Capital's Logistical Fix: Accumulation, Globalization, and the Survival of Capitalism

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Abstract
The growth and transformation of logistics have been attributed to a specific confluence of forces that compelled firms to turn their attention to the circulation of commodities in the second half of the 20th century. This article seeks to develop a more theoretically informed account of the logistics revolution by delineating the industry's role in promoting the accumulation of capital and the reproduction of capitalism. Drawing on Marxian geographical thought, I contend that the logistical turn of the past five decades has facilitated a multifaceted "spatial fix" to capitalism's chronic problem of overaccumulation—one that has reconfigured the geographies of circulation as well as production, consumption, and appropriation. This argument has important implications for our understanding of globalization. By enhancing the mobility of both commodity capital and the production process itself, advances in logistics have been an essential, albeit neglected, condition of global economic integration since the 1970s.

Keywords
Logistics, supply chains, spatial fix, circulation, economic globalization, crisis

Introduction

Over the past half century, logistics—the management of the circulation of goods, materials, and related information—has grown into a multitrillion-dollar business with a central role in the functioning of the global economy. The industry's rapid expansion has been accompanied by a far-reaching reorganization of capitalist methods of producing, distributing, and selling commodities. This shift, known as the logistics revolution, has affected virtually all aspects of business since the 1960s. It has entailed, among other

changes, innovations in transportation technology, such as the intermodal shipping container and recent experiments to use drones for package delivery; the development of new built environments, including vast port terminals and high-tech logistics parks; the extension of production lines around the world and their restructuring according to the doctrine of "just in time"; changing technologies, practices, and business models in retailing and warehousing; the explosion of e-commerce; the rise of specialized third-party logistics firms; and new methods of extracting value from workers along the supply chain. At the heart of this "revolution" is a shift in corporate strategy. From its initial narrow focus on transportation and storage, business logistics has developed into a wide-ranging "science of circulation" (Cowen, 2014: 25) responsible for the integrated management of the supply chain as a total system, from purchasing and production to packaging and final delivery.

In light of these developments, scholars are paying increased attention to the booming logistics industry and its role in shaping the conditions of contemporary political, economic, and social life (e.g. Bonacich, 2005; Bonacich and Wilson, 2008; Cowen, 2010, 2011, 2014; Mezzadra and Neilson, 2013, 2015; Reifer, 2004; Sekula, 2002; Toscano, 2011). For Jasper Bernes (2013), the logistics revolution marks a mutation in the structure of capitalism as a whole, one characterized by the absolute prioritization of the principle of flow and, consequently, "the subordination of production to the conditions of circulation." As logistics emerges as an important site of critical inquiry, however, the underlying reasons for this metamorphosis remain elusive. Why did capital turn its attention to the circulation of commodities in the second half of the 20th century? What ends did this reorientation serve? Most writing on logistics has attributed the industry's rapid growth and transformation to a specific confluence of economic and technological factors that compelled businesses to overhaul transportation and distribution systems in the decades following World War II. While this historical-conjunctural explanation is instructive, it overlooks the deeper, structural motives behind the ascension of logistics, which derive from the logic of capital itself. As Marx showed in *Capital*, the history of capitalism is marked by periodic upheavals in the means of transportation and communication. A comprehensive accounting of the logistics revolution, then, also requires us to identify the systemic forces that impel capitalist firms to make investments in the sphere of circulation.

This article seeks to develop a more theoretically informed understanding of logistics and its attendant "revolution" by delineating the specific mechanisms by which changes in the industry have solved problems of profitability for capital. To this end, I bring the conceptual tools of Marxian geographical thought to bear on the ongoing reorganization of capitalist circulatory systems. This approach highlights the profoundly spatial nature of

the work done in logistics: the field's rise and importance, I contend, hinge on its power to produce space in particular ways. The paper's central claim is that the logistics revolution has facilitated a multifaceted spatial fix to capitalism's chronic problem of overaccumulation since the crisis of the 1970s. By remaking the geographies of circulation as well as production, consumption, and dispossession, this "logistical fix" has played a vital role in promoting the accumulation of capital—and the reproduction of capitalist social relations—into the 21st century.

For the growing literature on logistics, the article offers an alternative interpretation of the field's growth and transformation, one that is rooted in the exigencies of capitalist competition and accumulation. This account recasts the rise of logistics as one episode in a much longer history of time-space compression; it therefore serves as a caution against overstating the "revolutionary" nature of recent developments. Moreover, by theoretically grounding the physical movement of commodities in the social circulation of capital, a Marxian geographical approach can help to foster new analytical and political linkages among the moments where value is appropriated, produced, distributed, and realized. Insofar as the logistics revolution has altered sociospatial processes at multiple sites along the supply chain—the extraction zone, the factory, the waterfront, the retail store—the analysis developed here emphasizes the ways in which seemingly disconnected acts of exploitation and dispossession may be intertwined or driven by a unifying logic.

