, doings and actions – all of which matter economically. The paper then puts the concept of assemblage to work, drawing on research during escorted tours to steel plants and employing literary narrative to frame the day-to-day rhythms and ruptures of industrial work. The effect is an economic geography of steel making that recasts overlooked and routine work (like monitoring, handling and transforming materials; repair and maintenance; and health and safety) as fundamental to economic activity and the creation of value.

1. On a steel plant somewhere in northern Europe

A grubby office sparsely furnished with a battered table, an ancient computer, discarded safety kit, yellowing photographs of a work’s football team, a kettle, mugs, piles of union pamphlets and health and safety posters. I am issued with my personal protection equipment – bright orange woollen overalls, heavy foundry boots, a hard hat, and safety goggles. It is a warm day, and in this protective clothing I feel unbearably hot and encumbered. Habitual movements become laboured.

As we leave the 1970s office block Paul, my guide, pauses at a poster and insists on talking me through the production process with the aid of this diagram. The basic oxygen steelmaking (BOS) process is distilled to a linear sequence. Paul explains that the ‘hot metal’ (molten iron) arrives by rail from the blast furnace some miles away. First the sulphur content of the molten metal is reduced, before the molten iron is poured into a BOS vessel that is already charged with about 40 tonnes of scrap metal. The ‘heat’ lasts about 30 minutes, during which oxygen is blown into the molten metal through a lance. When the required chemical composition and temperature are reached the vessel is ‘tapped’ and the liquid steel is poured into a ladle. During the tap various alloys are added and argon is injected to ensure the correct grade of steel is achieved. The liquid steel is then transported in ladles to a continuous caster, where it is formed into slabs, blooms or billets.

Once Paul is satisfied that I understand the rudiments of the process, we sign a register recording who is ‘on site’, and walk along a dusty approach road towards an opening in a vast shed. Leaving behind the July sunshine, we are engulfed by an oppressive, gloomy atmosphere. The dimness is punctuated by intense floodlights that illuminate areas of activity (walkways, stairways, crane riggings, scrap bays, control rooms, etc.) and shards of daylight that pierce holes pock marking the corrugated panels of the shed. These holes – Paul points out – are the traces of many minor explosions. Disquieting reminders of the liveliness of material transformations. As my eyes adjust to the darkness I notice particles – dust, graphite and metal fines called ‘kish’ – hanging in the air. The sensory assault is not only visual. The air is thick with the sickly stench of burning metal and grease. The cavernous shed is filled with an unrelenting din. A cacophony where the thunderous material transformations contained by the BOS vessels jostle with the noisy reverberations of extractor fans, pumps and locomotives; the whining of cranes passing over head; the reversing alarms of earthmovers; and the occasional crash as tonnes of scrap metal are charged into an empty vessel.

We venture further into the shed, following a route marked by lines painted on the ground, railings, staircases and suspended walkways. We snake past giant ladles, new refractory bricks, and lines painted on the ground, railings, staircases and suspended walkways. We snake past giant ladles, new refractory bricks, and...
lobby decorated with health and safety reminders, a basin and instructions to wash hands and cover dirty boots with overshoes – without pausing. The control room is cool and quiet. The only noise is the gruff conversation between workers and the background murmurs of air conditioning units and computers. Six men sit back on swivel chairs. Only one seems to concentrate on a bank of computer screens and CCTV monitors. The blackened desk space in front of the screens and control panels is cluttered with mugs of tea and plastic bags filled with sandwiches, crisps and tabloid newspapers. The banter of the control room hushes as we enter. The men stare at me, before one asks my guide who I am and what I am doing there. Paul answers. The conversation quickly resumes, not least because Paul is a union rep., and they rarely see him on the shop floor because he spends his workday in a crane rig. The discussion moves quickly, ranging from the latest rumours about takeovers, pensions and redundancies to grievances about overtime, missing safety equipment and workplace disputes. As Paul gets drawn into these conversations, I talk to the worker next to me. He explains that only one vessel is working at the moment. Another is undergoing scheduled maintenance, while a dart that monitors temperature and chemical composition of molten steel on a third has failed and is being repaired hurriedly by engineers. Everyone is waiting for the next tap. And so I begin to understand the stuttering business of making steel, whose rhythms are shaped by breakdowns, scheduled maintenance, accidents, order books, environmental regulations, or the ability of other parts of the steel plant to supply and handle materials at any given time.

We’ve been in the control room for about 15 minutes when news comes through on a radio that the dart has been repaired. They are ready for another heat. Paul and I follow four furnace-men out the control room. As we reach the far side of the vessel the second of two skips filled with scrap metal is being tipped into the vessel. Another crane then manoeuvres a ladle carrying molten iron into place. The driver, frustrated by the delay in charging the vessel (and his lunch break), empties the ladle containing 160 tonnes of ‘hot metal’ in about 20 seconds, instead of the usual 2 minutes. The rapid mixing of cold scrap and molten iron sets off a violent reaction. Flames leap from the vessel. Showers of “penny sparks” – fragments of burning metal – are expelled across a 30-m radius. Thick, acrid fumes escape the extraction hood designed to capture off-gases. The plumes rise and escape through an opening in the shed roof. The vessel is returned to its vertical position, we move behind a worker who is positioned underneath a conveyor belt that dumps lime and dolomite into the molten metal. He stands feet away from the vessel, peering through an open blast-proof window observing the turbulent bath of the incandescent molten metal, his forehead beaded with sweat from the intense heat.

