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China as Chimney of the World: The Fossil Capital Hypothesis

Andreas Malm[1]

Abstract

What has caused the early 21st-century emissions explosion in China? Driving a global explosion, it appears to stand in some relation to processes of globalization, but these links have mostly remained unexplored. This article revisits some established frameworks for understanding the connection between globalization and environmental degradation and argues that they are insufficient for explaining the Chinese explosion. A new hypothesis is outlined, called "the fossil capital hypothesis." It proposes that globally mobile capital will tend to relocate production to countries with cheap and disciplined labor, but only through the accelerated consumption of fossil energy. Via three specified "effects," the inflow of global capital will therefore set off massive increases in CO_2 emissions. The hypothesis is applied in a brief analysis of developments in China between 2001 and 2008, and in other Asian countries after the Chinese strike wave in 2010.

Keywords

CO2 emissions, globalization, China, embodied emissions in trade, labor, fossil capital, environmental Kuznets curve in reverse

Introduction

The links between globalization and global warming still call for some basic conceptual work. There is little doubt that the fossil economy—or "business-as-usual," as it is better known in climate change discourse—moved into higher gear at the turn of the millennium: From 1% in the 1990s, annual growth of global CO_2 emissions accelerated to an average 3.4% between 2000 and 2008 (Canadell et al., 2007; Le Quéré et al., 2009; Raupach et al., 2007). The financial crisis caused only a brief recess. Having fallen by −1.3% in 2009, global emissions rebounded in 2010 to an all-time record level of 9 petagrams of carbon, a 5.9% climb over the previous year (Friedlingstein et al., 2010; Peters et al., 2012). Emissions were cautiously projected to rise by 3.1% in 2011, and this does indeed appear to be the new 21st-century baseline of business-as-usual (Peters et al., 2012). If it remains in place, global mean temperatures are on track to a 4°C rise within 50 years, quite certainly with catastrophic consequences in train (Anderson & Bows, 2008, 2011; Betts et al., 2011; New, Liverman, Schroder, & Anderson, 2011; Sheehan et al., 2008). Given the abrupt acceleration at the turn of the millennium, the

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fact that annual emissions growth upward of 3% surpasses the most fossil-fuel intensive scenarios developed by the Intergovernmental Panel on Climate Change (IPCC) in the late 1990s, and the likely devastating consequences of this trajectory, we are warranted in speaking of an ongoing, 21st-century *emissions explosion.*[1]

This explosion seems to stand in some relation to globalization. While world trade has long grown faster than world output, a more epochal and qualitative shift has been the emergence of globalized *production*, manifested in a precipitous rise in foreign direct investment (FDI). From the 1980s onward, FDI flows grew faster than cross-border trade; from 1990 to 2009, they quintupled, reaching a historic peak before plummeting in the financial crisis (Dicken, 2007; Sauvant, Sachs, Davies, & Zandvliet, 2011; United Nations Conference on Trade and Development [UNCTAD], 2010).

The parallel growth of emissions and FDIs was not, of course, evenly distributed over the world. Both trends were centered on the People's Republic of China (PRC). Between 2000 and 2006, 55% of total global growth of CO_2 emissions happened in China; by 2007, the share had risen to two thirds (Levine & Aden, 2008; Yunfeng & Laike, 2010). In 2006, two decades earlier than forecast, China eclipsed the United States as the world's top emitter (Gregg, Andres, & Marland, 2008). Four years previously, it had overtaken the United States as the world's leading destination of FDI (Chan, Ngai, & Chan, 2010). While this might have been a pure coincidence, the correlation should be explored further, and the questions posed anew: How exactly is globalization associated with the early 21st-century rush toward runaway global warming? Is there any chain of causation between the two? What are the drivers at work, and more specifically, what forces set off the emissions explosion in China?

This article begins by arguing that established theoretical frameworks for understanding the nexus of globalization and environmental degradation are insufficient for answering these questions. A brief examination of five candidates—the environmental Kuznets curve (EKC), the pollution haven hypothesis (PHH), consumption-based accounting of CO_2 emissions, ecologically unequal exchange (EUE), and environmental load displacement (ELD)—finds them wanting in different key respects. A new theory is therefore sketched. Called "the fossil capital hypothesis," it suggests a causal link between the quest for cheap and disciplined labor power and rising CO_2 emissions, via three specified "effects." The hypothesis is not submitted to extensive quantitative testing, but applied in a general analysis of developments in China over the years 2001-2008, and in other Asian countries since 2010. Toward the end, some policy implications and avenues for further research are indicated.

How Not to Capture the Explosion

Illusory Curves, Elusive Havens

In debates over the ecological dimensions of globalization, an optimistic case has been made by proponents of the EKC. Globalization fosters growth, runs the argument, and growth leads to improvement in environmental performance. Poor countries have low impacts on the environment; as incomes begin to grow, so do their impacts—but only up to a turning point, after which rising incomes endogenously *reduce* environmental degradation, back toward the low starting point. Thus the relationship between affluence and pollution takes the form of an inverted U-curve (Figure 1; the literature on the EKC is enormous, but see, e.g., Andreoni & Levinson, 2001; de Bruyn, van den Bergh, & Opschoor, 1998; Dinda, 2004; Richmond & Kaufmann, 2006; Rothman, 1998; Stern, 2004; Suri & Chapman, 1998; Tisdell, 2001).

As is well known, decades of research have produced scant evidence for the existence of any real EKC. Global pollutants, whose damaging effects are not immediately felt at the

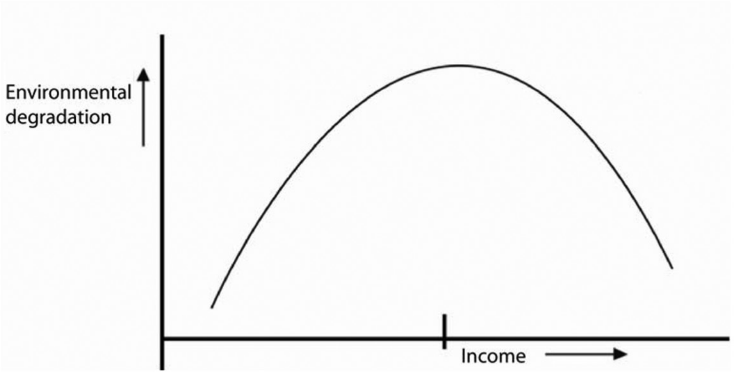

Figure 1. The environmental Kuznets curve

source, are particularly difficult to bend to the curve, CO_2 here being the paradigmatic example. Total CO_2 emissions tend to rise secularly with income (Kearsley & Riddel, 2010; Lipford & Yandle, 2010; Raymond, 2004; Romero-Ávila, 2008). Moreover, the EKC has been faulted for overlooking precisely the globalized nature of the world economy: It only depicts the environmental effects of an economy *within its national borders*. Because of world trade, critics of the EKC have argued and amply demonstrated, a significant share of consumed goods will originate from other countries, and so the full environmental effects of high incomes will not appear within the territory in question (e.g., Cole, 2004; Jorgenson, 2007, 2010; Muradian, O'Connor, & Martinez-Alier, 2002; Rothman, 1998). Suffering from methodological nationalism, the EKC founders on the realities of globalization, being virtually down for the count as a scientific hypothesis (cf. Gallagher, 2009; Müller-Fürstenberger & Wagner, 2007).

But there is one measure of environmental degradation for which the EKC, or some variant of it, does seem to hold: the *intensity* of pollution, or the amount of degradation generated *per unit of production*. In the CO_2 explosion of the 21st century, this variable is far from insignificant, and we shall have to return to it in some detail below.

A nemesis of the EKC has been the PHH. In a global economy, it says, heavily polluting industries will leave developed economies with stringent environmental regulations and settle down in less developed ones, where they can pollute with relative impunity. This relocation to "pollution havens" can be realized through trade, or—the mechanism mostly favored by the proponents of the hypothesis—FDI (e.g., Cole, 2004; Cole & Elliot, 2005; Dick, 2010). The state of the PHH in current research, however, is nearly as bad as that of the EKC. A handful of studies have suggested that lack of environmental regulation has in fact attracted industries, mostly on isolated occasions, but overall, the havens remain elusive (Dick, 2010; Gallagher, 2009; Javorcik & Wei, 2004; Kearsley & Riddel, 2010; Manderson & Kneller, 2012).[2] A common explanation for this state of affairs is that the costs of complying with environmental regulations rarely constitute a significant factor when corporations make their investment decisions (or set their prices). They do not have much reason to escape cumbersome laws in developed countries, nor to seek refuge in lawless havens: They are inclined to look for different things (Cole, 2004; Dick, 2010; Eskeland & Harrison, 2003; Gallagher, 2009). In other words, the PHH also fails to tally with the realities of globalization, primarily the drivers of FDI.

In the wake of the EKC/PHH debates, and in light of the emissions explosion in China, however, a third framework has emerged in recent years, far more promising in dealing with the problem at hand.

Promises and Pitfalls of Consumption-Based Accounting of CO_2 Emissions

Drawing on the critique of the EKC, scholars of global CO_2 flows have contended that most of the emissions associated with a commodity are often generated in the process of production, not final consumption (e.g., Davis & Caldeira, 2010). A Swede does not emit CO_2 through wearing a t-shirt from Bangladesh: It has already been emitted, from the factory where the t-shirt was sewn, from the power plant that supplied the factory with electricity, and further back the supply chain. A sequence of emissions, running all the way from the extraction of the fossil fuels through to assembly, can be seen as *embodied* in the commodity, so that the actual volumes of emissions caused by consumers in a country may stretch far beyond its borders (Caldeira & Davis, 2011; Davis, Peters, & Caldeira, 2011; Hertwich & Peters, 2009; Peters et al., 2009; Peters & Hertwich, 2008a, 2008b).