The paper also has important implications for our understanding of globalization. A wide array of scholarship has profitably highlighted the importance of new forms of mobility and interconnectivity in remaking the geographies of capitalism over the past 50 years (e.g. Castells, 2000; Epstein, 2005; Harvey, 1990; R Martin, 2002; Massey, 1984; Sassen, 2001). On the whole, however, this body of literature has tended to focus on seemingly abstract or immaterial forms of circulation—particularly electronic flows of information and finance capital—while taking for granted the problem of physically moving vast quantities of goods and materials through space. This is surprising given that, until recently, the task of planning and executing so many intricate movements posed a major obstacle to the consolidation of global production networks. By enhancing the mobility of both commodity capital and the production process itself, advances in logistics have been an essential, albeit neglected, condition of economic globalization since the 1970s. To foreground the role of logistics in recent processes of global economic integration is therefore to shift the emphasis of globalization studies from instantaneous financial transactions and digital data transmission to the decidedly slower and bulkier flows of goods and materials that, even in today's "information age," sustain human populations, fuel urban growth, and structure the uneven conditions of everyday life.

Beyond its immediate concerns, then, the article seeks to foster a richer appreciation of the *materiality* of global economic restructuring. The processes abstractly referred to as globalization are constituted in no small part by the concrete movement of goods through physical infrastructure networks.

The argument proceeds as follows. The next section offers a brief survey of recent writing on logistics, outlining the various historical factors that this literature has invoked to explain the industry's rise to prominence since the 1960s. In the following two sections I draw on a range of Marxian geographical thought in order to delineate the role of logistics in promoting the accumulation of capital. These sections lay out the mechanisms by which changing practices of circulation have undergirded corporate profitability by equipping capital with new tools for manipulating space. Reading these developments through Marx's writings on transportation and communication, the third section, "Annihilating Space," shows that changing distribution methods have reconfigured the geographies of circulation by facilitating the movement of commodities through space. The effects of the logistics revolution are not confined to the sphere of circulation, however. In the fourth section, "Producing Space," I draw on Lefebvre's notion of the production of space and Harvey's theory of the spatial fix in order to explore two further aspects of capital's logistical turn. First, the logistics revolution has helped to redraw the world map of value production by stimulating large-scale investments in infrastructure and by enabling the globalization of manufacturing. Second, it has expanded the horizons of consumption and dispossession, respectively, by infusing territories with commodities and by facilitating the extraction of cheap raw materials and labor power. Finally, in the paper's brief conclusion, I consider the implications of this multifaceted logistical fix for anticapitalist political projects.

The logistics revolution

Since the 1960s, the field of business logistics has undergone a period of extraordinary growth and change, fueled by innovations in transportation and warehousing, the restructuring of production and management relations, new ways of selling products, and a global assault on labor. In the corporate boardroom, the burgeoning science of logistics management has come to play a leading role in the profit-making strategies of many firms. The revolution in logistics has ushered in what might be called, following Vormann (2015), a new *regime of circulation*: a historically and geographically specific set of networked technologies, infrastructures, protocols, and organizational forms that enable the circulation of commodity capital. As capitalism reorganizes around a sprawling logistics industry, social scientists and humanists across a range of fields are exploring the manifold

implications of this ongoing shift. The ascension of logistics has inspired a diverse body of research in areas such as transportation geography (Hesse and Rodrigue, 2004, 2006; Rodrigue and Notteboom, 2009), global production networks (Coe et al., 2004; Dicken et al., 2001; Henderson et al., 2002; Yeung and Coe, 2014), and cargo mobilities (Birtchnell et al., 2015; Levinson, 2006; C Martin, 2013). The most critical strands of this literature have challenged the prevailing view of logistics as a purely technical or apolitical science, pointing to the field's origins in war and the ongoing acts of violence exacted in its name. Radical theorists have emphasized the role of new modes of logistical calculation in perpetuating the structures of exploitation that undergird contemporary processes of capitalist globalization (e.g. Bernes, 2013; Mezzadra and Neilson, 2013, 2015; Neilson et al., 2010; Rossiter, 2012). At a finer grain, the swell of critical inquiry into logistics has yielded detailed empirical studies of the particular urban landscapes, disciplinary techniques, and labor regimes that characterize today's global supply chains (Bonacich, 2005; Bonacich and Wilson, 2008; Hesse, 2004; LeCavalier, 2010; Sekula, 2002; Waldheim and Berger, 2008). It has also sparked lively debates on the implications of the logistics revolution for worker organizing and anticapitalist resistance (J Allen, 2015; Bologna, 2014; Reifer, 2004; Toscano, 2011).