2. A performative economic geography of steel

2.1. Introduction

This narrative reconstructs an escorted visit to a steel plant in northern Europe. It is an exercise in storytelling based on repeatedly observed and recorded practices in steel plants. This mode of writing takes its cue from recent arguments for a performative cultural economy that use literary narrative to ‘foreground materiality’ (Gregson, 2009, p. 285). The steel industry has been central to the development of several key ideas in economic geography, but the material transformations integral to making steel are precisely the things that are absent in many economic geographies of the steel (cf. Burawoy, 1989; Hudson, 2005a,b, 2011). This paper aims to recover the everyday struggles with matter that constitute ‘worldly production’ in a steel plant (Pickering, 2005, p. 360). I introduce the concept of assemblage to deal with the empirical and conceptual complexity of steel plants. Building on cultural economy’s recent emphasis on the performativity of instruments and technologies, assemblage offers a tool that copes with the overwhelming array of technologies, materials and cultures that must hold together for a steel plant to function and recognises the agency of matter. By framing the steel plant as an assemblage the paper makes two key contributions. First, it shows how all kinds of routine, reproduction work – health and safety, repair and maintenance, monitoring and inspection – are fundamental to production. Second, it demonstrates the potential for cultural economy to open up different ways of doing economic geography and understanding economies. To date much of the work in cultural economy has focused on cultural and creative industries (Amin and Thrift, 2007). By focusing on the steel industry – perceived by many as a dirty, technologically unsophisticated industry – this paper shows how cultural economy offers something to the analysis of all kinds of economic activity.

The opening narrative introduces these concerns in two ways. First, it writes the industrial workplace through the body. It transports the reader to the midst of the material practices of containment and transformation necessary to the business of steelmaking (Pickering, 2005; Gregson, 2011). Second, the narrative writes materiality into accounts of industrial work. It emphasises how work on a steel plant involves a series of collaborations with materials and technologies through the day-to-day labour of monitoring, sampling, handling, transporting, repairing, manipulating and transforming. The rhythms and ruptures of working with materials highlight the liveliness and recalcitrance of matter and how things inevitably go awry. Continuous production processes rarely flow smoothly – as production diagrams or accounts of steel making might have us believe. By refusing to tune out mishaps, near misses, breakdowns, accidents, and the never-ending work of containment, we begin to understand the unstable, stuttering nature of industrial production. Breakdowns, accidents, and the considerable labour of holding together production processes, need to be considered as fully economic activities.

In Sections 2.2 and 2.3, I position my arguments in relation to work on the steel industry and cultural economy. First, I consider how the steel industry has become iconic in economic geography, featuring in the development of many of the sub-discipline’s key theories and ideas. However, economic geography’s encounters with the steel industry have been dominated by Marxian political economy, imparting a particular orientation to research and particular ways of figuring economic activity. Accounts of the steel industry tend to be framed by the dynamics of capital accumulation, labour geographies, regulatory frameworks or to the place of regional economies within a globalising economy. That the steel plant produces steel is taken for granted in all of these accounts. Even where the importance of material transformations is acknowledged in conceptualisation of economies, everyday practices and material transformations involved in industrial activity continue to be overlooked (Hudson, 2005a). Second, I outline a sympathetic critique of cultural economy. Cultural economy stages important challenges to taken-for-granted ideas of what an economy is and conventional ways of doing economic geography. However, cultural economy’s focus on the creative industries and the ‘softer end’ of capitalist production has resulted in a neglect of the manufacturing industries. Furthermore, work in cultural economy tends to mobilise a notion of culture inherited from the anthropological tradition of material cultures that, ironically perhaps, tends to neglect the material register (Gregson, 2009).
Section 2.4 explores how the concept of assemblage might contribute to the development of a performativc cultural economy. Assemblages introduce a notion of culture that emphasises collaborations between humans and non-humans and admits the vital presence of matter. Thinking with assemblages performs a different kind of economic geography that foregrounds the processes through which production process hold together and pull apart.

In Section 3, I return to the routine labour of working with materials on a steel plant, using assemblage to highlight the material practices and encounters through which materials are transformed and production processed are made and unmade. Section 4 examines a catastrophic failure of an assemblage. It traces the events that led to an explosion in a blast furnace to demonstrate the agentic capacities of matter, and to rethink causality and responsibility. Section 5 brings the arguments together, suggesting that thinking with assemblages and experimenting with literary narrative offers a different – and supplementary – way of doing and understanding economic geography.

2.2. Economic geography and the steel industry

The steel industry has an iconic status in the development of economic geography (Florida and Kenney, 1992). It is possible to identify at least four areas where the steel industry has been central to the sub-discipline’s development. First, the steel industry has been enrolled to understand the shifting and uneven geographies of production and how these are the outcome of an interplay between changing production technologies, labour productivity and corporate structures (Sadler, 2004; Florida and Kenney, 1992; Dawley et al., 2008; Dunford and Greco, 2008; Fairbrother et al., 2004). Second, research on the steel industry has documented the flight of capital from ‘steel towns’ in Northwest Europe and the American ‘rust belt’ (Robinson and Sadler, 1985; Hudson and Sadler, 1989). As a result the steel industry figures prominently in understanding industrial restructuring as necessary to the restless geographies of capitalist accumulation (Sadler and Sadler, 1989; Beynon et al., 1991; Hudson, 2001; Dawley et al., 2008; Dunford and Greco, 2008). Third, the steel industry has been a muse for understanding how capital, state and labour shape regional economies, and how all three are implicated in processes of deindustrialisation and the production ‘old industrial regions’ (Hudson and Sadler, 1989; Beynon et al., 1991; Hudson, 2005b). Fourth, research on the steel industry has contributed to understandings of labour geographies. For example, the steel industry has provided evidence for claims that a new international division of labour has emerged with a global shift in the geographies of production (Dicken, 1986). Elsewhere the steel industry has been used to highlight how labour and trade unions have shaped the landscapes of capitalism and regional industrial cultures (Sadler and Thompson, 2001; Stenning, 2003) and how class-consciousness and identities are forged through workplace rituals (Burawoy, 1989). Economic geography’s engagement with the steel industry has clearly been productive, but it has also been partial. Economic geographers’ entrenched habits of looking up to capital accumulation, regulation theory or the labour process mean that they take for granted that a steel plant produces steel. Everyday struggles with the material world through which steel becomes tend to be obscured. There are, I think, a number of important reasons for this prioritisation. It reflects an interest in the ‘bigger picture’ of shifting geographies of production in capitalist economies and the exploitation of labour by capital in the creation of value. It also reflects the difficulties in gaining access to steel plants and the methods preferred by many economic geographers – namely the analysis of quantitative data on output, employment and investment, and corporate interviews. Furthermore, a widespread perception that the steel is a smokestack industry encourages a neglect of the work that keeps steel plants holding together and producing steel. Steel plants might be ‘big things’, but they are seen to involve relatively simple industrial production systems (Law, 2004, p. 13). These perceptions are misplaced. They fail to recognise the sophistication of production processes in steel plants that rely on high levels computerisation and automation (Aylen, 2004) to manufacture of thousands different steel grades in batch production processes that integrate material flows and transformations with logistics, supply chains and markets (see Hudson, 2005a, 2011).