In 1990, an estimated 20% of all CO_2 emissions originated in the production of commodities ultimately consumed in a different country. By 2008, the share had grown to 26% (Peters, Minx, Weber, & Edenhofer, 2011). Catching up with this growth of emissions embodied in trade (EET), researchers as well as policy makers—including from China—now advocate a reallocation of responsibility for emissions from producers to consumers (see, e.g., Z. M. Chen & Chen, 2011; Gong, 2011). Such a shift from production-based to consumption-based accounting would, it is argued, provide a more accurate picture of "*how* and *why* human actions affect CO_2 emissions" (Peters et al., 2009, p. 380).

Again, China is at the center of both EET and the ensuing controversy. In the period 1990-2008, 75% of the growth in emissions imported to Annex B—the developed countries with obligations under the Kyoto protocol—emanated from the PRC (Peters et al., 2011). In 2001, the year of China's admission into the WTO and full liberalization of investment rules, emissions embodied in exports from the country were almost four times larger than those embodied in its imports (Peters & Hertwich, 2008a). That was when the real explosion began. While a third of the Chinese emissions growth between 1990 and 2002 was directly attributable to export, the share rose to *half* in the following 3 years (Guan, Peters, Weber, & Hubacek, 2009; Le Quéré et al., 2009; Pan, Phillips, & Chen, 2008; Weber, Peters, Guan, & Hubacek, 2008). According to another estimate, fully 48% of *total* Chinese emissions between 2002 and 2008 were generated in the export sphere (Xu, Li, Crittenden, & Chen, 2011).

Other drivers of the Chinese emissions explosion were comparatively puny. In 2002-2005, population growth and changing lifestyles contributed an estimated 2% and 1%, respectively, to emissions growth, and government expenditure and household consumption 7% each, in contrast to the roughly 50% of export production (the remainder attributed to capital formation) (Guan et al., 2009). Even so, the figures for exports are likely to be underestimates, since they only take into account the emissions caused *directly* by the production of commodities shipped overseas. They do not include the emissions from the construction of a factory, a highway to connect two industrial zones, a high-rise apartment building to accommodate workers or any other infrastructural project geared to the expansion of the export sector, nor the emissions from household consumption and other economic activities indirectly stimulated by the miracle of Chinese export. Would these be added, the figures would, of course, be dramatically higher (cf. e.g., Minx et al., 2011; Peters et al., 2011; Weber et al., 2008).

The mountains of Chinese commodities, leaving an enormous cloud of CO_2 in their trail–larger than the total emissions of any other single country in 2007, except the United

States–mostly end up in developed nations (Minx et al., 2011). The United States is the major importer of embodied emissions, just as China is the main exporter (Davis & Caldeira, 2010). Members of the Annex B maintain a similar trade balance: for the year 2004, the data suggest that average "individual consumers in the most affluent and least populous countries of Western Europe, for example, are importing the same mass of emissions as are exported by 5-10 people in China" (Davis & Caldeira, 2010, p. 5689; cf. Dong, Ishikawa, Liu, & Wang, 2010). When countries in Western Europe keep statistics over their CO_2 emissions, they exclusively count those produced within their borders. But the imported emissions increase much faster (Le Quéré et al., 2009; Peters et al., 2011).

Such displacement of emissions is known, in terminology emanating from debates over the Kyoto protocol, as "carbon leakage." At an early stage of climate negotiations, fears arose that if only some countries—those in Annex B—would be covered by mandatory emissions reductions, emitting activities could simply move out. A car manufacturer wanting to emit unlimited amounts of CO_2 could relocate to a country outside Annex B, without obligations under the protocol, such as China; a country wishing to reduce its emissions could import instead of producing them. The idea of carbon leakage is the CO_2 equivalent of the PHH (see, e.g., Peters & Hertwich, 2008a, 2008b; Weber & Matthews, 2007).

However, no carbon leakage of this kind has in fact occurred. No mass flight from Annex B countries could possibly have been triggered by draconian emissions cuts, for none have transpired. A distinction is therefore made between "strong" and "weak" carbon leakage. Strong carbon leakage is the—so far hypothetical—phenomenon of production activities moving out *because of* stringent climate policies. Weak carbon leakage is the phenomenon of them leaving and setting up businesses in non–Annex B countries *for some other unspecified reason*. Only strong carbon leakage can thus be properly called a CO_2 equivalent of the PHH, and it has fared no better than the original: The recent research consistently demonstrates that the carbon leakage occurring over the past decade has been weak in character (see e.g., Davis & Caldeira, 2010; Peters et al., 2011; Peters & Hertwich, 2008a).

The notion of strong carbon leakage fails on the same count as the PHH, in that it ascribes relocation to environmental policies. Weak carbon leakage, meanwhile, avoids this empirically untenable postulate, but as a concept for understanding the process, it is precisely that: weak. It explicitly says nothing about the mechanisms involved.[3] A team of leading EET researchers note that "the likely cause of the large emission transfers we report here are pre-existing policies and socioeconomic factors that are unrelated to climate policy itself" (Peters et al., 2011, p. 8907). But they stop short of asking the next natural question: Then *what are* these causes? If car manufacturers move their factories to China not to escape climate change mitigation—then *why do they do it?* For all its merits, EET research has not been able to identify the causal drivers at work; precisely when it comes to explaining "*how* and *why* human actions affect CO_2 emissions," it draws a limit to its field of vision.

There is another, related trouble with the framework. It tends, paradoxically, to jettison the moment of production and lay all its emphasis on consumption. Thus we read, in Weber et al. (2008), that "while China's economic development benefits from export growth, so do the *consumers* in developed countries, and it can be argued that *they* should be held at least somewhat responsible for emissions occurring *because of their demand for low-priced goods*" (p. 3576; italics added; cf. e.g., Y. Li & Hewitt, 2008, p. 1913). In the words of Yunfeng and Laike (2010):

> The proportion of China's CO_2 emissions that are due to net exports is large and significant, which demonstrates China's position in international trade as a "world factory". Those who *consume* the goods made in China should also share the responsibility. (p. 356; italics added)

Now contemplate that statement. China is a world factory, emitting a lot of CO_2, and those who *consume* the goods should assume their responsibility. Isn't someone absent from the picture here?[4]

What emerges from the statistical argument of the consumption-based accounting approach is a theoretical conception of how the world economy works, never outspoken, but no less fatal to the analysis. Absolute sovereignty is attributed to the Western consumer. It is he or she that causes emissions to travel afar, presumably by standing in front of shelves and picking cheap Chinese commodities rather than expensive domestic ones. In this implicit version of recent history, the export miracle and concomitant embodied emissions from China were conjured up by Western consumers. Indeed, Peters and Hertwich pose the question of "whether responsibility should be placed on the actor that initiates a polluting process (the consumer) or the actor producing the pollution (the producer)" (2008b, p. 55). In such a vision of the world economy—flowing, paradoxically, from the consumption-based critique of the EKC[5]—production is considered a neutral element, responding passively to consumer demand, owners and managers of production being plainly invisible.

The implications may be stated explicitly. Studying the embodied emissions in U.S.–Chinese trade, Xu et al. (2010) argue that "workers making goods in the developed world enjoy comparatively lavish lifestyles versus their counterparts in the developing world, a lifestyle which in many cases *induces substantial environmental impact*." Chinese emissions are "dominated by the manufacturing of products consumed *by workers*" (Xu et al., 2010, p. 567; italics added). Representing a majority of American consumers, they—the workers—should assume responsibility, and this is indeed implicit in much of the research in the field: CO_2 from China falls on the shoulders of ordinary people in the West. No differentiation is made between rich consumers and others; consumption is pictured as a monolithic activity in the affluent nations—another case, one might argue, of obsolete methodological nationalism (see also, e.g., Caldeira & Davis, 2011).

It is of course undeniable that workers in rich nations benefit from cheap commodities produced in China and bought at WalMart, Tesco, or Ikea. But as a *science of why emissions have relocated to China*, this is not very convincing. American or other Western workers have never made the decisions to outsource production to China. In fact, if there is anyone that has ever resisted such moves, it is precisely the Western—including the American—labor movements, for sheer fear of losing jobs.[6]

Consumption-based accounting thus appears to end up in a partial or even distorted view of the dynamics of the emissions explosion. Considering the centrality of Chinese exports in igniting the process, the scientific task left untouched must be deemed urgent: a systematic inquiry into the actual causes of the carbon leakage.

Exchange, Loads, and the Need for a New Hypothesis

Two candidates remain to be assessed. EET research is sometimes loosely associated with a body of work perhaps more successful than any other in integrating, conceptually and empirically, environmental degradation and the global economy: the science of EUE. The main concern in this field is the flow of *biophysical resources* in international trade. EUE can most simply be defined as the net transfer of such resources from one part of the world-system (usually the periphery) to another (usually the core) by means of market transactions. The existence of the phenomenon has been conclusively demonstrated in studies of cotton, aluminum, nickel, coffee, pig iron, forest products, and a whole gamut of other resources, quantified in different groupings and historical and geographical settings (see, e.g., Hornborg, 2011;

Hornborg, McNeill, & Martinez-Alier, 2007; Jorgenson & Kick, 2006; Rice, 2009; Roberts & Parks, 2007).