Within this fast-growing research area it is now possible to discern the contours of a distinctive geographical approach to logistics (Cowen, 2010, 2011, 2014; De Lara, 2012; Gregson et al., 2016; Gutelius, 2015; Hepworth, 2014; Kanngieser, 2013). In various ways, this scholarship has critically interrogated the geometries of power that are taking shape within the transnational circuits of what Anna Tsing (2009) calls "supply chain capitalism." Whereas discussions of logistics within cultural studies and political theory have tended to adopt a relatively abstract, aspatial approach, this body of research offers a reading that pays close attention to the field's space- and scale-making practices. The work of Deborah Cowen (2010, 2011, 2014), in particular, has done much to develop this line of inquiry. In *The Deadly Life of Logistics*, Cowen (2014: 48, 104, 202) argues that the logistics revolution has blurred the geographical boundary between production and circulation, as capital has become increasingly attuned to the possibilities of generating "value added" across global logistics space. These changes have also reworked the geographies of citizenship, as old territorial forms of political organization have been overlain by the networked spaces of global circulation (12). Cowen's interventions have laid the foundations for a potent geographical critique of supply-chain capitalism—a "geographical political economy" of logistics, in Sheppard's (2011) words.

In seeking to explain the growth and transformation of logistics, commentators have cited a number of historical factors that put pressure on manufacturers, retailers, and

transportation providers, particularly in the United States and western Europe, to make investments in the circulation of commodities in the second half of the 20th century. Figuring centrally in these accounts is the economic crisis that beset many advanced capitalist countries in the 1970s. As several writers have noted, the logistics revolution was intimately linked to the 1970s' recession and the global restructuring of production systems that followed (WB Allen, 1997: 108; Bernes, 2013; Cowen, 2014: 42). In the decades leading up to the crisis, capitalist production and distribution methods were highly uneven in their respective levels of development (J Allen, 2015). Taylorist scientific management and the exigencies of wartime production had yielded considerable productivity gains in manufacturing, but transportation, warehousing, and retailing practices were inefficient and backward by comparison. Under these circumstances, the inflationary recession of the 1970s spurred managers to seek out efficiencies in physical distribution, which was regarded as "one of the last remaining frontiers for significant cost savings" (La Londe et al., 1970: 45). Further pressure to control transportation costs came from the oil price shocks of 1973 and 1979, which drove up freight charges (WB Allen, 1997: 108; Cowen, 2014: 42). Meanwhile, record-high interest rates—the US prime rate peaked at 21.5% in December 1980—prompted firms to seek out ways to reduce inventories, given the high opportunity cost of capital tied up in commodity stocks (WB Allen, 1997: 108). Inventory control took on further importance in light of the proliferation of product lines and the growing complexity of consumer tastes, driven in part by new marketing practices (WB Allen, 1997: 108; Bonacich and Wilson, 2008: 12; Bowersox, 1969, 64; Smykay et al., 1961: 3; Sharman, 1984: 72). A final factor was the offshoring of production. Beginning in the late 1960s and especially after 1980, goods producers in the capitalist core countries, their profits squeezed by strong unions and high wages at home, started moving manufacturing capacity overseas, especially to Asia, to take advantage of lower wages and lax labor and environmental regulations (Bonacich and Wilson, 2008: 26–30; Sowers et al., 2014: 120; Vahrenkamp, 2010: 5). This shift set in motion a secular increase in international trade that stimulated the development of new transportation and communication technologies.

If these events provided the impetus that made a revolution in logistics necessary for capital, what conditions made such a transformation possible? Observers have pointed first and foremost to the adoption of the intermodal shipping container, often described as one of the most important innovations of the 20th century (Levinson, 2006; Rodrigue and Notteboom, 2009: 1; Sekula, 2002: 49). The unitized steel box, standardized for commercial shipping during the 1960s and early 1970s, dramatically cheapened and accelerated the movement of cargo. Containerization was one product of a close, and

ongoing, relationship between military and civilian logistics. Another was the embrace of a "systems approach" to physical distribution, which had a profound influence on the fledgling science of business logistics when it found its way into corporate boardrooms in the 1960s (WB Allen, 1997; Cowen, 2014: 35–40; La Londe et al., 1970; LeKashman and Stolle, 1965). The complex total-cost analyses that characterized this new integrated approach to supply-chain management were in turn made practicable by developments in computing technology. Advances in data-processing power and modeling capabilities made possible rapid comparisons of changing freight rates and allowed firms to optimize route choices, facility locations, and order quantities (WB Allen, 1997). More recently, the Internet and satellite communication technologies have enabled the near-instantaneous collection and exchange of electronic point-of-sale data (Bonacich and Wilson, 2008: 9–10). Together, these new techniques and technologies constituted the conditions of possibility for a sweeping overhaul of capitalist circulatory systems.