My interest in the steel industry and focus on working with materials in a steel plant diverges somewhat from political economies of the steel industry. However, it is important to note that rethinking economy through assemblage does not seek to displace political economy, but it does encourage a different approach. Rather than viewing capitalist social formations as the outcomes of an underlying or essential logic of capital, assemblage sees them as effects of socio-material processes; as contingent achievements enacted in particular sites. This is not to deny the explanatory power of political economy, but assemblage theory resists political economy’s tendency to ‘succumb to the temptations of explanatory conclusions before we have entered into the difficulty of things’ (Dovey, 2011, p. 348). And so, assemblage explores the processes through which formations like value, labour or capital are brought into being and maintained through a dense circuitry of humans and non-humans that constitute the “becoming-being called capitalism” (Gidwani, 2008, p. x). Assemblage works through the complexities and incoherence of actually existing economies that are acknowledged, but marginalised in recent arguments for a cultural political economy (Jessop and Oosterlynck, 2008).

In the context of the steel industry thinking with assemblage might involve examining the complex socio-material arrangements and working practices that constitute a steel plant in the recognition that these are materialisations of histories of capital accumulation, investment and disinvestment; legacies of uneven spatial development; and the labour process. For example, the messy lash up of technologies and everyday practices that involve work routines, breakdowns, uncertainty, and improvisation, offers insights into how capitalist formations materialise on the ground. Hudson and Swanton’s (2012) account of the stalled construction of a steelworks on Teesside in the UK illustrates how legacies of industrial production, abandoned investments in the nationalised industry, and the privatisation and financialisation of the steel industry, produce a disintegrated steel plant manufacturing a low value product. Following the nationalisation of the steel industry in 1967, a modern integrated steelworks was planned for Teesside with an annual production capacity of 12–15 million tonnes, and a diversified rolling capacity. But in 1978 with two of five stages of the development completed, the modernisation programme was halted due to a collapse in the demand for steel and pressures on public expenditure. The result was a vulnerable and disintegrated works, where the plant was dependent on one blast furnace for iron and lacked modern rolling capacity. The lash-up of humans and non-humans and the everyday
practices involved in maintaining the production process can be seen as an effect of the socio-material processes of capitalism working out on the ground – alongside other factors including accommodating legacies of steel making, technological change, shifting labour relations, and retrofitting demanded by decay, environmental regulation and health and safety legislation.

Thinking with assemblage also extends recent work on the political economy of the steel industry in other ways. For example, a focus on working with materials resonates with Hudson’s (2005a, 2008, 2011) arguments that economic geography needs to consider the materials and the material transformations that underpin the creation of value. Hudson’s (2005a, p. 38) argument is that ‘economic activity involves the application of labour, deploying a variety of artefacts and tools, to transform and transport elements of nature to become socially useful products’. My interest is in thinking about the kinds of labour that sustain these material transformations. In particular I seek to disrupt the tendency within economic geography to recast the working bodies that handle and transform materials as the more abstract category of labour. Taking inspiration from Burawoy’s (1989) work on the Lenin Steel Works in Hungary, I argue that there is much to learn from going further into the workplace and engaging with the day-to-day realities of industrial work. Burawoy provides a vivid account of industrial work, arguing that lived experiences of production shape class-consciousness and labour mobilisation. While Burawoy is interested in the organisation of dissent under state socialism, his rich ethnographic accounts of working with materials capture the rhythms and ruptures of steelmaking. My aims are different, and health and safety legislation and discourse made it impossible to experience steelmaking in the same way as Burawoy, but I am similarly interested in drawing out the diverse set of practices through which matter is transformed and production processes are reproduced.

So far, I have sketched out how assemblage might offer a very different – but complementary – approach to economic geographies of the steel industry. In the next two sections I turn to cultural economy and assemblage to develop this approach.

2.3. A cultural economy of the steel industry?

Cultural economy has shifted the empirical focus of much social scientific work on economies. Cultural economy names both an ‘invisible college’ of heterodox economic knowledge drawn from across the social sciences that asserts culture and economy are not hermetically sealed (Amin and Thrift, 2007, p. 145; Barnes, 2001), and a site of struggle around the idea of what an economy is and might be (Lovell and Smith, 2010). The embedding of particular forms of cultural analysis in cultural economy has accompanied a growing academic interest in the rise of creative and cultural industries and the ‘soft’ capitalisms of the knowledge economy. However, this paper goes against the grain by taking cultural economy back to the factory. There are two motivations behind this move. First, it counters the marginalisation of a vast array of economic activity by cultural economy – most notably the ‘old’, supposedly technologically-backward economy of manufacturing (Amin and Thrift, 2007) – thereby significantly extending the scope of cultural economy. Part of my argument is for a more fundamental rethinking of economy than that offered by cultural political economy’s efforts to marry aspects of cultural economy with the traditional concerns of political economy (e.g. Sayer, 2001; Jessop and Oosterlynck, 2008). Second, taking cultural economy to the steel plant challenges a relatively neglect of material registers in cultural economy (cf. Pickering, 2005; Gregson, 2009). Within cultural economy efforts to take matter seriously have been limited by the anthropological tradition of material culture or have drawn on actor network theory that prioritises decoding of material semiotics and tracing associations (e.g. Callon, 1998; Law, 2002; Hardie and MacKenzie, 2007; Murdoch, 1997).