But the concept of EUE does not appear to be applicable to the case of CO_2 emissions growing through displacement. CO_2 is not a resource: It is a waste product, without any productive potential. It would not make much sense to claim that the flows of embodied emissions between China and the United States represent a net transfer of resources, draining China of useful matter. While flows of *fossil energy* can be submitted to EUE analysis to great effect (see e.g., Lawrence, 2009; Podobnik, 2002), there is, in a globalized economy, no necessary congruence between such flows and those of embodied emissions (see e.g., Davis et al., 2011; Wagner, 2010). China's CO_2 may derive from the combustion of fossil energy imported from Angola, Vietnam, Australia, or any other country. It may of course also—and this is indeed most frequently the case—come from the burning of Chinese coal, which could thus be said to have been extracted and consumed for the benefit of rich nations. But the ecological problem we are concerned with here is not the exhaustion of China's coal resources. It is not the (virtual) transfer of coal from China to the core of the world-system that is cause for worry, but precisely the exploding emissions of CO_2 in China.

Environmental load displacement or ELD, another concept related to EUE, is equally ill suited for application here. It has been defined by Muradian et al. (2002) as "environmental pressures (pollution, land transformation, resource depletion, etc.) linked through international trade chains to consumption in an importing country, but *suffered in an exporting country*" (p. 52; italics added). CO_2, however, is a global pollutant, and while China certainly suffers from climate change, there is no particular connection between the CO_2 emitted *on its territory* and the effects of rising temperatures experienced there. All ecosystems on the planet share the load of the CO_2 leaving Chinese soil. Thus Muradian et al. (2002) are wise to omit CO_2 from their analysis, treating only the displacement of local pollutants through trade.

To reach further, something more is required. If the PHH, EUE, and ELD are all negations of the EKC, and if consumption-based accounting is a negation of production-based ditto, we are in need of a negation of the negation. A new hypothesis is called for, to better explain the link between globalization and global warming, the emissions explosion and, in particular, the explosive emissions growth in China. It should fulfill at least three criteria:

1. It should offer an explanation *without recourse to environmental factors as drivers*, as in the case of the PHH or the strong carbon leakage concept. Emissions growth is clearly not caused for its own sake, so to speak: We need a theoretical framework that can identify it as the *effect* of a more fundamental cause.
2. It should concentrate not only on trade as the hallmark activity of a globalized economy, but just as much—perhaps even more—on *investment*, thus saving the moment of production from oblivion. After all, accumulation of capital through commodity production is kindled by investment, and in a globalized economy, FDI has restructured patterns of production.
3. It should accord proper place to the factor of *labor*. Here we encounter a perennial problem at the intersection between social theory and environmental studies: How can the sphere of labor and class relations be understood as constitutive of ecological processes (see e.g., Peck, 2006)? The faulty depiction of the causal role of workers found in some EET research is a reminder of the lacunas yet to be filled. In line with these three criteria, and as an alternative to the frameworks here examined, we may propose *the fossil capital hypothesis*.

The Fossil Capital Hypothesis

A Global Quest for Cheap and Disciplined Labor Power

In early 19th-century Britain, a momentous breakthrough occurred in the consumption of fossil fuels. Hitherto used for generating heat, or for pumping water in mines through the vertical motion of the first primitive steam-engines, they were now harnessed for the production of *rotary* motion. Machines and vehicles could henceforth run on coal. With this leap, two crucial moments of capitalist growth were wedded to fossil fuels: the mass production of commodities by means of machines, and the transportation of commodities by means of, to begin with, railways and steamboats. Unlike in ovens or mines, the mobilization of coal for the running of machines and vehicles opened up unlimited vistas of application, where the accumulation of capital could extend fossil fuel consumption across the planet and push it to ever new heights (see further, Malm, 2012).

A minimal definition of a fossil economy—an historical oddity, now so ingrained as to be synonymous with "business-as-usual"—would be one characterized by a sustained growth in production, predicated on growing consumption of fossil fuels, and therefore generative of a constant growth in CO_2 emissions. The drawn-out transition to steam-power in early 19th-century Britain was a decisive phase in its emergence. To gain ascendancy, steam-engines had to displace water-wheels, up to at least the 1820s the predominant prime mover in the cotton industry, the frontrunner of capitalist growth. Why did cotton manufacturers turn from water to steam? Not because the latter was a cheaper source of rotary motion—to the contrary, it was far more expensive—but because, in the words of the most authoritative steam-engine manual of the time, "[n]atural falls of water are mostly found on rivers in the open country; but steam-engines can be placed in the centres of populous towns, *where labourers are easily procured*" (Farey, 1827, p. 7; italics added). Or in the words of *Edinburgh Review*, house organ of the cotton manufacturers: "The steam-engine has relieved us from the necessity of building factories in inconvenient situations merely for the sake of a waterfall. It has allowed them to be placed *in the centre of a population trained to industrious habits*" (McCulloch, 1833, p. 323; italics added).

The greatest advantage of the steam-engine—such is the picture emerging from the literature and archives of the era—was perceived to be access to abundant supplies of labor. Workers "easily procured" and "trained to industrious habits" were found inside the towns; waterfalls were mostly in the hills. From the very beginning, there was an intimate relation between the rise of the fossil economy and *the quest for cheap and disciplined labor power*. In Marxism, of course, this quest is understood as a manifestation of the capitalist drive to maximize the production of surplus-value. In an eco-Marxist analysis, then, fossil energy has been the general lever of surplus-value production ever since the early 19th century: It is mobilized by capital to power the extraction of surplus-value from workers (cf. Clark & York, 2005; Huber, 2009). Making the complicated story of the diffusion of steam-engines unduly short, and adopting the eco-Marxist analysis without further probes, we may thus venture a leap over the centuries and formulate the fossil capital hypothesis:

> Globally mobile capital will relocate factories to situations where labor power is cheap and disciplined—where the rate of surplus-value promises to be largest—by means of new rounds of massive consumption of fossil energy.

What do we mean by "globally mobile capital"? We mean, first of all, industrial capital that is free to invest across national borders, and capable of carrying production technology to the new location. Capital from source country A is globally mobile if it is free to construct factories (greenfield investment) or buy companies (mergers and acquisitions) in host country B, and if it is able to bring with it machines, technical expertise, management principles, and other key assets from A to B—and, of course, if B is flanked by a range of other, similarly available host countries. As the world economy has developed since the 1970s, these conditions have been progressively realized. They imply that capital can move across borders with roughly *constant levels of productivity*. Put differently, the productivity of a transnational corporation (TNC) is largely a firm-specific asset, something it owns and can insert in the host country, regardless of the average levels of productivity attained there (Ádám, 1975; Larudee & Koechlin, 1999, 2008). But this only holds—and as we shall see, the distinction is crucial—for *production technology*, in the wide sense of the term, while not for *infrastructure*.

As capital roams the globe with portable productivity, it is free to choose between potential host countries on the basis of *their* specific assets. One profoundly nation-specific endowment is labor power, for labor is rarely free or able to move across borders the way capital is. As capital moves around, it will thus attach great weight to the national characteristics of the labor supply (Ceglowski & Golub, 2007; Larudee & Koechlin, 1999, 2008; UNCTAD, 1994). It will look for cheap labor: places "where labourers are easily procured." It will look for workers amenable to discipline, accustomed to high intensity of labor and long working days: "a population trained to industrious habits." A favorable combination of these factors will translate into a high rate of surplus-value and, ceteris paribus, entice TNCs to invest; conversely, if laborers become dearer and more rebellious, TNCs will, again ceteris paribus, *move out* from such places. The simplest standard indicators of high rates of surplus-value are low labor costs, commonly and roughly translated into low incomes. It follows that industrial production will, in a globalized economy, *tend* to move from nations with higher incomes to those with lower ones.

But things are not, of course, that simple. Features of labor power are an independent determinant of FDI flows, but far from the only one (cf. Larudee & Koechlin, 2008). A TNC might, for instance, wish to position itself in the midst of a *market*, serving customers face to face the better to adapt products to their tastes, enhance the value of a brand, or excel competitors in some other way. In this case, it is the consumers of the country, not the workers, who attract FDI. But if the TNCs *export* their products from the host country? Then we have prima facie reason to suspect that it is the workers—not the consumers—who have enticed them to set up shop there. Labor might figure in a market-oriented strategy as well—a country offering both moneyed consumers and inexpensive workers will be a particularly good choice for production in situ—and foreign affiliates may easily switch between selling on local and external markets, but as a general rule, export-oriented FDIs are more determined by attractive features of labor power (see, e.g., UNCTAD, 1994, 2002).

In a truly global economy, such as the one evolving since the 1970s, customers—unlike workers—can be reached from practically anywhere, sites of production can be dissociated from sites of consumption, and capital can choose between national economies for establishing export platforms. We may thus posit that capital, guided by the compass of maximum surplus-value, will flow from, again in the simplest possible terms, a country where labor is expensive to one where it is less so. This does not imply that *all* industrial production will have to leave a high-wage country, only that globalization will entail a *flow*, a process of relative relocation.[7] And the lever that allows capital to reach and exploit attractive supplies of labor is fossil energy. As in the era of steam-power, fossil fuels are requisite for initiating two crucial moments of capital accumulation: mass production of commodities by means of machines, and transportation of commodities by means of various vehicles. The flow of capital will be realized through new rounds of massive consumption of fossil energy. This is the crux of the fossil capital hypothesis, and it requires some more careful explication.

The Expansion Effect

The dynamics at work is three pronged. A necessary condition for labor power to be cheap and disciplined is the presence of a reserve army of labor: full employment dilutes both factors. From the classic case of Britain, we may surmise that a sizable reserve army will most likely be found in a country in the throes of the passage from a social formation based on agriculture to one based on industry. A whole new laboring population will be released for procurement, as ex-farmers leave their villages en masse and congregate in towns.