Through variations on the narrative presented here, the existing literature has characterized the revolution in logistics as a response to the particular challenges and opportunities facing capital in the latter half of the 20th century. These forces converged in the years following World War II and took on greater urgency with the downturn of the 1970s. But the economic, technological, and institutional conditions of the postwar era are better understood as catalysts of capital's logistical turn. Underlying them are the coercive dynamics of competition and the structural imperatives of the accumulation process. Apprehending the deeper logic behind the logistics revolution, then, is a matter of explaining how new methods of circulation have promoted the accumulation and reproduction of capital. Fortunately, this task need not start from scratch: a handful of authors have already pointed to some of the ways in which advances in logistics serve to shore up corporate profits (Bernes, 2013; Bonacich and Wilson, 2008; Cowen, 2014). Their insights, while fragmentary, offer valuable starting points from which to develop a more extensive theorization of the role of logistics in the accumulation process. It is to this task that I now turn.

Annihilating space: Reconfiguring circulation

How exactly has the revolution in logistics promoted the accumulation and reproduction of capital? I have suggested that the answer to this question lies in the industry's role in making and remaking economic space. In this regard, the most immediate and apparent effects of capital's logistical fix have been felt in the sphere of circulation. Over the past 50 years, advances in logistics have ushered in a significant wave of time-space compression

aimed specifically at facilitating the physical movement of goods and materials. Here I draw on Marx's economic writings, particularly the *Grundrisse* (1973) and volume 2 of *Capital* (1978), to show that the kinds of mobility improvements made possible by this reorganization of capitalist circulatory systems—namely, increases in the speed, cost-efficiency, volume, reliability, and flexibility of commodity flows—have their roots in the structural imperatives of competition and the inner logic of the accumulation process.

Among the underlying motives for advances in logistics, probably the most frequently mentioned in the literature is the competitive drive to increase the speed of circulation (Bernes, 2013; Bonacich and Wilson, 2008: 4; Cowen, 2014: 101–102). Capitalist firms have always had an interest in minimizing what Marx (1978: 233–236) called the turnover time of capital—whether by moving goods to market more quickly, by marketing products to promote sales, or by speeding up the production process itself. The logic behind these efforts is straightforward: a company that can manufacture, distribute, and sell a given quantity of products twice as quickly as its competitors stands to recoup its initial investment twice as often and thus to generate twice as much surplus value. In recent decades, large retail chains have exploited this principle to enormous advantage. Walmart's credo of "Everyday low prices" means that the profit margin on any individual item is razor thin; Walmart makes up for these tiny markups with rapid turnover, a strategy made possible by its mastery of logistics (Bonacich and Wilson, 2008: 9).

Marx (1973: 524) famously coined the phrase "the annihilation of space by time" to describe capital's propensity to diminish the friction of distance through periodic revolutions in the means of transportation and communication. His point was that the perpetual acceleration of material and information flows—a phenomenon that Harvey (1990: 240) later reconceptualized as "time-space compression"—is not an accident of history but an intrinsic tendency of capitalist development. While profit-seeking enterprises have always sought to speed up the movement of their commodities, the logistics revolution signals a crucial inflection point in this long-run trend, a moment at which the pursuit of shorter turnover times on the part of individual firms cumulates in the reorganization of the circulatory system as a whole. The standardization of container shipping technology was a key aspect of this industry-wide rationalization. Containerization dramatically reduced the time needed to load and unload a ship (Bonacich and Wilson, 2008: 52). It also hastened the turnover of capital by integrating three discrete modes of transport into a single network: cargo could now be moved interchangeably between ships, railcars, and trucks without needing to be unpacked and repacked at each transfer point.

Containerization not only sped up the movement of goods; it also cheapened it. Herein lies a second objective of logistics. Capital has pursued a range of strategies to further

reduce the costs of circulation since the mid-20th century. At the heart of these efforts is a wide-ranging assault on labor. The labor-saving technologies and new business practices introduced during the logistics revolution have had devastating impacts on transportation and distribution workers, who have been made to bear many of the real costs of cheap shipping in the form of low wages, harsh working conditions, and precarious employment. Longshore and railroad unions have seen their ranks threatened by containerization and automation (Bonacich and Wilson, 2008: 239), while commercial trucks have been transformed into "sweatshops on wheels" (Belzer, 2000). In marine shipping, the proliferation of "flags of convenience"—the practice of registering vessels in countries with weak environmental, labor, and safety regulations—has promoted a global race to the bottom in crew salaries and working conditions (Bonacich and Wilson, 2008: 162–164). Warehouse work, meanwhile, is regularly overseen by temporary staffing agencies, which ensure a steady source of low-waged, flexible labor while also guarding against unionization (De Lara, 2012: 82–83).