Both approaches tend to deaden matter. Material culture dwells on the biographies of things or cultural circuits of value, leaving the things themselves behind. In actor network theory things, technologies and matter are subsumed by the work of translation as everything is reduced to the relation. I use assemblage to develop a quite different idea of culture that is alert to the liveliness of matter (Bennett, 2004, 2010; Gregson, 2009), and joins recent performative accounts of economies that examine the material practices and becoming through which economic activity takes place (Callon, 2007; Mitchell, 2008; Mackenzie, 2009; Gregson, 2009; Lovell and Smith, 2010).

The ‘cultural turn’ in economic geography and beyond has posed important – and awkward – questions for both neoclassical economics and Marxian political economy about theory, practice and methods (Peck, 2005). There is considerable debate about the basis, success and costs of cultural economy’s challenge to established ways of thinking the economy, but my focus is somewhat different. I address the tendency for cultural economy to ‘focus’ on that which has already been prefigured as cultural, namely particular industries (film, advertising, music, fashion) and iconic products and brands (Sony, Apple, Nike)’ (Gregson (2009, p. 285); and question the apparent imperviousness of research on manufacturing industries to the challenges of cultural economy. To outline what I think a cultural economy adds to accounts of steel making, I examine the similarities and differences between the approach I develop through assemblage and cultural political economy.

Cultural political economy represents a sustained effort to establish a terrain of engagement between political economy and cultural economy (Jessop and Oosterlynck, 2008; Jessop and Sum, 2010; Sayer, 2001). Cultural political economy develops a post-disciplinary approach to contemporary capitalism that rejects historical analyses of capitalism; emphasises that (capitalist) social relations are the outcome of semiotic and extra-semiotic processes; and affirms the complexity of the social world through a distinction between the actually existing economy which is the chaotic sum of all economic activities and the economy that is narrated (Jessop and Oosterlynck, 2008). There are numerous sympathies between cultural political economy and my approach. Both learn from the insights of cultural economy, troubling some of the entrenched habits of thought found in political economy (like falling back on naturalised categories); both recognise the complexity and incoherence of actually existing economies; and both introduce the idea of performativity to grasp how social formations come into being. But there are also important differences, including cultural political economy’s narrow interpretation of culture that seeks to reduce the ‘cultural turn’ to a concern with semiotics, and the sleight of hand with which cultural political economy recognises, but then brackets off, the complexity of ‘actually existing economies’.

At the heart of these differences is an imagined trade-off between the explanatory force of political economy and its account

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1 Hudson (2008) offers a rare acknowledgement that economic geographers might learn from the epistemological tactics of cultural economy, but he rejects any claim that the economy is more ontologically cultural. For Hudson, economies are still structured by the ‘hard realities’ of political economy, namely commodity production and the creation of surplus value.

2 These differences emerge. I think, from cultural political economy’s desire to contain the ontological and epistemological challenges of cultural economy and its insistence – in the final analysis – on the explanatory power of political economy. For example, cultural political economy takes on board some of the epistemological critiques of conventional political economy, and integrates semiotic analysis to understand how cultural contexts and social relations make a difference to political economic processes through institutional arrangements and labour relations (Jessop and Sum, 2010; Sayer, 2001). This offers some important corrective tendencies to trans-historical analysis and a reliance on fetishized concepts in political economy, but it also severely truncates how ‘culture’ might be imagined in its analysis of economy, or what kinds of activities might properly count as economic.
of power, and the kinds of concerns nurtured by cultural economy and by assemblage thinking. In the context of this paper, the trade-off sees a focus on working with matter on a steel plant (and the insights it generates) as coming at the price of obscuring political economic explanations of how these encounters between humans, technologies and materials come to be organised as they are. However, assemblage thinking does not necessarily produce this trade-off. Assemblage certainly engenders a different approach to the concerns of political economy but it is a supplement to, rather than a replacement for, a (cultural) political economy of the steel industry. My primary interest is in what monitoring, managing and containing material transformations might tell us about the economic activity of steel making. But this does not mean that assemblage downplays the concerns of political economy. Indeed, assemblage might better describe the material practices through which capitalist social relations are reproduced through the arrangements of humans, technologies and materials in a steel plant; through labour relations; through legacies of investment and disinvestment.

The approach I develop to the steel industry is more in the spirit of Timothy Mitchell’s (2002, 2008) work that rethink economy by emphasising the importance of material objects in the enactment of the economy. Mitchell disrupts the accent in economic sociology on the embeddedness of the economic in social ties and cultural meaning. He argues that economies need to be thought in terms of socio-technical arrangements. For example, in his account of Thomas Edison’s development of the early electricity industry in New York, Mitchell (2008, p. 1117) argues that the industry’s emergence depended on networks of relations that tied together humans and electrons in a set of intersecting projects that included “new technical processes, new forms of distribution and monitoring, new forms of calculation that were simultaneously economic, electrical, chemical and social”. The strength of Mitchell’s account lies in his insistence that the economy is a project that is continually being enacted, and this enactment requires enormous effort to bring together and align heterogeneous elements. While Mitchell’s focus is on the emergence of markets, my interest is in understanding the construction of steel plants as economic entities, and the effort required to make steel and money.