But a country experiencing this passage will also, in all likelihood, undergo the transition to a *fossil* economy. To the extent that inflowing capital stimulates and expedites this process, it will serve to extend business-as-usual to places where it did not exist before, other than in undeveloped forms: There will be an *expansion* of the fossil economy attendant on the relocation of production. This expansion will materialize in two ways, the first and most obvious of which is the CO_2 exhumed from the chimneys of the foreign-owned factories themselves, perhaps in surroundings that until recently were rural in character. The TNCs bring their technologies into the country; these emit CO_2.

But second, and no less important, the arrival of foreign capital will stimulate an expansion of the *infrastructure* of the host country. No capital would flow to a place where it would have to establish all infrastructure from scratch. After all, the physical presence of abundant labor power can never be a sufficient condition for attracting FDIs; rather, such labor power will only be de facto-accessible for surplus-value extraction if there is already a basic infrastructure in place—first and foremost, power plants and electricity grids capable of delivering the indispensible *energy*. If a country offers cheap labor power but constant outages, lasting for long periods of time, the endowment will not be of great value. The TNCs must be able to rely on an energy infrastructure upheld by the host country's government and other public institutions, and count on their capacity to further absorb growing demand from inflowing capital (Kentor & Grimes, 2006; Khadaroo & Seetanah, 2010; Kumar, 2001; Urata, 2006; Urata, Yue, & Kimura, 2006).

Conversely, an item high on the agenda for countries wanting to attract FDI—and in the globalized economy, FDI inflows are often considered synonymous with development—is investment in infrastructure. We should thus expect a self-reinforcing spiral of infrastructural expansion: Basic energy infrastructure is a prerequisite for TNCs to invest in a country, their arrival will encourage further expansion of it, which will in turn draw more FDI, and so on. If this infrastructure runs on fossil fuels, the expansion effect will not stay inside the factory gates of the foreign affiliates, but spread along the wires, plants, possibly coalmines and oilfields of the country, as TNCs induce and benefit from their magnification. The same goes for transport infrastructure, to which we shall return. For now, we may identify this moment of the dynamics as *the expansion effect.*

The Intensity Effect

A second moment concerns emissions intensity. This is, as indicated above, the sole variable where an EKC can be detected, robust enough to survive the inclusion of trade. In general, wealthy nations do have *lower carbon intensity* than poor ones: More CO_2 is generally emitted in the production of a t-shirt in Bangladesh than if the same t-shirt would be produced in, say, Sweden. Between the early 1970s and the early 1980s, an inverted U-curve did appear for developed countries, so that their continued rise in income coevolved with a decline in carbon intensity (Caldeira & Davis, 2011; Davis & Caldeira, 2010; Garnaut et al., 2008; Lawrence, 2009; Lipford & Yandle, 2010; Phylipsen, Blok, & Worrell, 1997; Richmond & Kaufmann, 2006; Roberts & Grimes, 1997; Roberts, Grimes, & Manale, 2006; Roberts & Parks, 2007; Unruh & Moomaw, 1998).

But is carbon intensity of any importance? For global temperatures, the amount of CO_2 emitted per unit of production is irrelevant: *total* absolute volumes of CO_2 are what count. Moreover, research on the Jevons's paradox shows that the decline in carbon intensity in developed nations has been accompanied by a rise in total emissions, more than offsetting any environmental gains of the former (see e.g., Foster et al., 2010; York, 2010; York, Rosa, & Dietz, 2009). York (2010) has even gone so far as to dub it "the paradox at the heart of modernity": "Modern societies have continually become more efficient while consuming ever-more resources and emitting ever-more pollution" (p. 9).

But there might be a further twist to the paradox. Suppose that a capitalist is about to reinvest his profit and expand the scale of production. Suppose, further, that he can choose between two countries to invest in, his homeland A and a potential host country B, and that the carbon intensity of production will be twice as high in B. If he bets on B, total CO_2 emissions from his expanded business will obviously be twice as high as if he would have stayed at home: The increase in scale will be compounded by a rise in carbon intensity. If this simple example is stretched out temporally, we may add the assumption that carbon intensity declines simultaneously and equally in both countries, with the gap between the two unchanged; even so, a move from A to B would push up the intensity of production relative to a scenario of staying put. In these cases, the expansionary logic of capital accumulation would not only trump the decline in carbon intensity, as in Jevons's paradox, but rather be realized *through a concomitant relative rise in carbon intensity*. Needless to say, this would be all the worse for total CO_2 emissions.

There are some intuitively appealing reasons for why carbon intensity should be lower in high-income than in low-income countries. The former will possess the most advanced and efficient technologies for power generation and transport; propped up by well-endowed governments, relying on relatively high wages for their tax revenues, their infrastructure will generate low amounts of CO_2 per unit of electricity supplied or good delivered. In developing nations, meanwhile, infrastructure is probably less sophisticated. Power plants will use suboptimal equipment and the cheapest available fuel. The scramble to expand infrastructure to keep pace with development will induce governments to set considerations other than costs aside; indeed, inward FDIs might incite governments to embark on crash programs for enlarging the capacity for e.g. power generation, with whatever equipment at hand and the least expensive fuel mix (Kentor & Grimes, 2006; Roberts et al., 2006).

As we have seen, TNCs on the move carry along their firm-specific production technologies, and there is no reason to assume that they will sink to the average productivity in the host country. To the contrary, we should expect the TNCs to have higher efficiency—and therefore also lower carbon intensity—than domestically owned firms. However, they have no choice, and no other interest, but to use the energy and transport infrastructure on offer: Here, they will take what they find. While we have reason to accept the EKC for the one variable of carbon intensity, we thus immediately find it turning into its opposite. As a corollary of the fossil capital hypothesis, there emerges an EKC *in reverse* (Figure 2).

If we insert the premise of globally mobile capital into the original curve—enhancing its realism in an era of globalization—we are led to the prediction that capital will move *back* when a turning point in income levels has been reached, *to countries near the peak of carbon intensity.* It will not move to the poorest countries, for the infrastructure will be inadequate there (cf. Khadaroo & Seetanah, 2010). Neither will it stay in the richest, most carbon efficient countries, for there the rates of surplus-value will be low: instead, it will hover around the apex of the curve. In the terminology of world-systems theory, the extreme left roughly corresponds to the periphery, the peak to the semiperiphery, and the extreme right to the core. The tendency will be for capital to move toward the semiperiphery, *increasing carbon intensity with every round of relocation from the core*. Note again that this does not require increasing intensity in absolute terms in the semiperiphery, only that the gap remains in place.

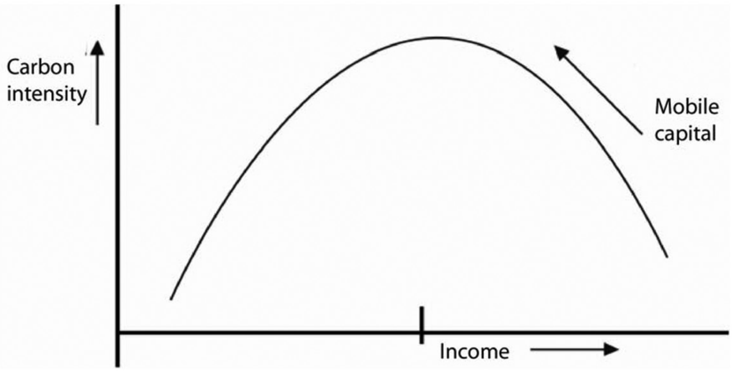

Figure 2. The environmental Kuznets curve in reverse

If high incomes and low carbon intensity form a single package, as they seem to do, and if low incomes and high carbon intensity are their mirror compounds, then a rise in incomes—equivalent to a rise in wages—will, given that capital is globally mobile, cause a relocation of industrial production to more carbon-intensive countries. This is not because capital desires such intensity for its own sake, but because it is thrown into the bargain when it scours the globe for maximum surplus-value. We may call this second moment of the dynamics *the intensity effect.*

The Integration Effect

Globalization is unthinkable without transport. As production circuits span the globe, growing volumes of raw materials, intermediary goods, finished products, and other forms of matter must be ferried around to keep the wheels in motion (Bunker & Ciccantell, 2005). Since modern transport systems are almost completely reliant on oil—accounting for 61.4% of all oil consumed in 2008—globalization will translate into larger emissions of CO_2 in this sphere as well (D. Banister, Anderton, Bonilla, Givoni, & Schwanen, 2011). The more fragmented and integrated the production circuits, with parts and components running between facilities specialized on certain segments of the production process, and the more extended and dispersed the supply chains, the more oil will be burnt in trucks, supertankers, and ships. Offshoring of production from high-income to low-income countries will tend to increase transport requirements—and CO_2 emissions—per product (cf. Cadarso, López, Gómez, & Tobarra, 2010; Curtis, 2009; Grimes & Kentor, 2003; Kentor & Grimes, 2006; Nieberger, 2009).

