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VALUE, NATURE, AND THE VORTEX OF ACCUMULATION

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Introduction

Of all the domains of Marxian political economy, nature is by far the most vexing. Is nature an economic input as in the notion of natural resources; is it the object of labour in the process of production; or is it something broader, as in the idea of land and the territory upon which capitalism develops? Such questions rest on a conception of extra-human nature, but some have argued that because people are part of nature, then resources, labour, and conditions of production include the social integument of built environments, levels of education, and the work of families. But does this go far enough? Perhaps capitalism should be thought of as a “life process” that unfolds within the web of life? But even there lies a crucial debate about whether the chief problem of political economy is the fundamental rift between capitalism and nature or whether the web of life is imbricated in every accumulation strategy and the crisis-prone process of capitalist expansion. These are some of the key questions posed by Marxist theory since the 1980s (Walker 1979; 2016; Smith 1984; O’Connor 1998; Harvey 1996; Burkett 1999; Foster 2000; Moore 2015a; Foster, Clark and York 2010).

This chapter grows out of our long conversation around the relations of nature and capital. It takes shape out of our conviction that political economy has too often taken a back seat to larger musings in which philosophy has been foregrounded and economic theory treated as derivative rather than requiring additional argumentation. This tendency has at times discouraged a clear analytical reckoning with the fundamentals of Marxian theory such as capital accumulation, the labour process, commodity circulation, and the theory of value. Our purpose here is to elaborate a model of capital-in-nature outlined in *Capitalism in the Web of Life*, but which remains preliminary (Moore 2015a).

Why bother with value theory? When the classical political economists began to deploy a theory of value to understand the economy it was because the

generalization of markets meant that commodity prices had come to be regulated by exchange. For the classicals, value was an objective foundation behind the vagaries of prices, and in a pre-industrial era of handicraft or “manufacture,” labour time was the obvious standard determining value. At the same time, however, they were engaged in fierce debates with opposing views of economy, state, and society. In these debates, the theory of value was mobilized as a weapon of social change, which is why it was called *political economy* (Varney 2012; Farber 2006).

Marx trod in the footsteps of his predecessors. The labour theory of value was the obvious starting point on a long analytic journey to uncover the workings of capital. For Marx, value was not just the basis of price determination, but the key to unlocking the source of profits, class struggle, and capital accumulation. Along the way, he made technical corrections to the classical theory of value to account for the greater complexity of nineteenth-century industrial capitalism (Marx 1977).¹ Most of all, he made two great discoveries: how *surplus value* could arise in a system of equal exchange and how generalized value turned into *capital accumulation*.

After Marx, the neoclassical counter-revolution jettisoned value theory for equilibrium prices and “utility.” The neoclassicals argued that labour has no special standing, capital is productive, there is no exploitation, and profit is zero at the margin. This is why mainstream economics cannot come to grips with class inequality, exploitation, and the capitalist thirst for surplus value. It has no idea of capital as a social relation replete with conflict nor of the vortex of accumulation at the heart of modern growth (Vaggi and Groenewegen 2006). Hence, an essential step to recovering the lost spirit of political economy is to return to a Marxian concept of value. But to make it relevant for today’s politics and economics, we have to incorporate nature into the calculus and ask what it means for the fate of the Earth.

The co-production of value

The key to the reconciliation of value theory and the wealth of nature is to go back to the foundation of economic life: production. The starting point has to be the unity of labour and nature in all work and, more broadly, all social production (and reproduction). Nature is always there. As Marx says, human labour confronts nature as one of its forces and transforms it through labour. Nonetheless, the standard Marxist answer to the role of nature in production is to say that labour creates (exchange) value and nature only counts on the use-value side of the commodity. This dualism will not suffice (Marx 1977, 7; Robertson, Morgan and Wainwright 2013; Moore 2015a).

Marx defined value as “socially necessary labour time.” We might think of this as the average labour time embedded in the average commodity. It is an average of how much work is required to produce any manufactured good and a prevailing mean that imposes itself on competing producers. Value is “a real abstraction,” an abstract force with concrete effects revealed all the time (in the same way as “the market” and “the economy” are real abstractions, too, even if they have an imaginary/ideological side). In this it is like “average global temperature”: a statistic

assembled from many specific measurements and a real force felt worldwide despite wide variations across time and space. Labour time is a simple measure, common to all modern commodity production. By contrast, there is no easy way to measure nature's extraordinarily diverse contributions to production by reducing them to a single *numeraire* as elegant as labour time.² But that is not sufficient reason to put nature's contribution aside and focus only on labour.

To begin with, labour is not addressing an inert nature or simply working alongside natural forces. Nature is an active participant in every labour process: the web of life, both visible and invisible to humans, is always at work. Yeast transforms grain into alcohol in brewing, crystal lattices form in metal alloys, and electrons run through circuits on silicon chips—not to mention the metabolism working behind the scenes to animate the human and horse. All are natural, *productive* forces. In short, labour and nature work together, hand-in-hand, in a synthetic way. They are two moments of a singular, historical nature. We have always been cyborgs, as Haraway (1991) puts it.