Mitchell’s focus on economies as socio-technical arrangements and the effort of assembling and maintaining, offers an opportunity to take seriously the complexity and incoherence of the actually existing economy. His work – when coupled with assemblage – provides a basis for rethinking steel plants as sites of on-going struggle with the material world, where humans seek to manipulate, transform and contain matter in the creation of value. A focus on factories as sites where humans encounter non-human machines, technologies and materials is nothing new. Pickering (1995) has noted that Adam Smith, Karl Marx and Charles Babbage were all preoccupied with the conditions under which human labour and non-human machines were brought together in manufacturing. But this focus has waned as social scientists have concentrated on workplace atmospheres and cultures, while the material encounters between humans with non-humans in production processes have become the domain of engineers (Pickering, 1995). Here I work against the grain of this academic division of labour to frame industrial work through the practices, doings and becomings that arise from working with materials. It is about the containment of, and collaborations with, materials that are recalcitrant and unruly; that escape; that threaten to harm.

This focus on working with materials also cultivates a quite different sense of culture to that encountered elsewhere in cultural economy. It is a notion of culture that takes inspiration from the ‘energetic’ or ‘vital’ materialism found in the writing of Spinoza, Whitehead, and Deleuze and Guattari to attend to the liveliness of the world (Bennett, 2001, 2004, 2010; Thrift, 1996; Whatmore, 2006; Latham and McCormack, 2004). This concern with the liveliness of the world shifts the focus of cultural analysis away from representation and discourse and towards practice and performance; away from the interpretation of signs and symbols and towards affect (Whatmore, 2006; Bennett, 2004). Through the lens of vital materialism, matter is no longer dull, immutable and passive. It is vibrant and recalcitrant. Bruno Latour captures the spirit of this liveliness when he writes: ‘Whenever we make something we are not in command, we are slightly overtaken by the action: every builder knows that’ (Latour, 1999, p. 289, emphasis in original). A performative account of economy that is attentive to the liveliness and agency of the material world offers a tactic for dislodging the social as the only source of action and the basis for explanation (Pickering, 2005, p. 399). In the next section, I argue that assemblage embraces this vital materialism, and brings working with matter centre stage in an analysis of economic activity.

2.4. A steel plant is an assemblage

Thinking with assemblage engenders a distinct approach to economic geography. It challenges economic geography’s taken-for-granted concepts and analytical frames through a resolute focus on questions of formation and becoming. Rather than viewing economic activities as expressions of an essential capitalist logic, assemblage sees them as the contingent achievements of socio-material processes. The effect of this ontological shift is that assemblage emphasises the enactment of economies and values thick description that captures the precise ways in which technologies, materials and humans are assembled and maintained in the becoming of capitalist social formations. Therefore, assemblage is particularly helpful for questioning the ‘coherent giveness’ of the steel plant as a ‘self-evident thing’. It helps frame a steel plant as an on-going economic event by encouraging a focus on the socio-technical practices through which a steel plant is made and unmade (Jacobs, 2006; Law, 2005).

Assemblage views social entities – like a steel plant, an electric power grid (Bennett, 2005), or even neoliberalism (Ong and Collier, 2005) – as being formed through the connection of heterogeneous components (Bingham, 2009). More specifically, assemblages direct attention to how the properties of social entities are the effects of the relations of that entity’s heterogeneous components. In this sense, assemblage offers a way of thinking culture and materiality together. It emphasises the value of looking down at materials and mundane arrangements (McFall, 2009) and it provides analytical space for both humans and non-humans to be the sources of action and the basis for explanation. This strong focus on the arrangements of, and relations between, human and non-human components directs analytical attention to how social entities hold together (Law, 1987; Mitchell, 2008). What is particular about rethinking economy with assemblage is the insistence that coherence is an achievement, and that the labour, friction and accommodation necessary for this coherence matters.

Thinking with assemblage involves shifting the action from concrete things to the processes that give rise to phenomena (Harman, 2008; DeLanda, 2002); they focus attention on the interaction between heterogeneous components (humans, technologies, cultures and materials) that hold together more or less coherently (Bennett, 2005; DeLanda, 2006). Like actor networks, assemblages pay attention to the ontological diversity of actants in a functioning whole and the ‘construction work’ involved in building groupings (Hetherington and Law, 2000; Anderson et al., 2012). But whereas

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5 I am grateful to the comments of one of the referees in encouraging me to examine this trade-off more fully.
an actor network offers a seamless whole that assimilates all its component parts, an assemblage is not conceived as the aggregation of the properties of these parts. Assemblages take form through the interaction of the capacities of its parts, but are never reducible to those parts. The formation of an assemblage is a result of what DeLanda (2006) calls ‘relations of exteriority’.

These relations imply, first of all, that a component part of an assemblage may be detached from it and plugged into a different assemblage in which its interactions are different. In other words, the exteriority of relations implies a certain autonomy for the terms on which they relate, or as Deleuze puts it ‘a relation may change without the terms changing’. Relations of exteriority also imply that the properties of whole can never explain the relations which constitute a whole, relations do not have as their causes the property of the [components parts] between which they are established. Although they may be caused by the exercise of a component’s capacities. (DeLanda, 2006, pp. 10–11)

The emphasis on a whole emerging form the interaction of the capacities of parts has at least two important implications.

First, it focuses attention on the processes through which heterogeneous elements in an assemblage hold together. It exerts a strong emphasis on processes of formation and becoming, shifting the focus from steel products to processes of production and reproduction. The steel plant can no longer be black boxed as fixed capital or a ‘big thing’ that produces steel. A steel plant is enacted. It is the on-going effect of material practices and the labour of containing and transforming matter.

Second, assemblages disrupt how the relations between parts and wholes are normally figured. Relations of exteriority emphasise the autonomy of parts and recognises the vitality and agency of matter and how this matters economically (Bennett, 2004, 2005, 2010). This allows for a ‘decentring of the social’ as the transforming and transforming an overflowing material world that threatens to resist and exceed human efforts to contain it. Even when an assemblage – like a steel plant – appears to be relatively stable, this stabilisation is the effect of all kinds of hidden labour and there is constant threat of destabilisation (through changes in corporate structure, technological advance, accidents, more stringent environmental regulation, and so on). Assemblage is a concept that embraces this nervous tension. It deals with technologies and practices that seek to order and contain, but also recognises that humans and non-humans have the capacity to exceed these attempts (unruly materials leak and escape; machines break down; workers break rules; mistakes are made; procedures are not followed).