Analytically, the transportation industry occupies a peculiar place within the circuit of capital. Marx (1973: 534) considered the transport of commodities to be an integral part of the production process, since "the product is really finished only when it is on the market." From this perspective, the extraction of diamond ore from a mine on a conveyor belt is not categorically distinct from the diamond's subsequent delivery to a store by truck: both movements are required before the final act of consumption can occur, and hence both contribute to the value of the finished product. What distinguishes transportation from other branches of industry is the unique commodity it sells—a "change of location" (Marx, 1978: 227). In other words, the production process is contained in the act of movement itself. If the transport of goods is generative of value, Marx (1978: 135, 227) reasoned, it is also potentially a source of *surplus* value. A railroad engineer is exploited in precisely the same manner as an assembly-line operative: by generating more value for her employer than she is paid in wages. The drive to extract ever-greater amounts of surplus value from transportation and distribution workers is one of the structural forces that has underpinned the modernization of logistics systems over the past 50 years.

There are additional methods of reducing circulation costs, however. One is inventory control. The just-in-time manufacturing model pioneered by Japanese automakers in the 1950s has been extended beyond the factory walls. Management consultants now tout the benefits of "lean" production systems that aim to minimize inventories across the supply chain as a whole. Excess inventories threaten profitability on several counts. Not only do they generate unwanted storage and handling costs; they also act as prisons of value, their lifeless bodies trapping capital in an immobile, and thus unproductive, form. "Finished

goods or raw materials held in inventory," writes W Bruce Allen (1997: 110), "are just dollar bills in disguise being warehoused." Unlocked and invested elsewhere, that idle capital could be generating a return for its owner. The solution is to manufacture products in smaller batches as needed and, as far as possible, to eliminate idleness by keeping commodities in continuous motion. Under the old model of distribution, manufacturers "pushed" goods downstream; surpluses would pile up at various points along the supply chain, and retailers were poorly equipped to respond to a surge in demand for a particular product (Bonacich and Wilson, 2008: 4). By contrast, in today's demand-driven production networks, retailers track consumer behavior in real time and use this information to "pull" new stock from suppliers. The aggressive application of this principle of flow has allowed inventories in some industries to be reduced to as little as 15 minutes' worth (Hesse and Rodrigue, 2004: 174).

Together, these and other measures have proved highly effective in cheapening the circulation of commodities, both for individual companies and for capital as a whole. Walmart's dramatic rise over Kmart since the 1980s, for example, is often credited to its obsession with logistics: while Kmart's focus on marketing often left it struggling to plan and control inventory, Walmart pursued supply-chain efficiencies that allowed it to undercut its competitors (Ballou, 2004: 17–18). In this way, firms that adopted new methods of circulation early on were able to outcompete those that did not, and the practices spread throughout the economy. Across the United States as a whole, transportation and logistics costs fell from about 16% of GDP in 1980 to less than 8% in 2009 (Larkin, 2014: 3). This point, perhaps more than any other, underscores the extent to which new ways of moving goods and materials have bolstered corporate profits since the 1970s.

While the literature has focused on speed and cost, these are not the only impulses behind the logistics revolution. A third is the inherently expansionary logic of capitalist production, which implies a constant growth in the total volume of commodities in transit (Marx, 1978: 329). To accommodate this material expansion, the throughput of freight systems must be constantly augmented. This necessitates, among other things, continual increases in the physical capacity of transport infrastructure and increasingly frequent service in order to move an ever-growing mass of products. When Marx (1978: 327–328) marveled that "freight ships leave Liverpool for New York … on different successive days of the week, and goods trains run at different hours of the day from Manchester to London," he was naming the same tendency that now results in over 300 weekly transits of the Suez Canal and 140 daily flights into FedEx's mammoth sorting hub in Memphis, Tennessee. Once again, within this long-term progression the revolution in logistics

represents a phase of discontinuous expansion—a tipping point at which quantitative increments in the amplitude of commodity flows give way to qualitative changes in the circulatory system as a whole.

A fourth watchword of logistics is reliability. This imperative, too, can be explained by recourse to the metamorphosis of capital. Corporations' interest in ensuring the smooth movement of *goods* has its basis in the need to ensure the uninterrupted circulation of *value*. Capital, after all, is "value in process" (Marx, 1976: 256).[1] If value cannot metamorphose continuously through its various phases (productive capital, commodity capital, money capital), the capital invested no longer functions as such, and the accumulation process grinds to a halt. Harvey (2006: 83, 2010: 336–338) has stressed this point in his discussions of crisis, identifying numerous moments at which a blockage or delay in the circuit may prevent capital from changing its state. In today's just-in-time supply chains, the failure of a single part to reach an assembly plant can bring several downstream operations to a standstill. As a result, even a brief interruption to value's metamorphosis has the potential to precipitate a wider crisis. The drive to preserve the integrity of the circulation process has in recent years fueled the rapid growth of the field of supply-chain security, which aims to protect commodity flows against such disruptions as natural disasters, labor actions, and pirate attacks (Cowen, 2010, 2011, 2014: chap. 2).