Transport, however, is unthinkable without infrastructure—ports, rails, highways, airports, warehouses—which any TNC arriving in a host country would balk at having to construct on its own (Bunker, 2005; Bunker & Ciccantell, 2005). With the same logic as in the expansion effect, it will look to the state to ensure reliable transport infrastructure, without which nominally attractive labor power would remain out of reach for the circuits of capital. Needless to say, this imperative of massive transport infrastructure will be particularly strong when TNCs *export* commodities from the host country (Bellak & Leibrecht, 2011; Dick, 2010; Khadaroo & Seetanah, 2010; Urata et al., 2006). Dual like the first, this third moment might be designated *the integration effect.*

Fossil Capital as Environmental Kuznets Curve in Reverse

Combining the three moments—the expansion effect, the intensity effect, and the integration effect—we arrive at a more precise version of the fossil capital hypothesis. Here is the dynamics through which globally mobile capital will speed up the consumption of fossil energy *through* its perpetual drive to maximize surplus-value. The three moments cannot be neatly separated from each other, but are rather interlocked. We may even retain our EKC in reverse as a general metaphor for their dynamics: The push factor of dear labor power and the pull factor of cheap ditto will, via the combined effects, cause capital to move toward ever higher CO_2 emissions—not merely displacing them from high-income to low-income countries but increasing their total volumes. Since conditions for accessing cheap and disciplined labor power tend to be inextricably bound up with conditions of expanding business-as-usual, comparatively high carbon intensity and increased transport, the quest for such labor power will in itself engender emissions growth. The arrow runs upward.

This new hypothesis seems to fulfill the criteria set up. The aim of it is not, of course, to account for *all* CO_2 emissions growth, but to locate the link between globalization and global warming, and to begin to throw some light on the emissions explosion. To achieve the latter aim, we must, first of all, explore developments in China over the years 2001 to 2008. It is to this task we now turn.

China as Chimney of the World

Cheap, Diligent, Good With Their Hands

Globalization is no longer driven primarily by trade. In 2011, the Vale Columbia Center, a leading FDI research institution, declared that "international investment has become roughly twice as important as trade in delivering goods and services across frontiers" (Sauvant et al., 2011, p. xix). By the time the crisis struck, "emerging markets" had decisively surpassed developed countries as receivers of FDI, and among them, China outshone all others. Having doubled in 2000-2008, annual FDI flow to the PRC was, in the last year of that period, almost twice as large as those to Russia and India combined (Davies, 2010; Kekic, 2011). But a figure of perhaps more material importance was China's unrivalled position as the country with most workers employed by foreign capital: some 16 million people in 2008, or a fifth of the world total (UNCTAD, 2010).

Where did all this capital come from? The circulation of FDI flows through Hong Kong and various tax havens—notably the Virgin and Cayman Islands—before touching ground in mainland China made it notoriously difficult to pin down their origins, but a trend manifested itself after WTO accession in 2001 (Davies, 2010). While neighboring Asian countries had been the preeminent sources of FDI in the 1990s, flows from the United States and the European Union now took off (Yongding, 2006). As of 2008, the United States, the European Union, and Japan each supplied 7% of FDI—to be compared with 14% from four tax havens—while 39% was registered as arriving from Hong Kong (Davies, 2010). At the same time, China became the new home for factories relocated from all over the globe; one study of 2001-2004 found the United States to be the number one country of origin for immigrating industry, followed by the European Union, Japan, Taiwan, the Philippines, Canada, Singapore, and Mexico (Bronfenbrenner & Luce, 2004). Industrial capital settling on Chinese soil had a propensity to *export*. Over the years 1998-2005, 19% of domestic manufacturing firms were exporters, as against 63% of foreign affiliates (Lu, Lu, & Tao, 2010).

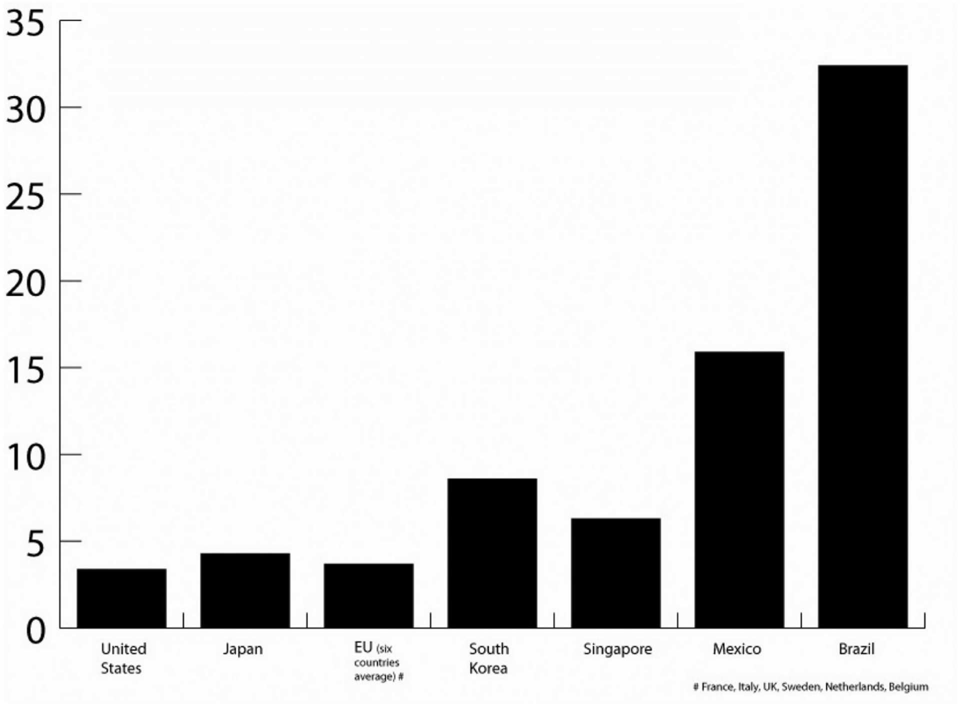

Figure 3. Chinese manufacturing wages: Average in 2002 as percentage of average in selected countries
Source: United Nations Industrial Development Organization data in Ceglowski and Golub (2007).

The chief reason for capital to flock to China and use it as an export platform was hardly a secret. In October 2004, *The Economist* affirmed that the ascent of China was safeguarded by its

> almost unlimited supply of cheap labor. By some estimates, there are almost 200m under-employed workers in rural areas that could move into industry. This surplus labour may take at least two decades to absorb, helping to hold down wages for low-skilled workers. ("The Halo Effect," 2004)

Figure 3 shows how Chinese manufacturing wages compared with those of some other countries in 2002.

As predicted by *The Economist*, the relative wages barely rose at all during the first decade of the century; the cost of labor power in China remained a trifle of that in developed countries (see e.g., Ceglowski & Golub, 2007; Hung, 2009; Lett & Banister, 2009; Yang, Chen, & Monarch, 2010). In 2008, hourly labor compensation costs were still 5% of those in Japan, 4% of those in the United States and 3% of those in the Eurozone (J. Banister & Cook, 2011). It was an immensely powerful magnet. One 2006 survey of FDIs in the PRC asserted that "low-cost skilled labor has long been regarded as China's most important advantage in attracting foreign companies to make goods in China"; furthermore, "Chinese workers are not only cheap, but diligent, motivated to improve, and good with their hands" (Yongding, 2006, pp. 436-437). In the words of another study, employers in the early 21st century became "accustomed to having a seemingly unlimited supply of very cheap labor, and being able to insist on certain qualities in their workers," such as "a compliant and flexible personality, and the willingness to work very long hours" (J. Banister & Cook, 2011, pp. 46, 51). Easy to procure, trained to industrious habits.

The force that weighed down on Chinese workers and imposed on them these characteristics was, to begin with, as explicated by *The Economist*, the gargantuan reserve army of labor. Bent on fast-tracking the transition to a social formation based on industry, the post-Maoist state released—benevolently interpreted—hundreds of millions of young farmers from the countryside into the cities. But the "floating population" kept one foot in the villages, falling back on traditional sources of income in need, further reducing the reproduction costs of labor power. Inside the cities, attempts at forming independent union organizations were nipped in the bud, the working class subdued and delivered to foreign investors (Blecher, 2010; Chan et al., 2010; Hart-Landsberg & Burkett, 2005; Hung, 2009; Lee, 2007; So, 2009; "Swimming Against the Tide," 2010).

An illustrative contrast was South Korea. By the late 1980s, rapid industrialization and near-full employment had spawned a highly organized working class, capable of bringing the Korean economy to a standstill and enforcing a secular rise in wages (Frenkel & Peetz, 1998; Kim & Kim, 2003). In 1997, the country was hit by its largest general strike ever—after which FDI outflows suddenly soared, the bulk going to China (Debaere, Lee, & Paik, 2010; Kang & Lee, 2007; Park & Koo, 2010). The flight was joined by American and other TNCs, relocating their factories—car plants, not the least—from strike-ridden South Korea to quiet China, and in 2002, the latter passed the former to become the world's fourth largest car-producer (Hart-Landsberg & Burkett, 2005). The magnet soon pulled in FDI from all over the world, South Korea merely exemplifying a broader trend: *Capital left comparatively expensive and powerful labor for the inexpensive and subordinated workers of the PRC* (see, e.g., Bronfenbrenner & Luce, 2004; Hung, 2009; Kimura & Ando, 2006; Luo & Zhang, 2010; Tseng & Zebregs, 2002). The arrow had been shot.

Foreign Agents of the Export Miracle

The Chinese export miracle was an outstanding feature of the early 21st-century world economy, sending forth streams of embodied emissions to the United States and other parts of the core. It would scarcely have been possible without foreign capital. In the 1980s, foreign-invested enterprises (FIEs)—that is, either joint ventures or wholly foreign-owned companies (WOFEs)—produced a meager 0.1% of the goods exported from China (Figure 4). In 2001, the share exceeded 50% for the first time. It stayed above the mark throughout the decade (Tang, Metawalli, & Smith, 2010; cf. Whalley & Xin, 2010).