In Sections 3 and 4, I examine how assemblage can help us understand how the fragile coherence of a steel plant is the outcome of everyday struggles with matter. In the process all kinds of practices that are normally overlooked in economic analyses become visible and understood as economically vital. Repair and maintenance, health and safety, the routine labour of ordering and containing the material world, as well as industrial accidents, become fundamental components of an economic geography of the steel industry.

3. Holding together

This section focuses on moments of everyday industrial work that provide a glimpse of the varied labour of holding a steel plant together. Based on ethnographic observations during numerous escorted visits, I use three narrative fragments that emphasise just some material practices. These fragments offer steps towards a performative account of industrial work that evokes the embodied experiences of working with materials; the unruly nature of materials that refuse to be easily handled and contained; and the never-ending labour of repair and maintenance that tries to slow the rate at which fixed capital comes apart. In short, these fragments shift economic geography’s analytic gaze away from blooms, billets and slabs, and onto the everyday accommodations with matter and the labour through which an assemblage is continuously made and unmade.

3.1. Monitoring work

Much of the work on modern steel plant is mediated by screen technologies. In the BOS control room arrays of computer screens and CCTV monitors of different ages mediate encounters between steelworkers and the materials they handle and transform. These screens do not simply relay information; they are calculative agencies that produce specific effects of cognition and action (Callon and Muniesa, 2005; MacKenzie, 2008; Pyke, 2010). In a secondary steelmaking pulpit, Andre splits his attention between a screen that displays real-time information about the chemical composition of the steel in the vessel and the surface of the molten steel in the ladle below. He tells me that he concentrates on the levels of carbon, silicon and manganese displayed as percentages on the screen, and guided by these he controls the rate at which argon is injected into the ladle and barks orders to one of his team who adds alloys via a chute while the steel is tapped.

These screens provide more than a simple representation of thermal and chemical conditions in a vessel. During a heat they relay simulations based on complex algorithmic equations to model thermal and metallurgical processes based on the actual conditions in the vessel. The screens guide operators, predicting required weights of additives and alloys and treatment actions optimising material inputs and usage, minimising costs, increasing productivity, and producing yields of homogenous steel quality that fulfils certification requirements. Screens, visualisations, algorithms, electronic networks, and various sampling and surveillance technologies exert a kind of agency. These distributed calculative agencies choreograph the steelworkers’ actions, determining the quantities of flux and alloys added, the flow of oxygen through the lance, the timing of the heat, the extent of bottom stirring and so on. Together these monitoring technologies, sophisticated process models and process technologies enable steelworkers to predict and manage the molecular transformations occurring in the converters. They provide the vessel crew with the capacity to manipulate material transformations to produce hundreds of different grades of steel with desired properties and qualities, allowing them to produce higher value steel to customers’ specifications (Hudson, 2011).

Most of the time this work is boring and repetitive. But, monitoring work also requires the embodied know-how of metallurgists and steelmakers who understand the alchemy of steel making and can judge the temperature and qualities of molten steel based on colour, smell, and surface turbulence. Remote monitoring and surveillance, sophisticated software, and automated process technologies may reduce the direct exposure of working bodies to unruly materials, but industrial work is always about a series of accommodations with matter. Often these accommodations are routine, involving, for example, managing the rate at which parts of the steel plant decay and fall apart. Paul tells me about the strategies that vessel crews deploy to care for converters – or more precisely their refractory lining. Crews will protect a newly relined converter, using it less intensively. Meanwhile, vessels with already
degraded linings that are due for maintenance are used ‘hard’. But the material transformations involved in steelmaking can – and do – go wrong. Materials behave in unexpected ways; equipment fails or breaks down; computers crash; chemical reactions go out of control; pipes leak. And if things go awry, these workers need to use their experience and know-how to ensure that production processes hold together safely.

3.2. Containment

For the last 15 minutes Stefan and two colleagues have been monitoring and controlling the addition of calcium carbonate and magnesium to molten iron from the ‘desulph’ control room. These additions reduce the sulphur content of the iron, producing finished steel that is less brittle. Stefan has been keeping an eye on a screen that flickers as tables and graphic visualisations update. Taking his cue from the screen, Stefan signals that it is towards the end of the desulphurisation process, and he needs to descend two flights of stairs to a pulpit. The impurities in the hot metal have reacted with the calcium carbonate flux added during the treatment, forming slag on the surface of the molten iron that needs to be skimmed. I look over Stefan’s shoulder into a dark void. We are standing in a cramped pulpit overlooking a ladle containing more than 200 tonnes of molten iron. We are protected from the ladle by sheet steel, a pane of cracked, heatproof glass, and a jet of cool air. Looking ahead, Stefan uses a lever to tilt the ladle. Slowly, the window is illuminated by the molten iron. The temperature becomes uncomfortable as we are exposed to the intense heat in the ladle. Stefan shifts slightly, and takes a joystick. Continuing to look ahead he operates a mechanical arm and blade. The blade judders back and forth, skimming off the blackened skin of slag to expose the incandescent molten iron beneath the surface. The slag tumbles into a slag pot positioned below.

