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# Pluralizing and Problematizing Carbon Finance

**Authors:** Gavin Bridge, Harriet Bulkeley, Paul Langley, Bregje van Veelen\*. Durham University, UK.

**\* Corresponding author:**

## **Abstract**

*Growing emphasis on finance as key to decarbonization requires social science research that critically attends to the emergent and diverse forms taken by carbon finance. First, we pluralize research into carbon finance, building on existing work to identify four main forms: carbon markets; ecosystem services; natural capital investment; and, capital allocated to low-carbon enterprises and projects. Second, we propose that research should problematize the processes through which carbon is variously translated into financial value. Illustrated with reference to low-carbon investment in electricity generation, our agenda thereby extends from the difficulties of producing carbon-as-commodity to the uncertainties of constituting carbon-as-asset.*

**Keywords:** carbon markets; ecosystem services; low-carbon investment; commodification; assetization;

## Pluralizing and Problematizing Carbon Finance

### I Introduction: from carbon markets to carbon finance

The strategic significance of financial markets to climate change policy was confirmed at COP21 by the Paris Agreement of 2015 (Andresen et al., 2016). As stated in Article 2, the Paris Agreement entails a commitment to ‘making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development’. Financial markets are positioned within climate change governance as key to unlocking action to prevent global warming in excess of 2 degrees Celsius by enabling investment in a low-carbon transition at scale. It is estimated, for instance, that an additional \$800 billion of investment in low-carbon activities will be required each year in order to stay under this threshold (Campiglio, 2016; European Commission, 2018; McCollum et al., 2013; Global Commission on the Economy and Climate, 2016). However, current investment levels fall well short of what is calculated as necessary to meet global targets (Buchner et al., 2017; Campiglio, 2016), despite the unprecedented policies of cheap money pursued by the leading central banks in the wake of the global financial crisis and the recent expansion of financial markets that are variously termed ‘green’ (City of London Corporation, 2016), ‘sustainable’ (DB Climate Change Advisors, 2012), or ‘environmental’ (Bertl, 2016). The growing emphasis on ‘finance flows’ as a means to decarbonization is significant, nonetheless. It not only marks a significant shift away from carbon trading and heralds a recognition of its limitations as a market-based strategy for low-carbon transition (Bryant, 2018; Ervine, 2014; Lane and Newell, 2016), but also requires a critical social science agenda capable of attending to the diverse forms of what we term ‘carbon finance’ that are now being mobilized towards this end. In this paper we seek to both *pluralize* the understanding of carbon finance within human geography and the social sciences, and to *problematize* the various processes through which carbon is translated into financial value.

First, we seek to map out the terrain of multiple and relatively discrete forms of carbon finance that explicitly seek to act on carbon emissions alongside the extraction of financial value. We adopt the term carbon finance to expressly avoid confusion with the alternative rubric of ‘climate finance’ that conventionally and narrowly refers to donor funding or development aid consistent with the principles of the United Nations Framework Convention on Climate Change (UNFCCC) (Ballesteros et al., 2010; Clapp et al., 2012; Godinot et al., 2017; World Bank, 2017). To delineate carbon finance, we draw into conversation literatures on the governing of climate change, the political and cultural economies of carbon markets, and wider bodies of research concerned with ‘neo-liberal natures’ (Bigger and Dempsey, 2018) and the ‘financialization of nature’ (Ouma et al., 2018). While it is indeed the case that, as Felli (2014: 252) observes, “the climate governance ‘regime’ appears extraordinarily complex, specialised, even unfathomable”, this body of work enables us to identify the principal forms which carbon finance adopts as its strategic significance grows within that regime.

55 These include: markets that price and trade emissions rights (Callon, 2009; Knox-Hayes, 2016; McKenzie, 2009;  
56 Lovell, 2015) and ecosystem services (e.g. Asiyanbi, 2016; Corbera, 2012; Fletcher et al., 2016; Gupta et al.,  
57 2012); forms of investment in natural capital designed to generate value through conservation and carbon  
58 sequestration (Dempsey, 2015; Fairhead et al., 2012; Kay, 2018; Sullivan, 2018); and, raising capital expressly  
59 for low-carbon investment in enterprises, projects and initiatives (Bracking, 2015; Christophers, 2016, 2018;  
60 Karpf and Mandel, 2018), especially to provide for the greening of urban infrastructures (Castree and  
61 Christophers, 2015; Knuth, 2018a) and the renewable and 'clean tech' energy sectors (Hall et al., 2017; Knuth,  
62 2018b; McCarthy, 2015).

63 Our second motivation in this paper is to problematize carbon finance in all of its different forms. In  
64 the context of contemporary climate change governance, problematizing carbon finance is essential if we are  
65 to move beyond narrow questions about the scale of finance flows that - animated by assertions of a 'carbon  
66 finance gap' between the size of the decarbonization challenge and the current levels of finance being directed  
67 towards it - tend to preoccupy policymakers. In the first instance, 'problematization' is a methodological  
68 approach (Foucault, 2003). It directs our attention to consider how the problem of climate change is itself  
69 rendered governable in such a way that carbon finance appears capable of providing for solutions and securing  
70 the future of life (Langley, 2019). As Sullivan (2018) has shown for investment in biodiversity and ecosystem  
71 services, for example, the method of problematization lends itself to the grounded investigation of the  
72 conditions of possibility and practicalities of carbon finance. Such a method is also broadly consistent with  
73 wider calls for a more pragmatic research orientation to the financialization of nature (Castree and  
74 Christophers, 2015; Ouma et al., 2018), particularly one that suspends theoretically-driven judgements on the  
75 systemic contribution of capital switching via the financial markets for addressing the 'second contradiction of  
76 capitalism' and providing a purported 'socio-ecological fix' (Ekers and Prudham, 2015; see Harvey 1978, 1982).  
77 Notwithstanding that carbon finance is conducted on the basis of the maximization of (albeit more  
78 sustainable) capitalist growth, problematization is a method that questions the privileged role of carbon  
79 finance in meeting the challenges of climate change and which pragmatically centres on the relational  
80 processes, contingencies and limits of the various and discrete forms taken by carbon finance.