A final means by which the logistics industry facilitates the circulation of capital is by enhancing the flexibility, or "agility," of commodity flows. This motive is of paramount importance for Bonacich and Wilson (2008: 4), who write that the "underlying systemic impulse" behind the logistics revolution is "the disjuncture between production and distribution, or supply and demand." Bonacich and Wilson regard the rise of logistics as a response to capitalism's chronic tendency toward overproduction. Manufacturers and retailers face a constant risk that their commodities will have to be sold off at discounted prices or will be unsellable altogether. Logistics thus developed, alongside "advertising, market research, product proliferation, branding, and consumer credit" (4), as a way of bridging the gap between supply and demand.

This explanation, while insightful, underemphasizes the profoundly geographical nature both of capitalism's overproduction problem and of the fix offered by logistics. We

1. Marx is often said to have understood capital as "value in motion," but he never actually used this phrase. The distinction between "motion" and "process" is not insignificant. The former suggests a change in location, while the latter describes a change in form. The metamorphosis of capital does not always entail its physical movement, as is demonstrated by the case of the housing sector. In the logistics industry, however, the two processes tend to be closely intertwined.

have seen that capital, in order to accumulate, must flow without interruption through its circuit. But value does not circulate on the head of a pin: "Circulation proceeds in space and time" (Marx, 1973: 533). In the vast majority of industries, there is necessarily a spatial separation between the production of value in one location (via the labor process) and its realization in another (via a sale). If this geographical disconnect cannot be overcome, and in a timely fashion, the circulation of capital comes to a standstill. Logistics specialists recognized the centrality of spatial and temporal considerations to their work as early as the 1970s:

> In order to have a satisfied customer, the product must have time and place utility as well as form and possession utility. A well conceived product, with optimum packaging and promotion mix that is in the wrong place geographically and not available at the time the consumer needs it, results in a "short circuit" in the successful implementation of the marketing concept. (La Londe et al., 1970: 46–47)

A recent textbook makes this point more emphatically:

> Value in logistics is primarily expressed in terms of time and place. Products and services have no value unless they are in the possession of the customers when (time) and where (place) they wish to consume them. (Ballou, 2004: 13)

Profitability, here, is understood as a function of the firm's ability to rapidly manipulate the spatial coordinates of commodities: to the extent that goods can be hurtled instantaneously through space, supply can be synchronized with demand and the threat of devaluation can be neutralized.

Viewed in this light, corporations' embrace of "agile" or "nimble" supply chains can be understood as a method of opening up new opportunities for the realization of value by dynamically reshaping the spatial pathways through which commodity capital circulates. Many of the new transportation, warehousing, and retailing practices that make up the logistics revolution are underpinned by this logic. In the shipping industry, the relative speed and cheapness of containerized transport, along with its standardized format, have greatly enhanced the flexibility of cargo flows. On short notice, retailers can now reroute merchandise to locations where demand is highest, while shipping lines can divert cargo away from restive longshore unions or covetous port authorities. In the warehousing sector, conventional facilities intended for long-term storage have been replaced by new kinds of spaces premised on the logic of throughput (Hesse, 2004: 163). The latest-generation distribution centers (which replenish nearby stores) and fulfillment centers (which dispatch orders directly to consumers) are sprawling, highly automated facilities that serve to maintain a constant stream of goods into the surrounding market. Walmart's busiest distribution centers operate around the clock and turn over 90% of their contents every day (LeCavalier, 2010). This emphasis on circulation allows firms to respond to rapid shifts

in consumer demand, helping them to keep store inventories at optimal levels and to replenish fast-selling items before they run out. Finally, in the retail sector, e-commerce platforms like Amazon.com reduce the risk of a product's not finding a buyer by replacing the local retail store, with its limited customer base, with a network of fulfillment centers capable of dispatching goods almost anywhere in the world. This business model greatly enlarges the pool of potential buyers for a given item; it also defers the normally speculative work of distribution until the sale is already complete. The computer manufacturer Dell, one of the pioneers of mass customization, takes this logic a step further by not even *assembling* products until after they have been sold. Each of these advancements, by enhancing the flexibility of commodity flows, has improved capital's ability to match supply with demand. The efficacy of such methods has been further increased by innovations in information and communications technologies, including the use of bar codes to collect sales data and radio-frequency identification tags to track shipments (Bonacich and Wilson, 2008: 9), the development of predictive purchasing and distribution models (LeCavalier, 2010), and the use of web analytics to monitor online shopping behavior and engage in targeted marketing.