As it cools this slag forms a fine dust that is picked up by the slightest breeze. To prevent the dust becoming airborne, the slag must not be moved for 12 hours or until it cools below 80 °C. But treating each ladle of hot metal produces 6–7 tonnes of slag and the slag pots have to be moved before the slag has had sufficient time to cool. Moving the slag pots and storing them on the shop floor allows the steel to be moved. Tipsing the slag before it has cooled leads to complaints from local residents and inspections from the environment protection agency as this unruly material escapes and sticks to windows and drying sheets in near-by residential areas. And so an accommodation with this unruly material has been reached. Slag crane operators monitor the wind direction. A traffic light system is in place. A red light indicates the prevailing wind is heading towards the town, while a green light means the wind is blowing out to sea. This slag is only moved and tipped into the slag pits when the unruly particles will travel out to sea.

3.3. Sweeping the floor

The plant is on a stop. The flow of materials has been disrupted by a decision to idle the blast furnace for 36 h each week. The rhythms of steel making have been disturbed by the credit crunch and the collapse of a slab off-take contract. The plant is making steel no-one wants. But continuous production processes – and the blast furnace in particular – cannot be stopped and started. Slight changes in burden and blowing can have serious and unpredictable consequences as scaffolds of burden build up on the furnace’s inner walls, restricting the upward flow of gas with damaging consequences for the safety of industrial processes and the quality of hot metal. The idling of the blast furnace also means materials fail to flow through the rest of the production process; the assemblage starts to fall apart.

The shop floor in the BOS plant is eerie. The usual cacophony is substituted by a muffled roar of burners that prevent the refractory linings in the inverted converters from cooling too much. This reduces the risk of refractory contracting and cracking, and therefore the need for costly repairs. The stand in front of the vessels is clear. Uneven stacks of alloys, used pallets, discarded cardboard sampling tubes, old newspapers, plastic packaging have disappeared. The tracks left by brush bristles are visible on the still dusty floor. The shifts see this work of clearing up as futile. It kills time during a stop. But this work is part of the vital day-to-day labour of holding the plant together. Objects falling from height are a serious – and occasionally fatal – hazard. Clearing up – particular when much of the work is done several storeys above ground level – reduces the risk of injury and fatalities. Accidents are personal tragedies, but they are also economic events. They halt production; they tarnish corporate social responsibility records; and they cost money through fines, compensation and insurance premiums.

Most of the men are in cabins. As they wait for the arrival of the first torpedo that will bring the plant back to life, they sit sipping mugs of tea and sharing the latest rumours about redundancies and the future of the plant. On the shop floor there is some evidence of repair. At the concast, the tundish, mould, support roll and spray rolls have cooled sufficiently to give maintenance engineers access to areas that are too hot and hazardous during normal production schedules. While the heating and cooling caused by the stop leads to additional maintenance problems, it also provides opportunities for inspection and retrofitting. Jacob, a maintenance engineer takes me into the spray chamber – a hidden world of pipe-work, rollers and grease beneath the concast. Normally this area is inaccessible as liquid steel is cooled and formed into slabs just centimetres from where we stand. Jacob explains how during his last two shifts he has squeezed into claustrophobic, greasy spaces beneath the concast to inspect the rollers – any deformity on a roller, he says, will lead to deformities in the finished slabs of steel – and may mean they fail quality control. During these inspections, he has also been identifying and repairing leaks in the networks of water pipes that modulate the temperature of the machinery and cool the steel as it is formed into slabs.

3.4. Coherence

These three narrative fragments introduce a host of material encounters. They focus on everyday struggles to contain and transform lively materials and the overlooked – but economically vital – work involved in decelerating the rate at which a steel plant falls apart. Focussing on industrial processes, rather than products, begins to foreground all kinds of work – maintenance; repair; monitoring; retrofitting; health and safety – that hold an assemblage together. These material encounters underscore the importance of the labour of reproduction that ensures that the steel plant coheres and produces steel. In Section 4, I use the catastrophic failure of an assemblage to illustrate the agentic capacities of matter in industrial production processes.

4. Falling apart

In the social studies of science failures are routinely used to analyse how things normally hold together, and sustain the ‘machinic qualities of the black box’ (Jacobs, 2006, p. 19). Failures mark the point where heterogeneous elements refuse to collaborate in their existing configurations. The point of failure also exposes unseen labour that is necessary for the assemblage to more or less cohere, but often falls out of economic analyses. In this section, I use
an explosion in a blast furnace in South Wales to foreground particular aspects of industrial work. The explosion provides a stark and tragic reminder of the vulnerability of working bodies. It also provides an example of how the vitality of matter can force an assemblage to fail.

On 8th November 2001 there was an explosion in blast furnace no. 5 at the steel works in Port Talbot. The explosion – caused by the mixing of water and molten materials – was so violent that the furnace and its 5000 tonne burden were lifted 0.75 m. As the furnace lifted gases and 200 tonnes of liquid, solid and semi-solid materials engulfed the cast house floor (HSE, 2008). Three steel workers were killed, and a further 12 steelworkers and subcontractors were admitted to hospital.

Here, I draw on an official Health and Safety Executive (2008) report, and an interview with the Health and Safety Executive’s lead inspector into the explosion, to reconstruct the events that ended in this tragic explosion. My account focuses on the vital, unruly capacities of matter and technologies and how materials constantly threaten to maim and extinguish human life.

One starting point for understanding this explosion is the morning of 7th November 2001. Routine maintenance was being performed on a water pump that supplied the furnace cooling system. The process of iron production is exothermic and generates temperatures in excess of 2000 °C. The furnace requires massive supplies of cooling water – in this blast furnace 90,000 l a minute.

The pump in question was running on a refurbished motor that was not a like-for-like replacement. The result of this imperfect substitution was that the motor ran at 98–99% of its capacity, instead of the intended 90%. A thermal overload protector had not been adjusted to accommodate the change in motor. As the electricity feeds were switched during maintenance the water pump tripped out too soon. A back-up pump came on line automatically, but it tripped because of a speed surge and a third water pump failed to come on line. These failures meant that for between 10 and 12 minutes the blast furnace received only 55% of its cooling water supply. The furnace crew monitored the drop in water supply and reduced the flow of hot air to prevent overheating. However, the reduced water supply led to the failure of a number of furnace coolers and to serious water leaks (it is estimated that 50–80 tonnes of water escaped into the furnace).