81 Our agenda for problematizing carbon finance is thus also an intervention in theoretical and  
82 conceptual debates that are present across the literatures we bring into conversation here. We will develop  
83 two related lines of argument that cut across the political economy and cultural economy approaches which  
84 dominate the literature. First, the critical analysis of carbon finance as a broad research terrain requires  
85 specific attention to the variegated processes through which carbon is incorporated into the extraction of  
86 financial value. Considerable work is necessary for carbon - as a material and discursive quality (e.g. high vs.  
87 low-carbon) - to be translated into financial value. We take seriously, then, recent arguments which stress that  
88 even though the abstraction of value from its material forms is a necessary part of the financialization of

89 nature, “it is vital that we do not portray the environment as a flat terrain over which financial investment can  
90 be unproblematically stretched” (Kay 2018: 172; see also Asiyambi, 2017). The materiality and spatiality of  
91 carbon matter to the ways in which carbon finance is made, and to the political economies it enables. While  
92 we draw on a broader literature concerning the financialization of nature that stresses the “frictional  
93 encounters of finance and nature” (Ouma et al., 2018: 501), we focus specifically on the frictions that arise  
94 from carbon’s particular social, political, spatial and material qualities.

95 Second, no single category can adequately conceptualize the contingent processes through which  
96 carbon is translated into financial value across carbon finance’s multiple forms. Although it is now widely  
97 questioned by political economists who have recently settled on the category of ‘rent’ for analysing the  
98 extraction of financial value from nature (Andreucci et al., 2017; Felli, 2014), we find commodification provides  
99 for an effective conceptualization of processes of carbon finance that feature speculative trading, especially  
100 when rights to emit carbon are priced and exchanged on carbon markets. However, speculation on carbon is  
101 but one mode of financialized accumulation on nature (Bryant, 2018; Ouma et al., 2018). Recent research into  
102 investment in natural capital and low-carbon technologies and infrastructures – some of which explicitly  
103 conceptualizes the extraction of financial value in these forms of carbon finance as ‘rent’, and some which  
104 does not - is pointing to the important ways in which carbon is figured as an ‘asset’ that can generate future  
105 revenues, and thereby act as collateral for the leverage of debt and creation of interest-bearing capital (Kay,  
106 2018; Knuth, 2018a, 2018b; Sullivan, 2018). Our conceptual contribution explicitly connects this research with  
107 an emerging body of work in cultural economy that, via the categories of ‘assetization’ and ‘capitalization’,  
108 furthers critical analysis of economization processes that leverage debt for capital investment (Birch, 2017a,  
109 2017b; Muniesa, 2017; Muniesa et al., 2017; Ouma, 2016, 2018). Assetization is the process of turning all  
110 manner of things into “*capitalized* property” that generates an income stream and entails liabilities and  
111 obligations (Birch, 2017a: 468, *original emphasis*). It is thus inseparable from capitalization as “a technique for  
112 prospective valuation” (Muniesa et al., 2017: 12), wherein, from the perspective of the investor, “financial  
113 value amounts to a future return anticipated through a calculation of the cost of capital rather than to a ‘price’  
114 given to the asset on the market” (Muniesa 2017: 449). We seek to contribute, then, to calls for further  
115 research into how nature comes to be regarded as an investable proposition (Ouma et al., 2018), but suggest  
116 more rigorous understanding of these processes in carbon finance also requires insights from studies of  
117 assetization and capitalization in other domains. In sum, our agenda for the problematization of the processes  
118 of carbon finance in all of its forms extends from the relatively well-known difficulties of making carbon-as-  
119 commodity to the presently under-researched impediments of producing carbon-as-asset.

120 The remainder of the paper is divided into five sections. Section II reviews research on carbon-as-  
121 commodity within human geography and allied fields. Section III turns to consider research that questions the  
122 relevance of commodification processes for critical understanding of the extraction of value across carbon

123 finance. We explain why we want to retain a concern with carbon-as-commodity whilst, at the same time,  
124 developing a conceptualization of carbon-as-asset through the cultural economy literature on assetization and  
125 capitalization. Section IV illustrates our agenda for pluralizing and problematizing carbon finance by focusing  
126 on a key form of carbon finance – raising capital for low-carbon investment – that has received comparatively  
127 little attention to date. Our specific focus is on low-carbon investment in electricity generation, and we draw  
128 critically on applied and policy research to tease out some of the difficulties of rendering carbon-as-asset in  
129 this domain of carbon finance. Section V offers concluding reflections on how an agenda that pluralizes and  
130 problematizes carbon finance can be taken forward in human geography and related fields.

131

## 132 **II Commodifying Carbon**

133

134 Carbon markets price and trade two kinds of carbon credits: allowances, which are permits for  
135 regulated organizations to emit carbon dioxide; and offsets, transferrable credits that result from reduced  
136 emissions. That legally defined rights to emit carbon could be made to hold value in markets was initially  
137 recognised during the 1990s, leading to the suite of economic instruments that accompanied the 1997 Kyoto  
138 Protocol, including the Clean Development Mechanism (CDM) and various voluntary offset schemes.  
139 Development of carbon markets continued apace with the formation of the EU Emissions Trading Scheme  
140 (ETS) and various other regional carbon markets based on carbon allowances, including in Australia, China,  
141 Canada and the USA. Carbon markets are widely envisaged as a response to ‘negative externalities’ - i.e. the  
142 emissions that are produced but not owned by market actors. Producers are incentivised to not only reduce  
143 emissions, but also to ‘direct investment into lower-carbon technologies’ (Keohane, 2016: 27). As with all  
144 forms of market exchange, however, carbon markets rely on creating carbon as a commodity that can be  
145 priced and traded. Commodification, therefore, has been the primary focus for critical geographical and social  
146 scientific research over the past decades into the making of carbon markets.