But we wish to push the point farther: if the labour process is a dialectical unity, how is value to be measured? “Labour time” is always *unified labour-nature time*. Capitalism is a way of putting natures of every kind to work. That work pivots on social necessary labour time, but labour time itself is fundamentally shaped by unpaid work of humans and nature as a whole, which we consider later in this chapter. That is, nature's value is already reckoned in the calculus of labour value *because the average labour time includes the socially necessary amounts of unpaid work, performed by humans and the rest of nature*. The right amounts and qualities of materials, energy, chemical reactions, growing period, and so forth must be present for labour to proceed in the normal (average) way. This is obvious in the case of a mine, where the quality of the ore is critical to the relative labour time involved in extracting and processing it into metal. But it is equally true of a steel mill and how the quality of the ore, alloys, and furnaces contribute to the metallurgical transformations involved in making steel of average cost and quality.³

This levelling across both labour and non-labour inputs is what the market and competition bring about and why one can speak of a “law” of value in generalized commodity production. (It is a “law” in the sense of a broad historical tendency.) Labour-nature time is the coin of the capitalist realm of production. It is, furthermore, no different from the reduction of skilled labour to a common denominator, a puzzle that has bothered Marxists for a century. The idea that high skill labour is more productive of value than low skill labour—which even Marx toys with—is untenable. The skill required is already part of the market's competitive evaluation; socially necessary labour time already presumes that workers have the appropriate level of skill for the task at hand (Braverman 1974).⁴

Environmentalists may object that in this solution nature seems to disappear into labour, but that's not the case. Humans are a miniscule part of a universe dominated by the processes of the web of life. Only within the limited domain of social production are things reversed (just as the law of entropy can be reversed within limited domains). Even here, such reversals are temporary. Human beings

are necessarily the initiating partners in social labour, who put other natural forces and materials to work in a predetermined manner. This is not to say that natural forces and things do not exist apart from humans, but in the labour process they must be harnessed, set in motion, and engaged to work with people. It is not runaway humanism to say that there is a dominant element in the combination of labour–nature relation; it is good dialectics. While labour cannot function without its natural partner and labour does not have absolute command over natural forces (whatever humans may imagine!), social labour–nature time is still the measure imposed by the market and accepted by capitalists as they harness labour and nature to work for them in the modern economy (Walker 2016; Moore forthcoming).

Capitalism may begin with generalized value but it does not stop there. Capital feeds off surplus value and capitalists push to expand the rate of surplus value. How they do that will lead us beyond the boundaries of everyday capitalist production and to the geographical dynamics of capital accumulation.

The drive for surplus value

Surplus value is the crux of value theory. The theory of surplus value divides conventional economics, in which capital is a productive factor, from Marxist theory, in which capital ownership allows the boss to pocket the labour surplus. Surplus value is the excess of the value of any commodity over the value of its labour inputs. Profit is redistributed surplus value spread over the amount of capital invested (both fixed and circulating). The trick, for Marx, was to show that at equilibrium, where every commodity exchanges at its rightful value, surplus value is still realized by the capitalist. In so doing, Marx turned classical political economy on its head, showing that the division of wages and profits was not fair but based on exploitation of the workers by the capitalists.

The idea of a surplus is straightforward, regardless of whether it is put in terms of value theory or not. In market terms, the surplus derived from producing and selling a commodity is the difference between the (unit) price of the good and (unit) cost of production (over all inputs). The necessity of a surplus is clear: employers would not produce anything if the return were less than the cost. No exploitation, no profit. Broadly speaking, this applies equally to labour and nature. That ploughman's horse had better produce more in grain than it consumes, or it will be put out to pasture; and the same is true of the waged worker. Both the horse and the ploughman, or the chemist and her polymers, do more work than they cost on the market, and the difference goes to the employer. What really matters is that both kinds of surplus are “free gifts” to the capitalist of the extra work done beyond the costs of reproduction.⁵

Now let's put the same idea in terms of value. In a labour–nature value theory, labour works in tandem with natural materials and forces. The work done by each is impossible to disentangle. What counts as the market measure, however, is necessary labour time. Similarly, all forms of surplus work done by labour and nature are

present in the commodity, but the common measure is surplus labour time. Surplus value is an amalgam of labour–nature work and exploitation. There is no separate accounting of the surplus appropriated from nature, yet the free work of nature is embodied in surplus labour time, and hence surplus value.

Here, we use the term exploitation in a strictly analytical sense as the production of surplus value. Of course, in a more expansive—and polemical—sense, nature is exploited in production and beyond. We “exploit” the air we breathe, the water we drink, and the bacteria in our guts. There is also extensive “exploitation” of the unpaid work of social reproduction done largely by women. But value theory only applies directly to labour under capitalism. The real abstraction of value as labour time under capitalism is both relational and ideological. That is, only *some* work is valued: work done within the cash nexus (wage work, simple commodity production). Hence the negative dialectic that the valuation of paid labour is simultaneously the *devaluation* of unpaid work—the work of “women, nature, and colonies” (Mies 1986).⁶

Workers are exploited by capitalists, and therein lies the foundation for modern class society and class struggle, according to Marx. But there is more to his use of the concept of surplus value. Because surplus value is the basis of profit, capitalists have every interest in exploiting labour and nature to extract the maximum amount of surplus value possible, and the drive to *intensify* the exploitation of labour–nature is pivotal to the dynamics of capitalism. It compels capital to exploit every input to the maximum and to push relentlessly at the envelope of technology.

The simplest route to obtaining a higher rate of surplus value, according to Marx, is “absolute” surplus value, or extending the working day, without improving the methods of production. Absolute exploitation has been ruthlessly applied everywhere capitalism has taken root, and it played a vital role in the British Industrial Revolution. Moreover, as Marx denounced in no uncertain terms, it has repeatedly led industrialists to work people to death. Notably, he compared this directly to the capitalist farmer exhausting the soil in pursuit of quick returns (Marglin 1974; Marx 1977, 376–78, 636–38; Moore 2015a, 221–40).