A search for leaks was initiated, but none were found. But this search process was flawed. The watermen on shift were relatively inexperienced and they did not use an adequate system of labelling and tagging coolers that had been checked. Their work was hampered by the need to wear cumbersome protective equipment, including breathing apparatus. Moreover, years of retrofitting as part of maintenance practice meant that the pipework for the cooling system was chaotic and ‘spaghetti-like’, and a number of valves failed which meant leaks could not be identified quickly. The search for leaks was inadequate. However, a technologist had witnessed the furnace expelling a yellow-green flame – indicative of the presence of hydrogen and therefore water ingress – and the furnace was shut down. During the evening 3 failed coolers were identified and isolated. Believing they had found the leaks, attempts to ‘recover’ the furnace began, and charging recommenced. Attempts to recover the furnace went on through the night and the next day. During the last attempt to recover the furnace water came into contact with molten metal and/or slag, leading to a massive release of energy and over-pressure of the furnace interior.

There is a lot to learn from this explosion. While many analyses would treat this explosion as an anomaly and a tragic accident, I argue that it is simply an everyday part of working with matter in industrial manufacturing. It is an extreme event, but it is still part of the day-to-day work that involves human bodies encountering and transforming the material world, where matter is neither inert nor passive background. In a steel plant matter is active and lively (Bennett, 2004). This explosion also underscores the unruly, overflowing nature of the material world – variable electrical currents trip switches; machines breakdown; coolers melt; water escapes; pipes and valves hinder. These unruly materials press the assemblage into new configurations and incite all kinds of action – including blowing down, shutting down, searching for leaks, repair, recovering the furnace – and eventually lead to the catastrophic failure of the assemblage. Assemblage disrupts the ontological privileging of the human body as the site of agency (Bennett, 2004, 2005; Pickering, 2005). Assemblages recognise the vitality of materials in ways that have the potential to force an assemblage out of its current configuration as new alliances or rivalries are forged, or friction becomes such that cooperation between heterogeneous elements is no longer possible (Bennett, 2005). This is not agency in a reflective sense. Rather non-humans are agents because they have the capacity to make a difference. They produce effects and to initiate action across an ontologically diverse range of actants.

Recognising the agency of matter also transforms how causality and responsibility are understood. A notion of distributed agency widens the angle of vision and lengthens timeframes when we consider an event. The focus shifts from efficient cause to identifying a string or cascade of events, and this changes our notion of responsibility (Bennett, 2005). Moral outrage and assigning blame are no longer sufficient. Instead, responsibility becomes a question of ethics that is attuned to the effects of the assemblages we participate in, and the experimental work of trying to minimise or compensate for the suffering that these assemblages may manufacture (Bennett, 2005). So while the steel company was assigned responsibility for the explosion – and fined £1.33 million, with a further £1.74 million awarded in costs – there are other, more complicated, stories of causality and responsibility. Rather than assigning blame, this notion of responsibility centres on the long-term string of events that ended in the explosion. These include overly protective safety mechanisms; practices of retrofitting and modification; profit motives and the need to keep the blast furnace online; poor maintenance, inspection and testing; poor communication; inadequate training and experience; imperfect monitoring and understanding of conditions in furnace; risky work cultures that are insufficiently aware of the danger of contact between water and molten materials. Most of these are precisely the kinds of activities that are seen to be at the periphery of the core business of making steel.

This explosion is undeniably an economic event. It halted production. There were numerous and significant costs that even fuelled questions about the future of steelmaking in Port Talbot. The explosion also led to radical changes in the working cultures and practices on the site. But, many analyses would simply have dismissed the event as a terrible anomaly. This is the difference that working with assemblages can make. It produces a different kind of economic geography that highlights the labour of accommodating matter, and the hidden labour involved in slowing the rate at which an assemblage falls apart – and the unpredictable consequences of this work.

5. Conclusion

In this paper I have outlined a different kind of economic geography of the steel industry that writes industrial production through the lens of working with matter. Research on the steel industry has become iconic in economic geography. But the everyday industrial work and the scale, messiness and sheer materiality of steelmaking are often absent in these accounts. Economic geography simply takes for granted the fact that steel plants produce
blocs, billets and slabs. Here I have developed a different account of industrial production. It takes inspiration from work in cultural economy – and performative accounts of economies – to examine different ways of doing economic geography. Working with assemblages cultivates a particular orientation to industrial work, emphasising that this work is fundamentally about working with matter and the practices through which production processes cohere as they are made and unmade. In addition, the encounter between cultural economy and the steel industry nudges cultural economy away from an idea of culture that is taken from the anthropological tradition of material culture. It introduces an understanding of culture that is open to the vitality and agency of the material world, and joins recent performative accounts of economies that seek to undo the neglect of material registers in cultural economy (MacKenzie, 2009; Gregson, 2009).

The result of these conceptual manoeuvres is an economic geography of the steel industry that begins to recover all kinds of work, activity and material practices that tend to be bracketed off from the final analyses of economic activity. For example, the economic activity of making steel is framed as fundamentally about everyday struggles with the material world, material transformations, and effort to hold production processes together. Industrial work is as much about reproduction as it is production. So, assemblages have the potential to disrupt where economic geographers look for economically relevant activity. They start to recover all kinds of practices that are excluded or marginalised. These include repair and maintenance, health and safety, and the routine labour of ordering and containing, monitoring and inspection. While these activities are treated as peripheral to the core economic activities of making steel (and routinely subcontracted by steel companies), my account brings them centre stage, arguing that they are fundamental to the continued operation of production processes. Without various accommodations with unruly materials and technologies in the manufacturing processes, or the vital labour of repair and maintenance that ensure production complexes cohere, steel would not be produced and value would not be created.

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