147 Research on carbon’s commodification has been shaped by two broad perspectives: political economy  
148 and cultural economy. Those working within the tradition of geographical political economy have approached  
149 carbon markets with an eye for the dynamics of commodification they set in train, informed by wider interests  
150 in the forms of appropriation (property) that underpin the creation of markets and the growing role of “nature  
151 as accumulation strategy” (Smith, 2006). Others highlight more directly how carbon’s commodification has  
152 created specific opportunities for finance capital, and the constellation of financial actors associated with the  
153 promotion, implementation and monitoring of carbon markets. Janelle Knox-Hayes (2016), for example,  
154 skilfully shows how the market infrastructures that produce carbon-as-commodity divorce the use value of  
155 resources from the exchange value of financial instruments, unleashing a financialized form of accumulation  
156 centred on speculation around fluctuating prices (see also Bigger, 2016; Knuth, 2015). A related line of political

157 economy inquiry examines how markets for carbon and ecosystem services enable accumulation, but at the  
158 expense of landscapes and communities drawn into the production of carbon offsets or reliant on such  
159 ecosystem services for their livelihoods and survival (Bachram, 2004; Bumpus and Liverman, 2011; Fairhead  
160 et al., 2012; Paterson, 2010). Bumpus and Liverman (2008), for example, argue that offset schemes rely on  
161 existing patterns of uneven development to find ‘efficient’ forms of carbon reduction, enabling a process of  
162 “accumulation by decarbonization” in the global North through production of carbon credits in the global  
163 South.

164 Research on the commodification of carbon from a cultural economy perspective has also addressed  
165 carbon markets and markets for biodiversity and ecosystems services. It points to the development of  
166 elaborate apparatus through which carbon is either made into a unit commensurate with both other sources  
167 of (reduced) emissions and with monetary worth, or which enable the capacities and qualities of a range of  
168 entities (from forests to houses) to forego (future) carbon emissions to hold value. This suggests that processes  
169 of carbon-as-commodity take multiple forms around which different kinds of economy are assembled,  
170 allowing for (and excluding) different kinds of socio-material relations and their outcomes. Here the seeming  
171 intangibility of carbon has led to a focus on the performative socio-technical processes through which carbon  
172 is commodified (Callon, 2009; McKenzie 2009). Because “carbon is a new and unusual commodity”, cultural  
173 economy thus emphasizes how “credible systems of measurement and calculation are especially important”  
174 to the development of carbon finance (Lovell, 2015: 127; see also Asiyanbi, 2017). The stabilization of carbon-  
175 as-commodity requires significant work, as Lovell (2015: 127) explores in the context of the forest carbon  
176 market where marketization “has been, to date, almost entirely centred on debates about the measurement,  
177 reporting and verification of the carbon stored in forests”.

178 The complex processes of carbon-as-commodity are tied up with the nature of carbon itself. Rather  
179 than being a commodity in the strictest sense of being a good that can be bought or sold, the trading of carbon  
180 is more like the buying and selling of services – where the service is the calculated and qualified ability to  
181 contribute to reducing atmospheric carbon. The development of markets around the potential of forests and  
182 land cover to sequester carbon from the atmosphere has attracted sustained critical attention, particularly  
183 the rapid development of so-called Reduced Emissions from Degradation & Deforestation schemes (REDD, or  
184 REDD+ where additional sustainability benefits are involved) (Asiyanbi, 2016; Corbera, 2012; Fletcher et al.,  
185 2016; Gupta et al., 2012). As one of a number of processes that have expanded through the development of  
186 the concept of ecosystem services and its circulation in global environmental governance, REDD schemes may  
187 well be an example of “accumulation by conservation” (Büscher and Fletcher, 2015). Work in cultural  
188 economy, however, reveals the complex set of calculations and translations required for forests (and other  
189 ecosystems) to generate financial returns from for the ‘services’ they provide.

190 Reading across the political economy and cultural economy literatures that foreground the processes  
191 of carbon-as-commodity in carbon markets and ecosystem services, we can highlight two insights that are  
192 particularly relevant for problematizing the processes of carbon finance. First, research has shown how  
193 commodification is a precarious achievement, “a process of ontological reconfiguration through which  
194 different qualities of nature and resource-based production are translated into a financial value form to be  
195 traded in specialized markets” (Ouma et al., 2018: 2). The key point here is that value is neither latent in  
196 material things (an inherent property, awaiting capture) nor a product of discursive claims (a projection onto  
197 the world), but an achievement that entails bringing materialities, relations and discourses into alignment.  
198 Through the production and maintenance of these alignments, carbon can be made to bear value as a  
199 commodity that can be priced, traded and speculated upon. In turn, the performativity of markets should not  
200 be read (only) as an abstract set of techniques or forms of calculation by which carbon comes to be made  
201 valuable and fungible, but also as “practices that are imbued with a materiality ... [such that they] become  
202 material interventions into how economic action unfolds” (Lansing, 2012: 207).

203 Second, research into the peculiar ‘immateriality’ of carbon-as-commodity highlights processes of  
204 abstraction and “matters of measure” that are “used...to define adequate bearers of value” (Robertson, 2012:  
205 388). Early work on markets in ecosystem services commented frequently on their strangely ‘immaterial’  
206 character - i.e. how value is expanded not by the circulation of carbon per se, but by the exchange of a qualified  
207 abstraction acting as a proxy for an environmental service. However, as Robertson (2012) points out, markets  
208 in ecosystem services only look peculiar because we are accustomed to value circulating in the form of physical  
209 commodities (such as copper, coal or grain). Furthermore, he argues, the reason we see this as the normal  
210 way of things is that getting many classic materials (like coal) to bear value requires their physical  
211 displacement. Or, to put it another way, capital has been unable to figure out a way to commodify coal without  
212 its physical extraction and circulation. Ecosystem services, on the other hand, can be made to bear value in  
213 ways that do not require physical circulation of the underpinning materials: markets for ecosystem services  
214 rest on “the creation of a set of general abstractions adequate to allow nature to circulate – not just as  
215 commodified bits of material, but as financial and service commodities” (Robertson, 2012: 388). By taking  
216 seriously the “process of creating socially-necessary abstractions that are adequate to bear value in capitalist  
217 circulation”, Robertson (2012: 386) opens up for discussion the different forms in which carbon can be made  
218 to bear value, the techniques of classification and categorization through which this occurs, and the “the work  
219 (that) must be done to convince observers that these simplifications are adequate to the task of  
220 representation” (ibid., 396). At the same time, recent research demonstrates that while such processes of  
221 abstraction are essential and often centre on the making of nature as ‘natural capital’ (Sullivan, 2018), they  
222 are also shaped by the spatiality and materiality of the commodities/services themselves. In her account of  
223 the development of conservation finance in the US, for example, Kay (2018) shows how different practices of