A second path to a higher rate of exploitation is “relative” surplus value, which derives from raising the productivity of labour–nature. Relative surplus value is generated as the value of wage–labour falls due to cheapening of consumer goods because of rising productivity in those sectors. Agricultural revolutions are a prime example of this process, as cheapening food reduces the reproduction costs of labour power. Marx saw that all capitalists gain from the diffusion of a new technology that lowers the value of labour power by reducing the value of food, housing, clothing, and other basic elements of social reproduction. Furthermore, the same insight can be applied to improved productivity that reduces the cost of other inputs, including machinery, material inputs, and energy. Cheap energy reduces transportation costs for workers—variable capital—as well as the value of machinery and raw materials—fixed and circulating capital. In the latter case, the rate of profit is increased rather than the rate of surplus value (less capital required for the same amount of surplus value), but the principle is exactly the same.

Still, why do individual capitalists introduce technical change with such a passion? In the narrow sense they feel the sting of competition. The firm that comes up with an innovation gains an extra measure of profit over its competitors. The capitalist that fails to adopt newer and better methods over time will be driven out of business. This is true whether the innovation is a quality product that sells better, a machine that increases worker productivity, a more efficient energy source, or a new material that reduces unit costs or improves quality.⁷

So the exploitation of workers and natural forces by capitalists *necessarily* leads to a process of technical advance in production. The sources of such heightened productivity are many and diverse, from better machinery to improved organization of work to improved metallurgy. The umbrella term is “technological innovation,” and the unrelenting search for better technologies is the reason why capitalism has been such a dynamic production system. Technological progress is embodied in products and processes, but it represents the application of abstract human learning (scientific and practical) to specific problems, and technology is perhaps the greatest of the free gifts appropriated by the capitalists.⁸ But the advancing productivity and innovation requires investment, which we call “the capitalization frontier,” for reasons that will become clear in short order.

Rising productivity and the growth of throughput

Marx made brilliant use of the theory of relative surplus value to explain the appearance of large-scale industry—a crucial task at the time he was writing.⁹ He also had a clear idea of the way capitalism draws in new waves of “physically uncorrupted” workers from the countryside as it grows, in what he called “expanded reproduction” (Marx 1977, 380, 726–870; 1978, 565–99). The implications of rising labour productivity for the rest of nature were hinted at—and are implicit in the overall theory of value—but not systematically developed. The drive for increased labour productivity has profound implications that go beyond direct exploitation of labour-nature in modern industry: increased resource throughput, the search for new supplies of resources, the development of qualitatively new resources, greater waste output, and pressure on the rate of profit.

First, rising labour productivity entails something quite simple: every unit of labour time attaches to an ever-growing mass of materials and energy, setting in motion exponential growth curves of inputs such as wood, fibre, metals, water, and energy. This tendency was set in motion by the long sixteenth century but amplified in successive industrial revolutions. These growth curves have found popular expression in the ubiquitous “hockey stick” charts offered by Earth system scientists in recent years. There is, of course, a countervailing process of improving efficiency of use and technical substitution. But rising efficiency—sometimes called the Jevons Paradox—tends to reduce the value composition of inputs and advance labour productivity, thereby enhancing the rate of surplus value. Efficiency, then, scarcely reverses the geometrically rising uptake of material and energy flows (Barnett, Harold and Morse 1963; Steffen et al. 2015).

Second, it follows that capitalists engage in an ever-widening pursuit of new sources of supply. Capitalists have also improved the *methods* of search, discovery, and extraction of natural resources, which has added to the ability to extend the tentacles of resource extraction to new areas and new depths around the world. This has made capitalism the most geographically dynamic system in history, yet the Marxist tradition has emphasized global expansion via the need to sell excess goods and the export of surplus capital, while rarely talking about resource frontiers—a curious imbalance of outputs over inputs in the model. In recent years, the search for cheaper labour has come to the fore with the industrialization of Asia, and the thirst for oil has been a common cry among those opposed to imperialism and war in the Middle East. Historically, the renewed quest for Cheap Natures—including labour-power—has been tightly linked to “new imperialisms,” typically as new waves of industrialization unfold, as in the later nineteenth century and today. But a generalized Marxist model of resource and labour demand is still wanting (Bunker and Ciccantell 2005; Bridge and Le Billon 2013).

Third, rising throughput generates disproportionately rising waste. This assumes varied forms, including by-products along the production chain, such as carbon emissions and wastewater, and consumption waste at the end of the line. Waste output is overwhelmingly concentrated in the first moment: for every ton of waste in consumption, there is another 25 tons in production and extraction (Meadows, Meadows and Randers 1992). Every new phase of capitalism generates not only a quantitative expansion of waste, but a qualitative movement towards new forms of toxification. Mining effluents such as mercury and lead poisoned streams across the early modern Atlantic, but these pale in comparison to cyanide gold mining. Across the long twentieth century, mass industrialization has depended as much on chemicalization as mechanization. This inevitably creates another dimension of the waste problem: new and exotic by-products that are toxic to life. Some of the waste is dumped on land, in the waters or in the air as a means of externalizing it from market calculus—get rid of it as cheaply as possible by relying on the absorptive capacity of the Earth. But there’s another pathway. Capital’s twisted genius is the ability to turn some waste—including deadly by-products—into profitable commodities, assuring their diffusion far and wide. This represents greater productivity per unit of input, as well as new products embodying new value and surplus value—literally, turning dross into gold (Rogers 2005; Romero 2015). Both paths ultimately put more waste into humans and the rest of nature, where the evolving quantitative and qualitative mix activates negative-value: forms of nature such as superweeds, new diseases, and even climate change that cannot be fixed through technical innovation or by securing new waste frontiers (Moore 2015b).