The numerous changes associated with the logistics revolution, then, have equipped capital with a range of new tools for increasing the velocity, efficiency, bandwidth, reliability, and agility of material flows. While the history of capitalism as a whole is marked by a general tendency to enhance the mobility of commodities, the revolution in logistics represents a sharp acceleration of that trend. The effect has been to further liberate commodity capital from its spatial constraints—"the better to imitate and conform to the purest and most liquid of forms capital takes: money" (Bernes, 2013). The comparison is apt. It is now well established that the rise of finance has shored up corporate profits since the early 1970s (Epstein, 2005; Krippner, 2005), in part by enabling money to circulate quickly into and out of particular firms, sectors, and regions. But what Bernes (2013) calls the "hidden counterpart" to this process of financialization was a massive investment in the circulation of commodities. Both logistics and finance are coordinating mechanisms, employing algorithms and predictive models to allocate capital where the appetite for it is greatest. Critically, because the movement of commodities through space is inseparable from the movement of value through its circuit, the mobility improvements afforded by the logistics revolution have served as vital levers to promote the accumulation of capital.

Producing space: Logistics beyond circulation

The profitability gains made possible by capital's logistical fix do not only accrue within the realm of circulation. At the same time as advances in logistics have helped to stave off capitalism's crisis tendencies by smoothing the movement of commodities through space, they have fostered the development of new geographies of production, consumption, and dispossession. Over the past 50 years, the industry has come to constitute a potent force in the continuous social process that Lefebvre (1991) called the production of space. This has important implications for the perpetuation of capitalism as a whole. In *The Survival of Capitalism*, Lefebvre sought to explain how the capitalist mode of production, in spite of its profound internal contradictions, had managed to persist and even thrive well into the 20th century, over 100 years after Marx predicted its inevitable demise. It had done so, he argued, "*by occupying space, by producing a space*" (Lefebvre, 1976: 21). Lefebvre posited that the accumulation of capital—and, by extension, the reproduction of capitalist social relations—hinges on the creation of particular kinds of spatial arrangements. If capitalism is to endure, in other words, it must fashion landscapes that are appropriate to the production, circulation, and realization of surplus value. Moreover, insofar as the built environment is a locus of investment and an object of exchange, space also becomes enlisted in the accumulation process as capital itself. In both of these senses, the subsumption of space to the needs of the accumulation process has been a significant feature of the logistics revolution. The space-making practices of global logistics have promoted the production, consumption, and appropriation of value in three distinct ways: by diverting idle capital into the production of new infrastructures, by enabling the globalization of manufacturing, and by expanding the geographical frontiers of the accumulation process.

In the first place, changing transportation, warehousing, and sales practices have created new opportunities for the absorption of overaccumulated capital through investments in physical and social infrastructure. One of the fundamental lessons of neo-Marxian economic geography is that in order for some capital to circulate smoothly, some other capital must be embedded in the ground. Indeed, the past half century has seen the development of new kinds of built environments aimed at smoothing the flows of global trade. Containerization, for instance, has led to the overhaul of virtually every link in the cargo chain (Easterling, 1999: 120; Sekula, 2002: 136). Port terminals, rail yards, warehouses, even the turning radii of streets—all these infrastructural elements have been redesigned around the container's standard dimensions. In North America, containerization has influenced the shape of the transportation network on a continental scale, encouraging the development of an intermodal "land bridge" whereby fully loaded containers are imported via West Coast ports and then hauled overland by rail (Bonacich

and Wilson, 2008: 52–54). The free-trade zone is another key "infrastructural technology" (Easterling, 2014: 12) within this emerging nexus of logistical spaces: in its serial reproduction, the zone's routines and protocols have come to organize not only the movement of cargo but also the production of urban landscapes around the world.

David Harvey's theory of the spatial fix provides a framework for conceptualizing the specific mechanisms by which the development of such logistical infrastructures serves to promote the accumulation of capital. The spatial fix, first elaborated in *The Limits to Capital* (Harvey, 2006: chaps. 12–13), refers to a particular way of staving off crises of overaccumulation through geographical expansion or restructuring. Marx had shown that if surpluses of money, commodities, and labor power cannot productively be reinvested within a given territorial system of accumulation, they stand to be devalued, with potentially serious consequences for economic and political stability. However, Harvey reasoned, a "fix" exists in the possibility for some of this overaccumulated capital to be diverted into the development of physical and social infrastructure—what he termed the secondary and tertiary circuits of capital (2003: 109–111). The activity of producing the new infrastructure provides an immediate outlet for idle capital, some of which becomes "fixed" in place through investments in the built environment. Because of the large scale and speculative character of such projects, the spatial fix typically entails considerable state involvement in the form of coordination or financial backing.