224 abstraction, qualification and circulation were developed in relation to rangelands and woodlands, creating  
225 different vehicles for investment and for capital accumulation.

226

### 227 **III From carbon-as-commodity to carbon-as-asset**

228

229 We find commodification provides an effective conceptualization of processes of carbon finance that  
230 feature speculative trading on prices, even though achievements of carbon-as-commodity tend to be  
231 experimental and incomplete. Yet whether carbon markets are indeed a matter of commodification is moot  
232 (Bigger and Demspey, 2018). Felli (2014) argues, instead, that emission allowances and carbon offsets are a  
233 kind of ‘climate rent’. His Marxian analysis hinges on the distinction between accumulation via commodity  
234 production (i.e. creation of value through expanded reproduction) and accumulation via the appropriation of  
235 value produced elsewhere (or what Harvey (2003) terms “accumulation by dispossession”). Felli (2014: 271)  
236 observes that the right to emit greenhouse gases has “legally become a necessary condition of production”,  
237 “both a limitation and a right of access” for capitalist commodity production. As a consequence, “the  
238 distribution and circulation of (carbon allowances) through market-based mechanisms” should not be  
239 understood as speculative accumulation on carbon-as-commodity, “but rather as a form of rent” (2014: 254).  
240 Felli’s intervention has stimulated a growing body of work on financialization and nature that foregrounds “the  
241 circulation of money and profit through non-productive forms of value appropriation” via the conceptual  
242 category of ‘rent’ (Andreucci et al., 2017: 28; see also Kay, 2018, Kay and Kenney-Lazar, 2017; Knuth, 2015).

243 We read Felli’s (2014) objections to the efficacy of the concept of commodification as productive for  
244 the problematization of carbon finance in three main ways. First, Felli (2014) reminds researchers that the  
245 critical analysis of carbon finance needs to recognise the significance of acts of sovereign power, an argument  
246 that is consistent with wider calls for analyses of the financialization of nature to engage with “the multiple  
247 roles of the state in mediating the circulation of finance in and through nature” (Ouma et al., 2018: 500). Felli’s  
248 (2014: 251) starting point is that rights to emit greenhouse gases created through international law are actually  
249 “a form of public property” rather than commodities, such that the unequal distribution of these legally  
250 defined rights amongst states “amounts to the distribution of rights to climate rent”. More than simply  
251 affirming the systemic role of the capitalist state in securing the conditions for expanded reproduction (Felli,  
252 2014: 255-6), Felli highlights how specific juridical techniques and regulatory provisions are necessary  
253 (alongside socio-technical achievements and abstractions) for carbon to be translated into financial value.

254 Second, Felli’s (2014) novel account of the carbon market encourages us to specify more precisely  
255 what the concept of commodification brings to critical analysis of carbon finance. Here we underscore how  
256 commodification centres attention on the extraction of value through speculative trading on the price of things  
257 that have been made exchangeable. Rights to emit carbon may be analogous to land as property and have no

258 value in strict Marxist terms, as Felli argues, but they nonetheless do have a use- and exchange-value. In other  
259 words, Felli's analysis does not foreclose the critical purchase of commodification for understanding  
260 speculative trading within carbon markets. In Kay's (2018) detailed study of the emergence of conservation  
261 finance in the US, for example, such schemes are shown to feature arbitrage pricing that depends upon existing  
262 markets for land and other physical commodities. Precisely because it centres attention on speculation, the  
263 concept of commodification is similarly important to Bryant's (2018) nuanced analysis of the development of  
264 the EU ETS. He is clear that, notwithstanding the processes of carbon-as-commodity, "to date, carbon has  
265 become capital only occasionally rather than systemically" due to the political conditions of its making and its  
266 persistent low market worth (ibid., 615). Carbon markets are therefore not witnessing the leveraging of debt  
267 against carbon (i.e. they have not enabled interest-bearing capitalization). In practice, the logics and  
268 mechanisms of carbon commodification have developed in ways that allow for only the restricted and  
269 speculative extraction of financial value.

270 Third, we regard Felli's (2014) contribution to be productive for the problematization of carbon finance  
271 because it highlights the need to go beyond the category of commodification for understanding processes of  
272 carbon finance. His analysis points to how other political economies – in this case, of rent extraction and  
273 circulation – are constituted, at least in part, through the translation of carbon into financial value. It is clear  
274 for Felli (2014) that these processes rest primarily on the making of property relations. However, it is  
275 significant, we suggest, that others developing Felli's (2014) analysis tend to slide from his concern with  
276 property rights and "pseudo-commodities" into a concern with 'assets', a category that Felli does not use in  
277 his essay. For Andreucci et al. (2017: 33), for example, accumulation by dispossession and rent-seeking include  
278 processes that create "Pseudo-commodities ... as socio-ecological assets that can be incorporated within  
279 private property regimes, such as carbon credits, patents on genetic material, ecosystem services, and so on."  
280 Recent research into investment in natural capital and low-carbon technologies and infrastructures – some of  
281 which explicitly conceptualizes the extraction of financial value in these forms of carbon finance as 'rent', and  
282 some which does not - is also pointing to the important ways in which carbon is figured as an 'asset' (Kay,  
283 2018; Knuth, 2018a, 2018b; Sullivan, 2018). This work recognises the creation of assets that can generate  
284 future revenues as crucial to the extraction of financial value, not least because assets simultaneously act as  
285 collateral for the leverage of debt and creation of interest-bearing capital. Sullivan (2018: 56), for example,  
286 explores how framing nature as 'natural-capital' has led it to being considered more or less literally as "a bank  
287 of financial assets ... [or] 'countable capital'". In this sense, nature (and carbon more specifically) come to be  
288 regarded as 'financial' when they attract financial investment, that is, when they become 'assets'.