A fourth effect of rising productivity is to put pressure on the rate of profit. This was Marx’s pivotal idea in third volume of *Capital*. Marx (1981, 317–75) argues that advancing productivity requires greater capital inputs relative to labour, or what he called a “rising composition of capital” (in contemporary terms, a higher capital/labour ratio). This, in turn, puts downward pressure on the rate of profit (where profit = surplus value/capital investment per unit time). Marxists have generally

thought of the rising capital/labour ratio in terms of more machinery (fixed capital), but it also means more resource inputs, or circulating capital.

Marx mentions in passing that capitalists have a means of countering the rising cost of circulating capital by obtaining inputs at below their value (i.e., cost of (re)production within the market economy). Cheap labour and food generate more surplus value, while cheap energy and materials raise the rate of profit by lowering the cost of circulating capital. It follows from this that capitalists have every incentive to seek out new sources of cheap inputs such as displaced farmers and immigrants, fresh lodes and unploughed soils, or virgin forests and untapped oilfields. Unfortunately, Marx did not pursue the implications of this insight.¹⁰

Cheap inputs and the commodity frontier

The “commodity frontier” is the process of going beyond the highly capitalized zones of production to secure sources of labour, food, energy, and raw materials at below the prevailing average cost. The easiest way to obtain cheaper inputs is to look to those domains of life relatively independent of the circuits of capital. In these zones, resources can be obtained without paying prevailing average costs of re/production. The same is true of cheaper labour, which raises the rate of surplus value: take the search outside the boundaries of normal capitalist reproduction.

The search for the Four Cheaps (labour–power, energy, materials, and food) has been an accumulation strategy at the heart of capital’s global expansion for centuries (Moore 2010a; 2010b). Unfortunately, the search for cheap and better inputs has remained secondary in Marxian theory, relegated to counter-tendencies to the falling rate of profit. Traditional Marxism has stepped over this forward wave of capitalist growth in order to get to the more “modern” problem of the industrial revolution, but Marxist political economy today requires a major historical-geographical rethink to deal with the long and deadly trail of capitalist expansion across the Earth.

Incorporating the search for cheaper inputs into the theory of value and capital is a powerful idea because it allows a unified approach to capitalist and extra-capitalist sources of surplus work and surplus value. In this model, capital not only exploits labour and nature *within* the sphere of modern industry, it benefits from the work done by human and extra-human natures *outside* the realm of capitalist production. The latter is vital because it cheapens the cost of inputs and thereby raises the rate of surplus value and profit indirectly. We call the latter process the *appropriation* of the work of extra-capitalist labour and natures, in contrast to direct exploitation.

Appropriation, in this sense, differs somewhat from Marx’s use of the term, which was synonymous with exploitation, yet the two moments are tightly connected. If exploitation generates the demand for appropriation, conversely appropriation leads the way to further exploitation. Appropriation names the extra-economic processes needed to identify, secure, and channel unpaid work outside the commodity system into the circuits of capital. Primitive accumulation (or dispossession) is an essential foundation to this, serving to cut people, land, and resources loose

from previous social orders and turn them into commodities (private property and wage-labour). But much more is involved, extending all the way to the scientific, cartographic, and botanical revolutions of the modern era.

Arriving at a unified model of appropriation and exploitation means taking on board feminist and green critiques of Marxism and incorporating them within a theory of value, capital, and growth. Feminists have long balked at factories, wage-labour, and the industrial revolution as the sum of economic life and pivot of labour exploitation. They rightly ask about the labour of daily and intergenerational reproduction. Indeed, as Seccombe (1992) notes, historical materialism has long suffered from a “bilateral reduction: the effective omission of labour power as humanity’s first productive force... and the marginalization of raw materials supplied by nature.” How does the unpaid work of women and households figure in the theory of value and capital (Mies 1986; Seccombe 1992; Federici 2012; Dunaway 2014; Fraser 2014)? Similarly, environmentalists have wondered what happened to all the natural inputs and forces that human beings harness to help produce the commodities flowing into world markets (Cronon 1991; Bunker and Ciccantell 2005). The problem for critical political economy is to move beyond the capitalist fallacy that “the economy” stops at the boundaries of the market and firms (Gibson-Graham 1996; Mitchell, Marston and Katz 2004). Rather, the spheres of production and reproduction, formal and informal economies, social and ecological, require a unified theory of exploitation within and appropriation without the capitalist realm.¹¹

If *Capitalism in the Web of Life* (Moore 2015a) outlines a unified approach to exploitation and appropriation, a fully articulated Marxist value model demands further clarification and extension on three fronts: commodification, value extraction, and capitalization.

First, we need to specify what happens at the commodity frontier to turn non-marketized work of labour and nature into commodified work that can be appropriated by capital. Appropriation requires commodification, or integration into the market, to be properly exploited by capitalist industry. Since these new commodities must be cheaper than those (re)produced within the circuits of capital, labour and nature must do their work outside the market before materials, energy, bodies or products appear as commodities. The uptake of such new commodities allows the appropriation of the surplus/free work of households and natures. There are two main paths: *direct appropriation* via capitalist production and *indirect appropriation* via non-capitalist households, or what Marx called “petty commodity production.”

The direct appropriation of cheap inputs takes place where capitalist enterprises using wage-labour utilize new resources or labour forces. There are, broadly speaking, two sites of such uptake. One is at the point of extraction of natural resources: mines, plantations, sawmills, oil wells, and so forth. In this case, the land, forests, deposits, and workers come cheap because they have been seized, conquered, displaced, enslaved, or otherwise taken without (adequate) compensation, whether for the ecological work of growing trees, the geological processes that create fossil

fuels, or the human work of raising children. The other site of direct appropriation is in the centres of capitalist industry being fed from afar by the migration of displaced peasants, artisans, and indigenes. This has been the path taken by millions of rural people over the course of capitalist history and it still goes on today. In this case, the labour-power is not just reproduced outside the formal economy; it is delivered directly to the factory gate without the capitalist having to do anything. Migrant streams are free gifts that keep on giving.