Other methodologies produce even higher figures: Foreign affiliates might have accounted for more than 70% of total Chinese exports in 2005 (Lu et al., 2010). Beyond doubt, the export miracle was animated by the FIEs. Contrary to the expectations of mainstream economic theory, moreover, foreign capital tightened its grip on Chinese manufacturing export, rather than gradually relinquishing it to domestic enterprises (Moran, 2011). As Chinese exports moved up the ladder toward sophisticated high-tech products, transnational dominance only intensified: FIEs were responsible for 92% of all "advanced technological products" exported from China in 1996, up to 96% in 2002—hitting 99.4% of computers shipped abroad—while joint ventures tended to be discarded in favor of WOFEs (Moran, 2011, pp. 9-10). In 2009, WOFEs accounted for 76% of FDI, up from 62% six years earlier ("Foreign Companies Boost," 2010). *China Business Review*, a magazine published by the U.S.–China Business Council with investors as target audience, explained that the WOFE model offered the investor "full business control and profit rights," making it "much easier to recruit, train, and retain employees" (Ross 2010, pp. 14-15).

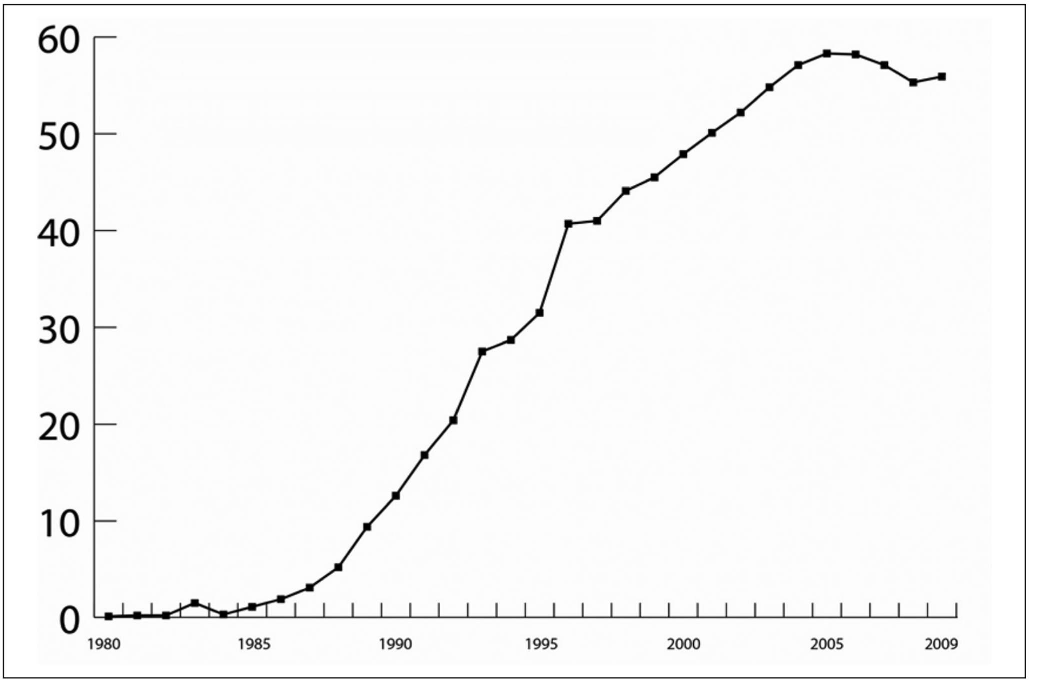

Figure 4. Share of foreign-invested companies in exports from China (percentage)
Source: Data from Investment Promotion Agency, China's Ministry of Commerce, in Tang et al. (2010).

The point of interest here, however, is not primarily if China remains "a 'workbench' economy largely bereft of the magnified benefits and externalities from FDI enjoyed by other developing nations" (Moran, 2011, p. 3). It is what this tells us about the dynamics of the emissions explosion. On the basis of figures similar to the above, *The Economist* argued in 2004 that the export growth "has more to do with foreign firms relocating their production to China than with Chinese businesses undercutting other producers" ("The Halo Effect," 2004). The conclusion can be extended straight to the atmospheric legacy of the very same products. It inverts the causation implied by the consumption-based approach: The agents behind exports of embodied emissions from China were not consumers in the West, but *owners of firms relocating to the country*.

Cheap and disciplined labor power was not, of course, the sole attractor in China. It was clearly flanked by the huge domestic market. But for capital moving to China and *exporting* its commodities, the characteristics of labor power must have exerted a stronger pull. Given the role of FIEs in Chinese exports, and that of exports in the Chinese emissions explosion, we may infer that the drive for maximum surplus-value must have been a paramount impulse behind the latter. China became the chimney of the world because it was seized upon by globally mobile capital as its workshop.

The Expansion Effect in China

Before we can say anything more specific as to the status of the fossil capital hypothesis, however, we must search for evidence of the three effects. There was a spike in fossil energy consumption in China after 2000 (Figure 5). Industry was the most voracious consumer. Having lost some appetite in the last 3 years of the 1990s, the volumes it took swelled again at the turn of

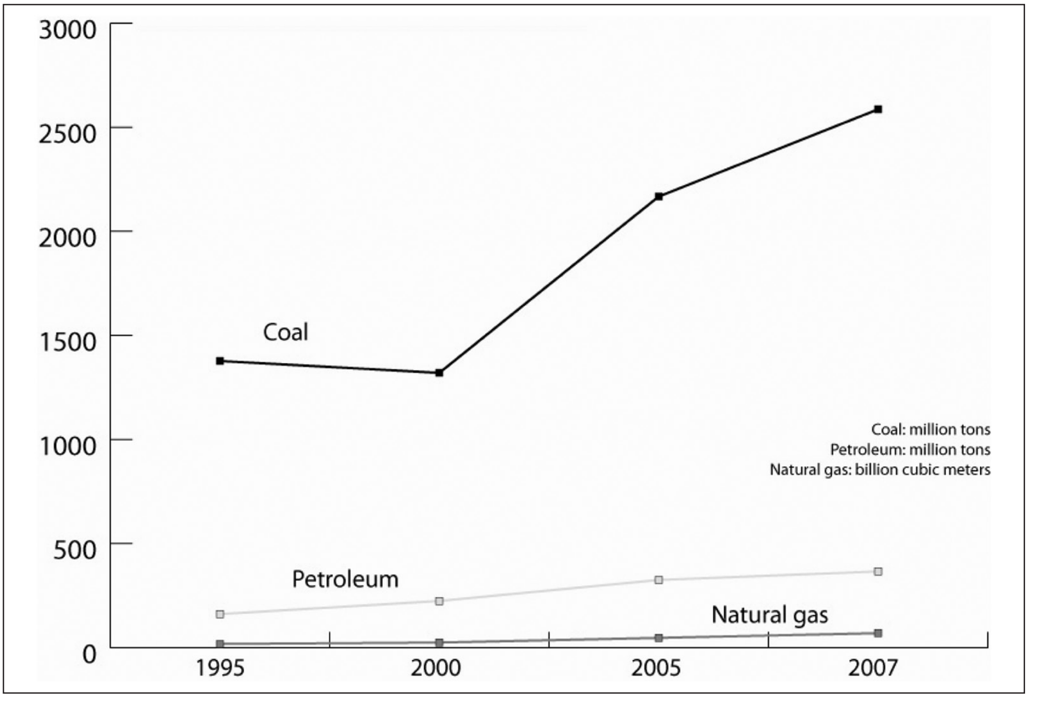

Figure 5. Fossil energy consumption in China, 1957-2007
Source: Data from China Energy Statistical Yearbook in Wang, Gu, and Zhang (2010).

the millennium; in 2002, it absorbed more than 90% of all coal. Three fourths of it was burnt in the generation of power and heat (Cattaneo, Manera, & Scarpa, 2011).

The spike coincided not only with entry into the WTO but also with the coming to fruition of governmental plans to attract foreign capital. Banking on FDI as the recipe for national development in the 1990s, Beijing resolved to expand energy infrastructure to cater for incomers, and the programs were intensified as WTO accession approached. A reminder of the dangers of insufficient energy supply came in 2002, when a shortage of oil, electricity, and even coal struck the nation (Jahiel, 2006; van Vuuren & Riahi, 2008; Wang et al., 2010). To secure a supply capable of keeping up with expanding industrial production, the government now further deregulated the coal market, allowing a thousand mines to bloom, of all sizes and efficiencies (Dan, 2008). But the state also undertook its own massive investments, not the least in the transmission of energy from inland power plants to the power-hungry, FDI-dense coastal provinces (Cattaneo et al., 2011).

In 2010, the Investment Promotion Agency of the PRC boasted on its website "Invest in China":

> In recent years, the construction of Chinese infrastructure has been improved greatly. The infrastructure in transportation, communication, and the supply of water, electricity and natural gas is almost complete. The ability of supply and quality of energies, raw materials and components has been improved obviously, which provides foreign investors with excellent external conditions in production and operation. (. . .) The bottleneck effect of infrastructure construction in hardware on the economic development, such as transportation, communication and energies, has been eliminated almost. (Ministry of Commerce, n.d.)

While making no pretensions to quantify the exact proportions of the expansion effect, we may conclude that there is some evidence for its existence. We shall encounter it again as it blends with integration.

The Intensity Effect in China

The post-2000 hunger for energy in China was mainly satisfied by coal, the dirtiest, most carbon-intensive fossil fuel. In 2003, 97% of all fossil-fired power was generated by coal, its shares growing at the expense of oil in the plants of the country, as well as in heat supply and gas works (Graus, Voogt, & Worrell, 2007; G. C. K. Leung, 2010; Levine & Aden, 2008; cf. Sheehan, 2008). There were good reasons for China to choose coal before the slightly cleaner alternatives. In 2008, oil was upward of six times more expensive than coal per unit of energy in the PRC (Kahrl & Roland-Holst, 2008; cf. Richerzhagen & Scholz, 2008). Relatively cheap coal was a reflection of an enduring feature of China's geology—abundant coal stocks, alongside slim reserves of oil and natural gas—appearing over the period as an extreme version of the emerging global energy predicament.