289 To advance this analytical turn towards processes of asset-making taking place across different forms  
290 of carbon finance, we suggest that it is productive to connect with emerging cultural economy research that  
291 explicitly articulates the categories of 'assetization' and 'capitalization' (Birch, 2017a, 2017b; Muniesa, 2017;

292 Muniesa et al., 2017). Others are also beginning to forge this connection in relation to the financialization of  
293 nature, broadly understood (Ouma, 2016, 2018). For Ouma et al. (2018: 501), then, nature’s financialization is  
294 “linked to the more general assetization of almost everything” (see Leyshon and Thrift, 2007). For us, however,  
295 the key point from this emergent cultural economy work is that the contingent processes that turn carbon into  
296 assets are quite different to the making of carbon-as-commodity. This is because, in contrast with  
297 commodities, assets are always already “*capitalized property*” (Birch, 2017a: 468, *original emphasis*); that is,  
298 they leverage debt against an expected income stream and necessarily entail liabilities, repayments and other  
299 obligations to investors.

300 To be regarded as an investable proposition in the first instance, an asset is deemed to be capable of  
301 bearing financial value not primarily because of its potential use- or exchange-value (although it might  
302 subsequently be commodified and speculated upon as a transferable ownership claim). The process of  
303 ‘becoming asset’ is primarily a matter of the potential to generate future returns on capital (Muniesa et al.,  
304 2017: 128-131), regardless of whether the assets in question are capitalized through the issuance of loans,  
305 debt instruments or other securities. Indeed, such is the difference between the valuation processes of  
306 commodification and assetization that, for Muniesa and his colleagues (2017), the separate category of  
307 ‘capitalization’ is used to refer to the processes of prospective valuation – both by and for investors - that are  
308 integral to assetization. It is the streams of repayments and other obligations inherent to financial assets  
309 which, strictly speaking, ensure they are not property relations as such, but are actually investor claims on  
310 credit-debt relations. Contrary to Andreucci et al. (2017), we thus find that the analogy that Felli (2014: 268)  
311 draws between property relations for land and rights to emit carbon is not easily generalizable to the relational  
312 processes of carbon finance and the financialization of nature. While each enable rentiership broadly  
313 understood as the extraction of value by owners of resources (Birch 2017b), contingent assetization processes  
314 are nonetheless not the same as making things into property rights.

315 In sum, the extraction of financial value across the various forms of carbon finance certainly features  
316 secondary trading and speculation on prices, and focusing on the contingent processes of carbon-as-  
317 commodity is crucial to the problematization of carbon finance in this respect. However, this should not  
318 obscure significant differences between capital and (pseudo-)commodity marketizations, regardless of how  
319 ‘immaterial’ and speculative the commodity markets in question might be. The problematization of carbon  
320 finance therefore also needs to be attuned to the production of carbon as an ‘asset class’ (see Kay, 2018),  
321 foregrounding the exigencies of assetization and capitalization processes and the difficulties of rendering  
322 carbon-as-asset. Crucial to the juridical and socio-technical achievements and abstractions that stabilize  
323 carbon-as-asset, we argue, is capitalization: that is, how a specific carbon sequestration initiative or low-  
324 carbon investment is deemed valuable and able to realize returns because it is capable of bearing debt.

325

#### 326 **IV Making carbon-as-asset: investment in low-carbon electricity generation**

327

328 In this section of the paper, we concentrate on an important form of carbon finance that - compared  
329 to carbon markets, payments for ecosystem services and investment in natural capital - has received relatively  
330 little attention in human geography and social science research: the raising of capital for low-carbon  
331 investments in enterprises and projects (cf. Bracking, 2015; Christophers, 2016, 2018; Karpf and Mandel, 2018;  
332 Tripathy, 2017). Our aim is to illustrate our agenda for problematizing carbon finance, especially as it mobilizes  
333 the insights from the literature we developed above and pertains to the processes of carbon-as-asset that are  
334 at the heart of low-carbon investment. Specifically, we focus on low-carbon investment in the renewable  
335 energy sector and, in the interests of brevity, we concentrate on the USA and UK where energy provision is  
336 largely already privatized and marketized. The energy sector's contribution to global greenhouse gas emissions  
337 has made it a logical first target of public and private initiatives aimed at a low-carbon transition. As revealed  
338 by existing critical research (e.g. Eadson and Foden, 2018; Mazzucato and Semieniuk 2018; McCarthy, 2015;  
339 Webb and Hawkey, 2017), decarbonization efforts in the energy sector tend to target electrical power  
340 generation, given the prevalence of large point-source emissions (e.g. coal-fired power stations), concentrated  
341 patterns of ownership (e.g. utility companies), and opportunities for shifting investment towards renewable  
342 energy sources. Conventional narratives around energy and climate change governance also identify a 'finance  
343 gap' in this domain, and highlight the challenges of turning low-carbon forms of energy into investible  
344 propositions (Hall et al., 2017; Webb and Hawkey, 2017).

345 Low-carbon investment in the power sector is a process of assetization that turns, first, on classifying  
346 and categorizing the carbon qualities (low/high) of different forms of electricity generation by reference to  
347 regulatory, market or other governance criteria; and, second, on assembling assets that qualify against these  
348 criteria – i.e. forms of capitalized property which yield an income stream, and which are sufficient to bear  
349 debt. The first dimension ensures the low-carbon qualities of the investment are a crucial consideration, but  
350 certainly does not guarantee they will figure in the related valuations and associated calculations about the  
351 cost of capital. Put another way, low-carbon investments in renewable electricity generation are not  
352 collateralized against future low-carbon impacts in ways that would parallel social impact bonds and  
353 environmental impact bonds (which only make payments to investors when measurable targets for the  
354 impact performance of the capitalized projects in question are met (Christophers, 2018; Langley, 2018a).