Indirect appropriation occurs where the means of production remain in the hands of small owners or households who do the work of farming, mining, processing, crafting, etc. Their products enter world markets as commodities, which can flow long distances to feed the maw of capitalist production and reproduction in the major centres of industry. As students of agrarian change have long argued, such small producers can survive for long periods of time through long hours and low remuneration. The other site of commodification is at the households in the midst of the developed centres of capitalism that create and maintain the wage-labour force. Here, the unpaid work of mothers, wives, and other household members reduces the cost of feeding and housing workers on a daily basis, raising children to enter the workforce, and caring for the sick, aged, and incapacitated who would otherwise be a burden on capital (Kautsky 1988[1902]; Hochschild 1989).

Second, a unified theory of appropriation and exploitation needs to be synched within the theory of value. How are the resources and labour flowing into the commodity system valued? We think the answer is straightforward for both direct and indirect appropriation.

If direct capitalist production is involved, the usual calculus of socially necessary labour-nature time obtains. If the labour-power has been recruited from non-capitalist milieux, it is obtained more cheaply: the new worker, say from peasant society, represents accumulated unpaid work—all the work necessary to raise a human from infancy to adulthood. Such workers represent a net subsidy to accumulation relative to workers born, raised, and educated at capitalist expense. This makes for an extra margin of (relative) surplus value—and where easily exploitable immigrant workers are involved, probably an extra dose of absolute surplus value from overwork, as well. If material inputs are cheapened because companies have not paid an average value for them, as when land is seized from indigenous people, a pittance is paid for an oil lease, or a mining claim yields an unexpectedly rich ore, then this means an extra measure of profit for that enterprise. In both cases, the outputs will be cheapened. To the degree that these outputs are generalized across the system—e.g. cheaper coal means cheaper steel means cheaper fixed capital—other capitalists benefit from cheaper inputs. For instance, as raw material prices fell during the 1980s and 1990s, the costs of fixed capital fell dramatically, by as much as 25–40% in the US and Japan (Bank for International Settlements 2006, 24).

The case of indirect appropriation via simple commodity producers is different. This is an old problem in agrarian studies, where agricultural output comes to be priced in global terms and households struggle to survive as their products are devalued (often called “declining terms of trade” for primary products). There are

three devaluations involved, as far as the world market is concerned. The labour-power (and tools) originate outside the market and have no value; the household is not a capitalist enterprise, so their labour time is not evaluated as “socially necessary”; hence the products entering the market fall below the “socially necessary” average on the world scale, thereby registering as cheap inputs in the centres of production and accumulation.

Third, appropriation needs to be understood as more than a complement to the process of raising productivity in capitalist production; it is deeply implicated in dynamics of industrialization. Capitalists continue to seek ways to exploit labour-nature more effectively by raising the rate of productivity and hence the rate of surplus value. Normally, this means more investment, or capitalization of production, to advance technology; hence we call it the *capitalization frontier*. Appropriation is called forth by capitalization in successive phases of boom and bust, but also facilitates and embodies the process, in turn.

It is easy to think of capitalization and appropriation as alternatives, a choice of technical progress versus cheap inputs, but in fact they usually work in synchrony. Throughout the long history of capitalist development, the two have gone hand in hand, or rather been caught up in a kind of dance in which capital calls the tune.

Cheap inputs have regularly allowed capitalists to invest more in machinery precisely because other costs have been lower, and new, cheaper labour forces have usually been the most pliant in the face of new forms of production, as in the introduction of Bessemer steel and Fordist mass assembly. Cheap coal and cotton made possible the massive technical recomposition of capital in nineteenth century textiles in Manchester, which is why von Tunzelmann (1981) and others argue that the first phase of the Industrial Revolution was more capital-saving than labour-saving—when the new methods so obviously raised the productivity of labour.¹² Moreover, there is no contradiction between terrible absolute exploitation of labour and cutting-edge machine technology.

Meanwhile, as commodity frontiers yield cheaper resources and labour, they are also commonly precocious sites of advanced industrial organization and technological innovation. That is, they are both commodity and capitalization frontiers. In early capitalism, for instance, the sugar plantation was a key forerunner of large-scale industry, and the seventeenth century’s only industrial structures worthy of the name were large-scale sugar refineries. Mining—the paradigmatic frontier industry—was the principal driver of systemic technological innovation until the end of the eighteenth century, as exemplified by the way the steam engine developed at the pithead of English coal mines (Mumford 1934; Freese 2003).

The industrially advanced character of commodity frontiers has been enabled only partly by capital itself. It has been crucially dependent on complex weaves of territorial power and new scientific knowledge alongside capital, which are necessary to secure and reproduce the Four Cheaps. In this, the food/labour nexus is especially important. A crucial means of reducing the value of labour-power is through agricultural revolutions that produce a rising aggregate volume with a declining amount of labour. Of course, agriculture yields more than just calories, insofar as it

produces raw materials it resembles extractive sectors, a reality underscored by the petro-farming model that has dominated capitalist agriculture since 1945 (Walker 2004; Moore 2010c).

Geographies at the frontiers of accumulation

A theory of capitalist exploitation and appropriation of labour and nature must be posed in geographical terms. In this section we lay out some spatial dynamics of commodity and capitalization frontiers that break with simple dualisms of centre and periphery that plague so much of the discussion of capitalist geography.