Predominance of coal is a major determinant of high carbon intensity (Richmond & Kaufmann, 2006). Adding to that, the levels of efficiency in China's fossil-fired power production—its coal plants in particular—were spectacularly poor: among 14 countries responsible for 65% of such production in 2003, only India came out lower (Graus et al., 2007; cf. Ou, Xiaoyu, & Zhang, 2011). When industrial production relocated to the PRC in the early 21st century, it was thus plugged into a relatively satisfactory energy supply, predominantly based on coal, transformed into electricity by highly inefficient technologies. The contours of the result can be discerned from Figure 6. Just as we would expect from the fossil capital hypothesis, the proportions here are a rough inversion of those in Figure 3. China had, relatively speaking, low wages and high carbon intensity, certain other countries high wages and low carbon intensity, *and capital flowed from the latter to the former*.

South Korea is, again, a case in point. After the crisis of 1997, coal and oil were gradually replaced by natural gas—the least dirty fossil fuel—in the fuel mix of the nation, making it the second largest importer of liquefied natural gas (Energy Information Administration, 2011). The government stimulated the introduction of top-notch technologies for electricity production, closing down old, wasteful power plants so that by 2003, South Korea had reached energy efficiency in fossil-fuelled power generation near the top in the OECD, above the level of Germany (Graus et al., 2007). While growth in total CO_2 emissions exceeded the OECD average, carbon intensity entered a modest but continuous decline after 1997 (Oh, Wehrmeyer, & Mulugetta, 2010). By this time, however, significant segments of South Korea's manufacturing base were in the process of being relocated to China. While South Korea could respond to high oil prices in the early 21st century by importing liquefied natural gas (cf. Oh et al., 2010), the option was less realistic for the People's Republic. Indeed, extreme reliance on dirty coal and comparatively inefficient infrastructure were integral parts of the Chinese economy—part and parcel, that is, of precisely the blend of adequate infrastructure and cheap labor power that made it so attractive for investors.

Here was the intensity effect at work. Capital moved *back* along the EKC, toward higher rates of surplus-value *and* higher levels of emissions per unit produced. The importance of the variable should not be underestimated. For the period 2000-2006, approximately 18% of the growth in atmospheric CO_2 concentrations stemmed from the "increasing carbon intensity of the global economy"—increasing, or *deteriorating*, by an approximate annual average of 0.3% (Canadell et al., 2007, pp. 18866-18867). The homeland of the trend was, once again, China, its already high carbon intensity rising further in the early years of the century and electrifying a constantly growing portion of the industrial production of the world (Gregg et al., 2008).

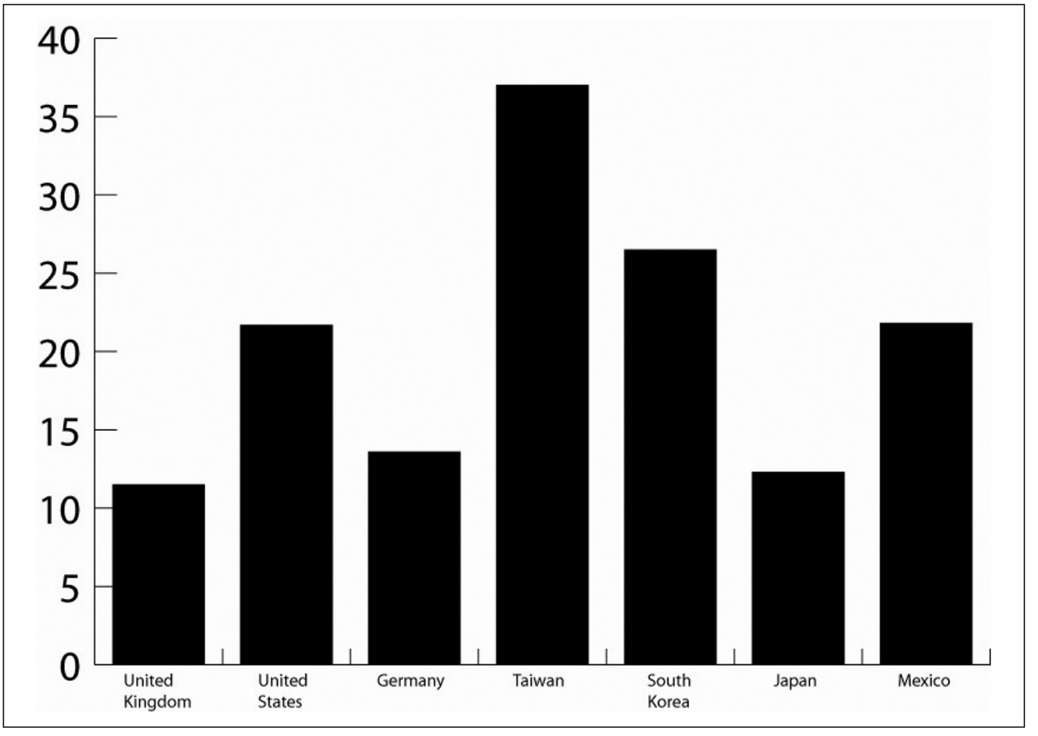

Figure 6. Carbon intensity of selected countries as percentage of China's carbon intensity, 2001-2008
Source: U.S. Energy Information Administration: Independent Statistics & Analysis, http://www.eia.doe.gov

The Integration Effect in China

To pave the way for FDI, a massive expansion of transport infrastructure in China was launched in the 1990s (G. C. K. Leung, 2010; McKay & Song, 2010; So, 2009; Yongding, 2006). It was most conspicuous along the eastern coast, the traditional, now rejuvenated gateway for incoming capital; over the period 1990-2004, 87% of FDI flowed to the coast, mostly to the three sprawling city-regions of the Pearl Delta, the Yangtze Delta, and the Bohai Rim (Zhao & Zhang, 2007). Initially most successful, the Pearl Delta was "transformed from an agricultural backwater to one of the world's leading-light manufacturing juggernauts" and "quickly blossomed into a vibrant export platform" (Zhao & Zhang 2007, p. 989). Indeed, export propensity among FIEs was highest along the coast, for reasons not entirely natural: The cities on the sea had to be equipped with enormous container terminals and port systems, airports, intermetropolitan networks for commuting businessmen, and other transportation loops sunk into global circuits (Zhao & Zhang, 2007; cf. Cheng & Kwan, 2000; Lu et al., 2010; Tseng & Zebregs, 2002).

While all cities waved the same basic bait—cheap and disciplined labor power from the inland—they sought to outmatch each other in transport infrastructure expansion, explicitly conceived to lure footloose investors (Zhao & Zhang, 2007). In 2006, it was observed that "companies can obtain everything in China, from raw materials to packaging, and get their products to customers anywhere in the globe almost as conveniently as in a developed country" (Yongding, 2006, p. 438). FDI and booming construction of everything from fiber-optic networks to highways went hand in hand.

Connected to the Chinese nodes, moreover, global circuits of parts, components, and finished goods were further stretched out. While there is a dearth of systematic research on the topic, one study suggests that CO_2 emissions have been growing markedly as a result of the shipping of goods from China: Relocations have caused “an overall increase in emissions per unit of production” (Andersen et al., 2010, p. 5797; cf. Fuglestvedt, Berntsen, Myhre, Rypdal, & Skeie, 2008). In the year 2000, the transport of inputs—raw materials, parts, and components—accounted for a stunning 85% of total CO_2 emitted in the cross-border transport of commodities, final goods only taking the remaining 15%, and growing slower (Cadarso et al., 2010). These emissions likewise gravitated toward China (e.g., Cadarso et al., 2010; Davis, Caldeira, & Matthews, 2010). An integration effect was at work as well.

Capital Considers Leaving

China became the workshop and chimney of the world over a particular historical conjuncture. There were never any guarantees that it would last. While the Chinese state appeared to temporarily weather the storm of the financial crisis with its stimulus programs, another contradiction soon erupted: In 2010, an unprecedented wave of wildcat strikes swept through foreign-owned factories (see, e.g., Bradsher, 2010; “Culture Shock,” 2010; “New Strikes Hit,” 2010; “Strike Breakers,” 2010; Watts, 2010). Disrupting tightly integrated supply chains, the strikes broadly succeeded in obtaining local wage hikes, and nervous authorities responded by raising minimum wages across the industrial districts (“Guangdong Ponders Another,” 2010; “Swimming Against the Tide,” 2010; “Wage Increases Quiet,” 2010). One estimate put the average pay rise for migrant laborers in 2010 at a whopping 40%: There was talk of a “wage explosion” (S. Leung & Kennedy, 2011). The trend persisted over the following year, reinforced by emerging scarcities of labor power, and in late 2011, strikes once again rolled through affiliates of giants such as Apple, IBM, Nike, and Adidas. New wage hikes appeared inevitable (J. Banister & Cook, 2011; “China Workers Strike,” 2011; Ni, 2011).

What was going on in the workshop of the world? According to state-owned *China Daily*, the industrial actions of 2010 heralded the “end to cheap labor” (J. Li & Yinan, 2010). In the eyes of *The Economist*, the “image of the country’s workers as docile, diligent and dirt cheap” had been shattered: “recent unrest has put Chinese labour at odds with foreign capital. Firms may have to get used to bolshier workers” (“The Next China,” 2010). In late 2011, business site China Briefing warned prospective investors against not only higher wages but also “waves of labor unrest and labor disputes, which could cause real damage to companies’ regular day-to-day operations” (Ni, 2011). Apprehension gripped the business press worldwide (cf. e.g., L. Chen & Estreicher, 2011; Ligorner & Liao, 2010; Pilling, 2010; “The Rising Power of the Chinese Worker,” 2010). Now, according to the fossil capital hypothesis we should expect foreign capital to begin relocating from China, to countries with more promising conditions for the production of surplus-value—and this is indeed what seemed to be happening.