355 A broad body of applied and policy work in this domain speaks to the processes through which low-  
356 carbon assets are constituted in the power sector. This research leads us to make four general points about  
357 the production of carbon-as-asset that are especially relevant to our research agenda for problematizing  
358 carbon finance. First, assetization processes in low-carbon electricity generation do not take a singular  
359 financial and organizational form: low-carbon 'becomes asset' via several financial mechanisms and

360 organizational structures. A range of structured debt, bond issues and equity models have also emerged,  
361 bringing lower costs of capital to the renewable energy sector (EWEA, 2018). We interpret this profusion of  
362 financial and organizational structures as experimentation with alternative assetization processes for  
363 unlocking income streams and attracting investors to the sector. Capital market creation is an incomplete and  
364 adaptive process in the renewable energy sector (Hall et al., 2017), with new actors and organizational  
365 structures emerging over time in response to policy shifts (e.g. in relation to energy price support and taxation)  
366 and broader developments in capital markets. That said, experimentation in the US and UK has largely centred  
367 on two models of assetization to date.

368 In the more widely used project finance model, assetization occurs at the level of a specific project  
369 (e.g. a wind farm or solar park): project developers establish a special purpose vehicle (a legal entity to  
370 undertake the project) and debt is raised against future sales of electricity from the project. Thus, the  
371 capitalization of low-carbon investment in the electricity generation sector is not simply “a dual process of  
372 valuation” (Muniesa, 2012: 31) that centres on the current and future economic prospects of the corporations  
373 and institutions involved. This is because project finance is provided on a limited or non-recourse basis – i.e.  
374 investors’ claims as creditors are restricted to the assets and income streams of the new project, and do not  
375 extend to the wider assets and cash flows of the consortium of companies that own and operate the project  
376 (Finnerty, 2013; Langley, 2018b). In this way, project financing of a low-carbon asset works “like a giant  
377 mortgage” as the only security for the loan is the project itself (EWEA, 2018). The project model brings together  
378 a consortium of actors (project developer, operator, contractors) with debt finance typically provided by a  
379 bank. Since the global financial crisis, however, bank lending to renewable energy projects has sharply reduced  
380 and key lending terms (such as the loan period) have tightened. In its place, securitization and other alternative  
381 techniques of project finance have emerged and, with this, institutional investors, sovereign wealth funds and  
382 others that comprise the so-called ‘shadow banking’ sector have come to play a growing role. Miller et al.  
383 (2018) highlight the diverse sources of capital currently associated with low-carbon assets in North American  
384 renewable energy, including project financing via public market capital (asset-backed securities and various  
385 debt products), hybrid bond financing, and even crowdfunding. Hybrid bonds are raised against a portfolio of  
386 renewable energy projects with a common owner rather than an individual project, and address key challenges  
387 (of space and time) associated with financing renewable energy projects. A portfolio of projects –  
388 geographically distributed and utilizing different technical designs - reduces risks to revenue associated with  
389 localised weather conditions (around wind and solar power), simultaneous design faults and, if the projects  
390 are in different jurisdictions, regulatory risks (EWEA, 2018). More generally, hybrid bonds can “expand the  
391 pool of available candidates” who can finance new projects: in the US context, for example, where production  
392 tax credits are a key driver of investment in renewables (see below), these bonds reach investors beyond those  
393 with heavy tax obligations (Tang et al., 2012: 693). Crowdfunding – such as through the Abundance generation

394 platform in the UK – is a further example of assetization processes of project finance in low-carbon energy,  
395 although currently limited to early-stage start-ups where high risks and the lack of collateral mean project  
396 developers cannot “assemble debt finance from banks or venture capitalists easily” (Lam and Law, 2016: 12;  
397 Vasileiadou et al., 2016).

398         The project finance model contrasts with green bonds that, despite funding a specified project or  
399 initiative, are assets that are issued against the issuer’s full balance sheet and earnings potential rather than  
400 against the specific credentials and returns of the decarbonizing project(s) to be funded. In the renewable  
401 energy sector in the US and UK, green bonds are one of the ways in which on-balance sheet funding is raised  
402 (via corporate debt, or internal cash flow management for small projects), especially where larger companies,  
403 such as utilities, have entered into renewables (Coughlin, 2012; EWEA, 2018; Hall et al., 2017). As a range of  
404 geographic research into the emergence and development of green bonds reveals (Bracking, 2015;  
405 Christophers, 2016, 2018; Clapp et al., 2015; Karpf and Mandel, 2018; Tripathy, 2017), these assetization  
406 processes are also a feature, more broadly, of low-carbon investment as a form of carbon finance. Over the  
407 space of a decade, green bonds as an example of so-called ‘labelled debt’ have “become a mainstream  
408 financial instrument” (Karpf and Mandel, 2018: 161), and ostensible “successor” to the CDM in the governance  
409 of climate change (Bracking, 2015: 2338). Globally, these fixed-income instruments are variously issued by  
410 corporations, banks, multilateral institutions, sovereign states and municipalities to fund specified projects  
411 and initiatives. In aggregate, they are roughly distributed between the renewable energy sector (~40 percent),  
412 retrofitting buildings and improving energy efficiency in industrial plant and processes (~20 percent), and new  
413 and renewed transport infrastructures (~15 percent) (author calculations, based on data from Climate Bonds  
414 Initiative, 2017).