Capitalism has been a spatially expansive system from the outset. The term “frontier” normally implies a movement outward, away from established territories of capitalist industry, cities, and states. While the search for markets is important, as is the export of surplus capital, an essential element in any such explanation has to be the commodity frontier, as capital seeks out new sources of cheap materials, energy, and food, along with new worker bodies (the Four Cheaps). New resources and labour supplies have repeatedly been sought by conquest and markets penetration into little known territory, opening up access, securing property rights, and displacing indigenous occupiers, from the Carolinas to the Congo. As Marx put it, capital comes into the world “dripping head to toe, from every pore, with blood and dirt” (Marx 1977, 925). Indeed, the process of primitive accumulation, or dispossession, still goes on full tilt on the outer edges of the world economy, whether in the Amazon, New Guinea, or the Arctic (Harvey 1975; Luxemburg 2003 [1913]).

Hard on the heels of primitive accumulation, commoditization opens up production for the market. Capitalism’s geographic expansion has often been led by small commercial operators, as in timber extraction in Norway in the sixteenth century or the North American family farmers in the nineteenth. Similarly, the use of slave or indentured labour has been commonplace, from the tobacco farms of the Chesapeake Bay in the seventeenth century to the rubber plantations in Malaya in the nineteenth. The tin mines of Bolivia and the shrimp boats of Thailand today are hardly better. Extraction at distant commodity frontiers does not have to be mediated, however; it can be undertaken by capitalist enterprises using wage-labour, as in the silver mines of Bohemia in the early modern era and the gold mines of Irian Jaya today. It has been common, however, for such frontier exploiters to utilize labour-intensive, technologically simple methods, as in tropical forest clearing.

Nevertheless, the commodity frontier can also be a *capitalization frontier*. That is, resource extraction is frequently a frontier of technological advance and modern industry, as it was in the mines of Bohemia in the early sixteenth century, the sugar mills of Barbados in the seventeenth century, and the American Midwest in the nineteenth century, all of which gave birth to new and better ways of putting nature to work that flowed back from the periphery to the older industrial centres. The same has been true from the textile mills of Lawrence, Massachusetts to advanced electronics factories of the Pearl River Delta, China, both taking advantage of

masses of wage-labour newly displaced from farmlands of the interior. Raising productivity has been central to the capitalist project from the get-go, and such capitalization has always involved a process of opening up new industrial spaces, whether for resource extraction or automobile assembly, as economic geographers have long argued.¹³

Conversely, new frontiers of appropriation and exploitation need not occur far away from capitalist centres; they can arise in the heartland or nearby edges of advanced capitalist territories. A striking characteristic of early modern resource frontiers is that they unfolded *within* Europe as much as across the Atlantic. These frontiers swept from the Baltic in the north, to Bohemia and Poland to the east, and Spain and Italy to the south. This is why it was said of the enrichment of the Dutch in the sixteenth and seventeenth centuries that “Amsterdam is standing on Norway” (Moore 2010a; 2010b). Just as striking are the internal resource frontiers that developed across eighteenth- and nineteenth-century Britain, which became the world’s biggest producer of raw materials and energy, as well as textiles and iron. How could that be? After all, Britain is an island nation and not, by world standards, terribly well-endowed with natural resources (Coyle 2010).

Similarly, the United States dominated resource production for a century after 1850. This is usually attributed to the continent’s “natural endowments,” but if that is so, then why was there so little mining in North America before 1850? The usual explanation is westward expansion, as if Conestoga wagons turned the wheels of commerce. The real reason was *capitalization of the commodity frontier*. There was, of course, rampant dispossession of the native peoples and a small commodity frontier of settlement and extraction, but the key to the US resource explosion was industrialization. American capitalists had the money and the machines to carve up the Earth, cut down trees or plough the soil at unprecedented rates. Drills, dynamite, harvesters, railroads, hydraulic pumps, elevators, and other capital equipment did their work and did it well. Resource prices fell (Wright 1990; Page and Walker 1991; Walker 2001).

Capital-intensive frontiers unfolded inside and outside national economies. The development of domestic resources proceeded apace while Britain and America were busy plundering the world via distant colonies and commerce to secure even cheaper inputs. It was far more than a matter of “centre and periphery.” The new imperialism of the late nineteenth century was so prodigious and so rapid in its transformation of planetary life because it produced so many peripheries, new centres, and new patterns of interaction across multiple scales (Barracough 1967; Davis 2001). This is the way we need to think about the complex geography of capitalist expansion.¹⁴

Our model overcomes the previous popular dualism of centre and periphery, intensive and extensive development. Hence, the debate about whether the colonies drove European development or Europe drove the colonies is moot (see, among others, O’Brien 1982; Wallerstein 1983). *Both* were at work, and the qualitative and quantitative transformations were a product of their combined development acting reciprocally. So, too, can we jettison the arid debate about whether US economic

development shifted from extensive to intensive accumulation. It was always *both*: a process of continental conquest and of industrialization that leapfrogged across and around the American continental economy (Aglietta 1979; Page and Walker 1991). In short, capitalism since the long sixteenth century has witnessed successive waves of geographical expansion that work by combining productivity and plunder (Storper and Walker 1989; Moore 2015a).

The accumulation vortex and the ends of the Earth

A final element of value theory relevant to the use and abuse of nature is the accumulation of capital. One of Marx's greatest insights is how the age of capitalism unleashed a limitless process of growth that catapulted humankind to an entirely new level of social wealth and exploitation. But why is accumulation such an inexorable, dynamic, and rapacious process? Marx's reasoning follows from value theory in ways that are often misunderstood.