In 2010 and 2011, reports of investors deserting China abounded. Among the countries cited as new havens were Vietnam, Indonesia, Bangladesh, and India: Chinese workers were now five times more expensive than their Vietnamese and three times more than their Indonesian counterparts (Brown, 2011; cf. Ceglowski & Golub, 2011; “Plus One Country,” 2010; “The Next China,” 2010). Other low-wage destinations mentioned—some patently in desperation—were Pakistan, Ethiopia, other parts of sub-Saharan Africa, even North Korea (Jacob, 2011; S. Leung & Kennedy, 2011; Ozawa & Belack, 2011; Shilling, 2011). At the end of 2010, UNCTAD proclaimed that the process of relocation had in fact begun, spearheaded by Japanese TNCs moving to Vietnam (UNCTAD, 2010). Predictions of a mass flight were made by the Vale Columbia Center and Bloomberg, *The Economist* and *Financial Times*, all pointing to labor unrest as the main impetus ("China Faces Dwindling," 2011; Davies, 2010; Jacob, 2011; Ozawa & Bellak, 2011; "Socialist Workers," 2010).

The predictions might have been premature. Their materialization hinges on a range of factors, such as future levels of working class militancy in China, remaining labor supplies in the countryside, the potential success of automation as alternative to relocation, the possible attraction of richer consumers, and movements in currency rates, to name but a few. One obstacle is particularly telling. In late 2011, *Financial Times* spoke to Frank Leung, owner of a Hong Kong–based women's footwear company, about his travels across the globe in search of more favorable sites for production now located in Dongguan. Bangladesh appealed to him, with wages 20% to 30% of those in China. But after his visit to the country, Mr. Leung was "shell-shocked. 'They have crazy traffic congestion and everyone uses a generator in factories (because the power supply is erratic)', he says. 'The logistics make it very hard to work efficiently'" (Jacob, 2011). For the same reason, the experts of Vale Columbia Center concluded, Sub-Saharan Africa would probably not receive much redirected FDI after all: Power, transport, and communication infrastructure was simply too deficient (Ozawa & Bellak, 2011).

As for Vietnam, the inflow of FDIs has already put pressure on the "creaky infrastructure (power cuts are still common, even in the capital)" ("Plus One Country," 2010; see further Tran, 2009). To make matters worse, "lengthy traffic jams slow down shipments and drive up costs," even while wages are low (Bradsher, 2008). But the Vietnamese government pursues massive infrastructure projects to accommodate incoming capital: above all, development of coalmines and coal-fired power plants of low efficiency (Do & Sharma, 2011). A similar situation prevails in Indonesia, where rampant electricity shortages "discouraging investment" are combatted by means of "a 'crash program' for expansion of base-load capacity through coal-fired power plants" (Narjoko & Jotzo, 2007, p. 162). The island nation has an abundance of the fuel, while supplies of oil and gas are constrained (Hasan, Mahlia, & Nur, 2012).

For India, one economist drew the lesson that FDI can be attracted if labor power is dressed up like in China: "quick to learn," "highly disciplined," wages low (Srivastava, 2008, p. 325). While that description might have already become outdated, the following lesson has not: The main hurdle for larger FDI inflows "is the lack of infrastructure such as power, roads, railways, oil and gas, aviation, telecommunications, etc. There is also a need to improve transport between the metro- and port cities" (Srivastava, 2008, p. 327). The Indian government has vowed to emulate the Chinese model in this regard; in 2010, it approved the construction of a new coal-fired power plant every second day (Petherick, 2012; Srivastava, 2008).

The future of these curves cannot be forecast with any confidence. If massive relocations from China were to transpire, however, they would, in all likelihood, unleash new expansion and integration effects, though a relative increase in carbon intensity would be more uncertain. A collapse of the manufacturing industry in China—a crisis of a scale that would *reduce* its CO_2 emissions—seems highly improbable. But then again EKC curves in reverse have rarely if ever cut actual emissions in the relatively forsaken high-income countries. To stretch the metaphor further, arrows might be shot across Asia by globally mobile capital, upward along the curve of climate change impact, without leaving behind it a Chinese affluence whose impact is *diminishing*. Capital accumulation is precisely a cumulative process, not a zero-sum re-division. Spiraling forward by the drive for maximum surplus-value, it requires fossil energy as the general lever or medium for its extraction—indeed, if there is anything the post-2010 insecurity around China and its Asian rivals demonstrates, it is precisely how unrestrained access to fossil energy is the sine qua none of accumulation. Fossil capital once elevated China to the workshop of the world; whether it will begin to elevate others depends on whether it receives its dues.

Conclusion

The fossil capital hypothesis does not lay claim to explaining all of the emissions growth in China or anywhere else. Neither does it propose a single causal driver behind fossil fuel consumption. More modestly, it suggests a certain chain of causation between globalization and global warming, and it purports to shed some previously wanting light over the emissions explosion of the early 21st century. In our admittedly cursory survey of developments in China, we have found supporting evidence for the hypothesis, but we have made no attempts to delineate exactly *how much* of the Chinese emissions growth can be attributed to the dynamics of fossil capital. The potential fruitfulness of the hypothesis is all that has been demonstrated.

That said, it does appear as if alternative drivers of Chinese emissions—population growth, lifestyle changes, autonomous buildup of the export miracle—account for comparatively small shares (cf. Levine & Aden, 2008). Likewise, the fossil capital hypothesis does seem to have greater explanatory power than any of the five theoretical frameworks initially examined, when it comes to the links between globalization and global warming as they have materialized in the PRC. Carbon leakage has been filled with content. It implies that the exploitation of labor has causal primacy over environmental degradation in the form of CO_2 emissions growth. But if accelerating CO_2 emissions are an epiphenomenon of accelerating exploitation of labor, it is only because fossil energy is the *necessary precondition* for such exploitation, and in light of this, the question of whether the social or the ecological dimension has primacy is perhaps moot. "Fossil capital" denotes a *unity* of energy and exploitation, realized *through* accumulation, in motion since the original transition in early 19th-century Britain.

If the analysis outlined here is broadly correct, any meaningful action on climate change would at some point have to challenge the dynamics of fossil capital as a global phenomenon. That would require, first of all, a sober acknowledgment of the power relations permeating the continuous growth of CO_2 emissions. In some of the literature on EET, one finds pious references to the responsibility we all share, without any particular distinctions: "Although international climate agreements may still be based around the standard IPCC emission inventory methods, the design of mitigation policy must consider the underlying drivers for emissions. Ultimately, *our daily consumption and production decisions drive global emissions*" (Hertwich & Peters, 2009, p. 6419; italics added). In what sense these decisions are in fact "ours" is not clear. The danger here is that continued targeting of the Western consumer as an abstract generality—or, worse yet, Western workers—guarantees the failure of climate politics, even if moving beyond production-based accounting, as the real culprit would be left untouched and unnamed (cf. Newell, 2011). Indeed, the very thought of targeting emissions attributable to global capital as an amorphous but highly centralized locus of power runs counter to the premises of international climate politics, and it is equally absent in most climate research. The distance between what is needed and what is being done—in this regard as in so many others—appears unbridgeable.

As business-as-usual proceeds toward the precipice, the analysis outlined here might contribute to a more critical analysis of the political economy of global emissions flows. The fossil capital hypothesis requires much elaboration. It may be further tested on China as well as other parts of the world where global capital has arrived in recent decades, such as Mexico and parts of Eastern Europe. It might be amenable to rigorous quantitative testing, and inspire research on the micro level– e.g., what are the environmental results of relocating a particular factory from, say, Gothenburg to Shenzhen? Perhaps it might also be applied to other forms of pollution than CO_2 emissions.

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1. On the relation between actual emissions growth and the IPCC scenarios, see Garnaut, Howes, Jotzo, and Sheehan (2008), Raupach et al. (2007), Sheehan et al. (2008). Betts et al. (2011) deviate from the standard interpretation of the IPPC SRES scenarios and argue that recent emissions are within the range of A1FI, the most fossil-fuel intensive scenario.
2. An exception, providing fairly broad and robust support for the PHH, is Spatareanu (2007). Cf. Dick (2010), who finds very weak support; Brunnermeier and Levinson (2004); and the methodological discussion of Ederington, Levinson, and Minier (2005).
3. Cf. "Although growth and structural changes in international trade are important, our analysis does not determine what factors cause these changes" (Peters et al., 2011, p. 8907). While such a limitation is, of course, perfectly legitimate per se, it does leave a major scientific task undone.
4. For an excellent critique of the one-sided focus on consumption in mainstream environmental discourse and a powerful argument for the paramount importance of production, see Foster, Clark, and York (2010, chap. 16).
5. Thus Rothman (1998), who developed the original argument, approvingly quotes Duchin's statement that "most environmental degradation can be traced to the behavior of consumers either directly, through activities like the disposal of garbage or the use of cars, or indirectly through the production activities undertaken to satisfy them"(p. 182).
6. On American job losses following relocation to China, see Bronfenbrenner and Luce (2004). On the attitudes of American trade unions toward China, see Luce and Bonacich (2009).
7. That is, including both actual relocation (Factory X being removed from Country A to B) and more rapid expansion (Company Y expanding production more rapidly in Country B than in A).

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