415         A second key point emerging from the applied and policy literature attests to the work involved in  
416 assembling low-carbon-as-asset – i.e. as an abstraction and organizational form sufficient to bear debt – and  
417 how traditional sources of energy finance have found low-carbon challenging. Investors conventionally  
418 perceived low-carbon projects as illiquid and relatively high risk, involving relatively immature technologies  
419 across a limited number of sites. That green bonds are issued against the issuer’s full balance sheet and  
420 earnings potential has, for example, been crucial to their appeal to risk-adverse investors in renewable energy  
421 projects (Christophers, 2016). More specifically, adapting energy finance to the material qualities of  
422 renewables has challenged processes of assetization: the intermittent and weather-dependent character of  
423 wind and solar power generation, for example, accentuates commercial risks for developers (Tang et al. 2012;  
424 Lam and Law, 2016; Miller et al., 2018). Owners and developers of low-carbon assets have created financing  
425 structures that attempts to work around the material challenges of renewables. This includes, for example,  
426 modifying the project finance model associated with conventional infrastructure and resource projects, where  
427 income streams are relatively predictable and pension funds and institutional investors have been ready to

428 enter into project finance. This widely-used model has been tailored for financing renewables, where revenues  
429 are subject to the stochastic variability of physical environmental systems, through a combination of  
430 organizational, calculative and regulatory adaptations.

431 Initially, banks provided an organizational fix that enabled project finance to take hold in the  
432 renewable energy sector, drawing on their capacity to issue long-term debt and negotiate key assumptions of  
433 the loan agreement to translate technical assessments of energy generation into expected revenues and  
434 repayment schedules. Further adaptations to the distinctive material qualities of renewables were necessary  
435 to draw non-bank actors into low-carbon project finance. On the calculative side, growing availability of  
436 operational data from projects has enabled more accurate projections of electricity production, and the use  
437 of increasingly robust algorithms for converting local weather and climate data into calculations of revenue;  
438 and in terms of regulation, price support mechanisms have evolved to bring more security to revenues. The  
439 UK government, for example, has sought – with some difficulty – to implement an approach to energy policy  
440 (and infrastructure more generally) that gives capital markets a central role (see Langley, 2018b). To further  
441 this objective in relation to low-carbon energy sector specifically, it has recently replaced a renewables  
442 incentive scheme, based on tradeable green certificates (Renewable Obligations Certificate), with a Feed in  
443 Tariff structure (via Contracts for Difference). The significance of the latter, as Hall et al. (2017: 291) explain,  
444 is that it “socialise(s) price risks by guaranteeing the subsidy support price (and)... eliminates both the risks of  
445 the support mechanism price being defined by a relative scarcity of tradable certificates, and wholesale price  
446 risk.”

447 This leads us to the third issue about the processes of carbon-as-asset that is, in effect, highlighted by  
448 the applied and policy literature on the financing of renewable energy: the growing involvement of  
449 mainstream investors in this discrete form of carbon finance has driven significant shifts in how assetization  
450 occurs (Hall et al., 2017). Rather than assembling a low-carbon asset sufficient to bear bank debt –  
451 characterised by long loan terms and specialist in-house/boutique knowledge - low-carbon electricity  
452 generation is increasingly assembled to perform as an ‘asset class’. The renewable energy sector is certainly  
453 not alone in this respect, as the drive for the so-called ‘mainstreaming’ of low-carbon investment is producing  
454 similar pressures to standardize assets across the broader market for green bonds, for example (G20 Finance  
455 Study Group, 2016). The consequences of this shift in the renewable energy sector extend beyond  
456 diversification of the organizational forms and devices associated with ‘becoming asset’ discussed above to  
457 the ecologies of finance created around low-carbon energy. Specifically, it extends to how assetization and  
458 capitalization may “affect the direction of the evolution of renewable energy” by differentially empowering  
459 some financial actors over others (Mazzucato and Semieniuk, 2018: 11). Researchers have found significant  
460 differences in risk appetite among investors in low-carbon projects with private actors favouring “low risk

461 much more than public ones”, highlighting the importance of understanding the consequences of privileging  
462 carbon finance as a mode of climate change governance (Mazzucato and Semieniuk, 2018: 18).

463 The fourth general finding we derive from the applied and policy literatures is that, as a consequence  
464 of the challenges of enacting this form of carbon finance in the renewable electricity generation sector,  
465 processes of becoming asset and capitalization feature various kinds of state interventions and public support.  
466 State support has played a very significant role in creating carbon-as-asset in relation to the energy sector,  
467 notwithstanding the way private finance in energy initially emerged via de-regulatory initiatives, limits on  
468 public sector borrowing, and the introduction of price-based competition in sectors like gas and electricity  
469 (Jensen and Dowlatabadi, 2017; Knuth, 2017). Particularly important have been a raft of public policy  
470 initiatives that includes tax credits, price support mechanisms (e.g. feed-in-tariffs) and renewable obligations  
471 (Tang et al., 2012: 693). This is illustrated, for example, by the wide-ranging mandate of the UK Government’s  
472 Green Investment Bank. Tax legislation is very significant in the United States, where the Production Tax Credit  
473 available for renewable power is a key influence on techniques of project finance for utility-scale renewables  
474 projects (Bolinger et al, 2009; Bolinger, 2011; Regante, 2012; Vasileiadou et al., 2016). More fundamentally,  
475 the making of low-carbon assets rests directly on differentiations and qualifications around carbon initiated  
476 and sanctioned by the state (Bridge, 2017). These include, for example, government rulings on the  
477 technological form and scale of electricity generation qualifying for price support or tax credits; the systems  
478 of green certification around low-carbon generation it either directly supports or rules admissible in law; and  
479 enabling acts of legislation that mandate action on decarbonization, differentiate low-carbon and renewables  
480 from other forms of generation and, as in the case of the UK Climate Change Act, set carbon budgets and  
481 legally-binding targets.

482

## 483 **V Conclusions**

484

485 The landscape of climate change governance has shifted since human geographers first critically  
486 engaged with carbon finance. There is now growing realization of finance’s “profound potential to remake the  
487 arteries through which capital flows and that are the lifeblood of the biological and social reproduction of most  
488 of contemporary humanity” (Castree and Christophers, 2015: 385). This paper is an attempt to respond to  
489 these developments by critically reviewing state-of-the-art research within human geography and related  
490 fields in order to advance an agenda that both pluralizes and problematizes carbon finance.