As Marx saw, value may be an abstraction, hidden behind the everyday workings of the market, but it has to be concretized in the form of money for the keeping of accounts and mediation of exchange. Money steps in as the universal equivalent and intermediary, providing a measure of price. Money is another "concrete abstraction," being at once an abstract accounting of trillions of units on electronic registers and flows of material currencies like dollars. As value's form of appearance, money comes to play a central role in market economies. As Marx put it, the generalized commodity system "sweats money from every pore" in the process of now trillions of exchanges (Marx 1977, 178–87).

But money does something more. It piles up as a store of value and it has the power to command all other commodities. Then it can be used to turn the process of exchange on its head, as money-holders re-enter the commodity market in order to make more money. As Marx's simple but powerful formula expresses it, $C-M-C'$ becomes $M-C-M'$, the same thing seen from a different starting point, but revealing a wholly different logic. As money is invested to make more money, capital is born, and as capital penetrates ever-more dimensions of life, it turns general commodity circulation into generalized *capital* circulation.¹⁵

The circulation of money as capital is peculiar. Capitalists, unlike all previous ruling classes, use money to make money and measure their wealth in monetary terms, which is why they are more than misers, money-lenders, or landed aristocrats, and ultimately more powerful than lords and emperors. They are money-makers, and there is no limit to what they can accumulate. Accumulation of capital becomes the driver of the modern economy, an unlimited spiral of investment, profit, and piling up of monetary wealth by individuals, families, enterprises, and corporations. Yes, competition matters, but the pursuit of accumulation precedes competition, which develops out of the accumulation of contending capitals (Marx 1977, 188–244; Harvey 1982, 157–66).¹⁶

Surplus value is what propels accumulation. The greater the surplus, the faster the spiral spins upward and outward. The exploitation and appropriation of labour

and nature is the lifeblood of capital and it can only want more. Because free gifts of labour and nature can issue forth from factories and farms, mines and wells, rivers and forests, capital will search out every source it can get its hands on.

The capitalist vortex is a maelstrom passing over the Earth and sucking up everything in its path. During capitalist booms, technical and organizational innovation within the circuits of commodity production links up with socio-ecological restructuring and geographical expansion. Together, these effect a virtuous circle. On the one hand, labour productivity surges in the capitalist centres—think shipbuilding, textile manufacturing, or Fordist assembly lines in their respective eras. Material throughput rises sharply in such moments, especially when measured per quanta of socially necessary labour time, and new, expanded, working classes emerge. On the other hand, agricultural, scientific, and extractive revolutions cheapen food, energy, and raw materials, even as the material volume of supply mounts up. Meanwhile, new geographic frontiers open up, rapidly displacing peoples through direct conquest and expulsion and the indirect effects of markets, as when cheap American grain destabilized eastern and southern European societies at the end of the nineteenth century (Wolf 1982).

Capitalism is at once a temporal and geographical regime. Because capital is the investment of value with the intent of securing more value in the future (M-C-M'), accumulation operates as a system of temporal deferment. As capital piles up, however, it becomes increasingly difficult for individual capitalists to find profitable investment outlets. This is the problem of overaccumulation. When surplus capital mounts up to the point where there is a generalized crisis of profitability—as during the 1970s—capitalists intensify the search for new technologies and for the Four Cheaps—usually through alliances with state and imperial power (e.g., research subsidies, patent protections, trade liberalization, debt regimes, privatizations, new enclosures, etc.). This is the truly *general law of accumulation*: endless search, continual absorption, unrelenting exploitation, unlimited horizons, unprecedented productivity, and growth without limit.¹⁷

Accumulation crises take shape when the virtuous circle turns vicious. This is the inverse of Marx's observation about cheap cotton and large-scale industry that we encountered earlier. The sources of accumulation crises are many and complex, but one crucial—and almost universally ignored—moment is the relationship between surplus capital and Cheap Nature. The argument that capital must go out and scour the world for cheap resources as a result of accumulation crises has long been recognized. Less well understood is that the *formation* of accumulation crises is linked to the rising value composition of the circulating moment of fixed capital—thus capital's relation to (and within) extra-human natures is intimately tied to the rising value composition of capital, and the tendentially falling rate of profit. In sum, the rising value composition of raw materials—impacting both the value of circulating capital *and* fixed capital (e.g. the price of oil affects the price of *both* consumer- and capital-goods)—effects two problems for capital as a whole. It affects the rate of profit, to be sure. But it also puts the brakes on the expansion of profitable investment opportunities that characterize booms.

Marxist political economy has not dealt effectively with this problem of rising input costs, effectively ceding the terrain of “scarcity” to neo-Malthusian arguments. Of course, Marx hated the language of scarcity—the stain of Malthus on economics is still with us—but he didn’t evade the issue (Meadows, Meadows and Randers 1992). Often overlooked in Marx’s account are his observations on a “general law” of underproduction. In this model, “the rate of profit is inversely proportional to the value of the raw materials,” i.e., the cheaper the raw materials and energy, the higher the rate of profit (Marx 1967, 111). But there’s more to it than that.

Circulating capital is the forgotten moment in Marx’s model. Recall that “constant” capital (as opposed to “variable” capital, or labour-power) comprises more than fixed capital, or machinery, factories and equipment. It also consists of energy and raw materials used up during a production cycle: *circulating capital*. Capitalism’s productive dynamism leads the:

portion of constant capital that consists of fixed capital ... [to] run significantly ahead of the portion consisting of organic raw materials, so that the demand for these raw materials grows more rapidly than their supply.

Marx (1967, 118–19)¹⁸

In short, the “overproduction” of machinery (fixed capital) finds its dialectical antagonism in the “underproduction” of raw materials (circulating capital). The issue, then, is not overproduction *or* underproduction, but how the two fit together in successive eras of accumulation.

The idea of underproduction crises can be joined with the theory of commodity frontiers to suggest an elementary barrier to capital accumulation—not inadequate flows of this resource or that, but insufficient cheapness of inputs in general. Whether or not capitalism in a moment of crisis can restore the Four Cheaps sufficiently to launch a new wave of accumulation remains an open question.

To this must be added the political element in economic reasoning. Capitalists are driven to exploit and appropriate labour and nature to the maximum until stopped by social protest, state control or warfare. In fact, this has been another dimension of the general law of capitalist development: the productive consumption of resources and labour with devastating rapidity, resulting in widespread destruction and extermination, undermining the reproduction of ecosystems and even whole societies. While all capitalist transformation of nature is not negative—it is vital to acknowledge what nature does *for* capitalism before moving to what capitalism does *to* nature. Nevertheless, the term “plunder” is not too harsh for what capitalism does to the Earth—and its creatures.

If capitalism cannot stop itself from feeding off surplus value and accumulating, who will stand up against the vortex of accumulation? Workers have fought back to put limits on working people to death, but, all the same, the levels of exploitation of migrant, slave, and child labour around the world today are chilling. Similarly, environmentalists have fought to limit the digging up, killing off, and befouling of the web of life, but capital keeps leaping over and battering down such barriers to

new terrains of destruction, from Indonesian forests to Canadian tar sands. There is the temptation to posit these as a separate set of struggles, but, as a unified value theory indicates, it will take a very wide swath of people to rise up to stop the madness (Kovel 2007; Klein 2014; Seabrook 2015).

Notes

- 1 Simple labour value made sense in the era of classical political economy when most commodities were made by handicraft (the manufacturing era). By the time Marx was writing, machines (capital goods) had to be worked into the calculus through the transformation to prices of production—with all the difficulties subsequent economists have had with the labour theory of value. The problem has grown worse in our own time, with the massive increase in indirect, extensive production systems. See more in Sayer and Walker (1992).
- 2 The problem is commensurability: what do iron and yeast have in common? Given the pervasiveness of energy inputs, BTUs (British thermal units) might serve as a proxy for a universal measure, as proposed by Georgescu-Roegen (1971). But this is no more satisfactory than letting labour time stand in for the rest.
- 3 “Socially necessary labour-time forms through the dialectic of capital-labour relations *and* the appropriation of unpaid work [of human and extra-human natures][...]. We are working with a double internality: of labour-in-nature and nature-in-labour, *not* with the Cartesian coupling of Nature/Society [...]. Value relations form and re-form through the active relation of life-making—the *oikeios*. Value in motion is *value-in-nature*. Socially necessary labour-time is [therefore] determined by more than commodification [and more than commodified labour-power]” (Moore 2015., 199 and *passim*).
- 4 There are even trickier problems in valuing labour time in complex production systems with extensive divisions of direct and indirect labour, which no one has tackled. See Sayer and Walker (1992).
- 5 The term “free gifts” comes from Engels, not Marx. We disagree with each other over the term. For Walker the term resonates. For Moore, the term suggests that extra-human natures exist as “low hanging fruit,” thereby underestimating the work it takes to mobilize the work of extra-human nature for capital accumulation (see Moore, forthcoming b).
- 6 The argument on “socially necessary unpaid work” is elaborated in Moore (forthcoming b).
- 7 A point overlooked by Marx but taken up by Schumpeter is product innovation, which opens up new markets and profits—or new fields of value and surplus value (Walker 1995; also Arrighi 1994).
- 8 On capitalism and technical progress, see von Tunzelmann (1995). In mainstream and Schumpeterian economics, by contrast, technological innovation chiefly arises outside the market and is adopted by capitalist entrepreneurs (Walker 1995). Among Marx’s great contributions is the analysis of the *internal* logic of capitalist growth, as well as the *internal* contradictions that generate problems and periodic crises, rather than attributing its successes and failures to external forces (Harvey 1982).
- 9 Conventional economic history has two major explanations for the industrial revolution, neither of which is as satisfactory as Marx’s: the exogenous development of science and technology or resource scarcity that led to deeper coal mines—both of which led to the invention of the steam engine. See, e.g. Landes (1970).
- 10 If Marx’s virtue was to provide a holistic model of capitalism, the flip side of that is neglecting things outside the frame (which he meant to get to but never did).

- 11 The exclusion of the useful work of women, ecosystems, and fossil fuels from value production is not just a failure of traditional Marxist theory. This is how capitalist valuation actually operates—work only has value if performed in service of the market and capital, making saleable commodities under capitalist supervision. But such commodity production always depends on the appropriation of unpaid work.
- 12 Similarly, Marx (1971, 368) observed that, “it was only the large fall in the price of cotton which enabled the cotton industry to develop in the way that it did.”
- 13 A critical blind-spot in Marxist theory has been the neglect of “resource industrialization” (Page, Brian and Walker 1991; Walker 2001). As a result, most Marxist historians have failed to recognize the “great labour productivity revolution” of early capitalism (Moore 2015a, 71). On geographical industrialization, see Storper and Walker (1989).
- 14 This process occurs at all possible scales, as recent spatial theory insists (e.g. Herod 2010).
- 15 Because neoclassical utility theory ignores the material foundations of production behind exchange, it ends up with no serious theory of money (the so-called Money Veil). Statist theories of money, by contrast, forget the essential link back to value in modern market systems (Ingham 2004).
- 16 Marx barely mentions competition until well into volume I of *Capital*.
- 17 Marx’s use of the term refers chiefly to the transformation of all workers into wage-labour but needs to be expanded to all labour-nature inputs (Marx 1977, Chapter 25).
- 18 Perelman (1996) sees the tendency towards the rising value composition of capital as Marx’s answer to Malthus.

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