491 Drawing on the existing literature on carbon markets and ecosystem services, we identified key  
492 insights essential for problematizing the proliferating and multiple forms of carbon finance. The  
493 commodification of carbon is a precarious achievement inexorably tied to both the means through which it is  
494 achieved and to carbon’s materialities, and abstractions and calculations are central to ensuring carbon-as-



495 commodity is able to bear value. From Felli's (2014) significant intervention and a rapidly growing literature  
496 that subsequently rejects a focus on commodification in favour of the production of property relations that  
497 enable rent-seeking, we draw the importance for critical analysis of the significance of sovereign power, the  
498 specific utility of commodification as a concept for centring attention on the extraction of value through  
499 speculation, and how processes of carbon finance cannot be adequately understood as commodification. To  
500 open up for analysis the forms of carbon finance that, in particular, invest in nature and raise of capital for  
501 low-carbon investment, we have built on existing research that highlights how carbon is figured as an 'asset',  
502 connecting our research agenda with wider cultural economy work that articulates the categories of  
503 assetization and capitalization to analyse economization processes that leverage debt for capital investment.  
504 From these starting points, the paper has sought to extend the problematization of carbon finance in all its  
505 forms from the relatively well-known difficulties of making carbon-as-commodity to the presently under-  
506 researched impediments of producing carbon-as-asset. Demonstrating the potential of such an approach, we  
507 turned to low-carbon investment in electricity generation, largely as it is taking place in the USA and UK. Here  
508 we highlighted how the processes of carbon-as-asset do not take a singular financial and organizational form,  
509 entail attempts to work around the material challenges of renewables, change as mainstream investors  
510 become involved, and feature various kinds of state interventions and public support.

511         Rather than seeking to set out a singular agenda for work on carbon finance, we would hope that our  
512 paper will generate further research centred on the diverse, contingent and problematic ways in which carbon-  
513 as-commodity and carbon-as-asset are constituted, and the consequences that this has for prospects of  
514 decarbonization. Although we have drawn attention to four main forms of carbon finance – markets for carbon  
515 allowances and offsets, ecosystem services, investment in natural capital for carbon sequestration, and the  
516 raising of capital for low-carbon investment – there are also several further forms of carbon finance that  
517 remain under-explored. For example, few studies have examined how carbon comes to be commodified  
518 beyond cap and trade carbon markets or offset schemes. Work on low-carbon housing and property markets  
519 is perhaps an exception, with research demonstrating how delivering carbon savings in this sector rests on the  
520 identification of metrics, monitoring, standardization and verification to attract investment (Edwards and  
521 Bulkeley, 2017; Lovell, 2004, 2015). Carbon savings of this kind do not function within traditional markets, but  
522 come to be commodified in quasi-markets that distribute and exchange forms of government subsidy or  
523 philanthropic donation. Often the assumption behind these forms of low-carbon qualification is that once their  
524 carbon value can be accounted for, markets will form around them. Yet so far there is limited evidence of the  
525 spontaneous formation of markets around these qualified commodities in relation to housing. Recent research  
526 suggests, however, that within certain urban markets for commercial property in the US, "many players are  
527 now working to convert green building into a resource for real estate developers, owners, and investors, and  
528 to harness those streams of green value added for new financial instruments and investment markets" (Knuth,

529 2015: 637). This shift is significant, in terms of our argument in the paper, as it indicates a move from away  
530 from a direct interest in the value of energy savings that can be derived from green buildings to “more  
531 speculative manoeuvring around the investment potential of green property” (Knuth, 2015: 637).

532 Equally, we are wary that problematizing the processes of carbon-as-asset is not narrowed to the  
533 financing of the renewable energy sector. Rather, we would want to encourage research that might investigate  
534 why carbon finance can be secured in relation to some forms of carbon – for example to its *absence* in  
535 renewable electricity generation – rather than others, such as the carbon content of the retail sector or  
536 energy-intensive industries, such as steel, plastic or cement. Similarly, we would also want to guard against  
537 the assumption that, paralleling the attention given to carbon markets by research into carbon-as-commodity,  
538 the problematization of carbon-as-asset necessarily entails a focus on processes that are solely located in  
539 capital markets. Chinese banks, for instance, are the subject of incentives and guidance by the People’s Bank  
540 of China and other regulatory agencies designed to privilege loans in support of low-carbon entities and  
541 projects, and there is pressure for similar arrangements that reward the capitalization of low-carbon assets to  
542 be incorporated into the macroprudential regulation of banking elsewhere (Campiglio 2016). Banks are  
543 increasingly interested in the carbon credentials of the assets in their loan portfolios, not least because central  
544 banks are coming to regard climate change and the prospect of a sudden collapse in the valuations of carbon-  
545 intensive economic entities as material to financial stability. The Financial Stability Board’s Task Force on  
546 Climate-Related Disclosures (2017) has, for instance, recently published a set of voluntary metrics and  
547 measures that seem likely to feature strongly in the processes by which banks calculate the ‘high carbon’  
548 qualities of the brown assets on their balance sheets and thus the extent of their exposure to the so-called  
549 ‘carbon bubble’. Climate change risk and the production of what we might term ‘high-carbon-as-asset’ is also  
550 presently at the heart of divestment campaigns in support of decarbonization by pension funds and other  
551 institutional investors, although it is noticeable that not all pension funds regard divestment as necessary or  
552 as the most appropriate response to climate change (Stausball, 2015). A pluralized research agenda for carbon  
553 finance that extends to problematizing the processes of carbon-as-asset can, therefore, be taken in new  
554 directions, where the pertinent questions centre on the ‘unbecoming’ of high-carbon assets and asset classes.  
555 What is clear, however, is that interrogating the relations between carbon’s material form, its abstraction,  
556 capitalization and political economy will be key if we are to understand the potential for carbon finance to act  
557 as the ‘game changer’ for climate futures it is presently heralded to be.

558

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