Today, the close relationship between the spatial fix and the movement of cargo is perhaps nowhere more evident than in emerging logistics intermediaries like Panama, Qatar, and the United Arab Emirates, which have pursued sweeping infrastructure programs in hopes of consolidating their positions as global goods-movement hubs (Sigler, 2013). In Panama's case, the country recently unveiled a major expansion of its century-old canal in order to accommodate the next generation of ultralarge container vessels, and the national government is investing billions more in highways, airports, and seaports in a bid to leverage the benefits of the enlarged waterway. State spending on logistics infrastructure helped to ensure that Panama's GDP growth rate never fell below 4.0% during the global recession of 2007–2009 (and by 2011 it had rebounded to 10.8%). It is in the growing number of "logistics cities," however, where the industry's place-making practices find their fullest expression. In developments like Dubai Logistics City and Basra Logistics City in Iraq, the same logic of frictionless flow that animates the corporate distribution center and the automated container terminal becomes inscribed in the physical and social fabric of entire urban areas (Cowen, 2014: chap. 5). These spaces function as massive sinks for capital and labor power: Global Gateway Logistics City in the Philippines, for instance, has an estimated construction cost of $3 billion. Thus, as the

logistics industry plays an increasingly important role in shaping local landscapes, it also helps to attenuate capitalism's crisis tendencies by serving as a productive outlet for idle capital.

But the spatial fix also has a long-term component, which points to a second way in which new logistical geographies have promoted the production of surplus value. Following the initial diversion of capital into the built environment through a fix, the new spatial configurations thereby produced can help to restore the conditions of profitability over the longer run (Harvey, 2003: 111–112). By enlarging the geographical basis of accumulation or by bringing capital and labor power into productive new combinations, the spatial fix literally lays the ground for a new round of economic expansion. Herein lies the critical link between the logistics revolution and globalization. The rise of logistics has not merely accelerated and cheapened the movement of commodities; it has also granted unprecedented mobility to production itself. Considered in terms of the circuit of capital, the offshoring process that began in the late 1960s had the effect of widening the geographical divide between the production of value and its realization. If this strategy was to be profitable on a large scale, capital needed to solve a connectivity problem: the emerging production centers in China, Japan, and Southeast Asia had to be articulated with existing consumer markets in the global North by way of rapid and efficient systems of goods movement.

Moreover, it was not only a matter of connecting producers and consumers. As the manufacturing process was disaggregated into phases that were in turn outsourced to discrete firms, production itself became distributed across global space (Cowen, 2014: 103). This trend was apparent as early as the late 1960s:

> It is not uncommon to ship sub-assemblies from one country, raw materials from a second country for final assembly in a third country. The finished product is then sold in the domestic market, exported to a third country and perhaps reimported to the country supplying the sub-assemblies. (La Londe et al., 1970: 48)

As it proceeded, the geographical dispersal of the production process created new challenges for corporate distribution managers. Firms with transnational supply chains now had to coordinate, optimize, and document a vast number of movements of raw materials, intermediate components, and finished products. A further difficulty stemmed from the increasingly flexible, short-term character of post-Fordist production relations. Temporary supply contracts, floating exchange rates, differential wage levels, and changing tax and tariff structures meant that the world map of commodity production had become highly dynamic. Not only was the assembly line stretched around the world; its geography was now constantly shifting.

In short, the increasing geographical scope, complexity, and fluidity of industrial production networks presented capital with what Coe et al. (2008: 276) call a "*logistics* problem." In the absence of new methods of moving commodities quickly and cost-effectively over vast distances, manufacturers and retailers could not realize the profitability gains promised by outsourcing and offshoring. The solution involved not only new technologies, infrastructures, and labor practices but also a radically new perspective on supply-chain management. As noted earlier, large companies in the 1960s began to take an integrated approach to physical distribution, analyzing the complex cost interrelations among various business functions in order to optimize them as a total system (WB Allen, 1997: 110; Bonacich and Wilson, 2008: 3; Bowersox, 1969; Cowen, 2010: 614–615, 2011, 2014: 33–40; La Londe et al., 1970). As W Bruce Allen (1997: 110) explains, "The secret is finding the right combination of inventory, length of production run, level of customer service, and so forth to maximize the profit of the firm as an entity: that is, a systems approach." Integrated logistics management brought new calculative practices to the planning and operation of global supply chains, allowing firms to efficiently coordinate complex flows.

The spatial fix afforded by globalization, in other words, hinged on a revolution in logistics. By consolidating the physical links that mediate between far-flung sites of extraction, production, and consumption, the emergence of a new regime of circulation facilitated the global extension of production networks and consumer markets. In this way the logistics industry has been centrally implicated not only in the production of space but also in the production of scale (see Smith, 2008). The primary benefit of this globalization strategy for capital, of course, has been to enable labor arbitrage on a global scale. In an age of low-cost shipping, industries that were once firmly tethered to the capitalist core are now free to scour the earth in pursuit of ever-cheaper sources of labor. Containerization, lean production, and total-cost analysis have abetted manufacturers in their search for low-waged, unorganized workforces, especially women in the global South. The globalization of manufacturing has enabled corporations to pit workers in different parts of the world against one another by exploiting identity-based differences such as gender, race, and nationality, exacerbating the fragmentation of the international working class (Tsing, 2009). The logistics revolution has encouraged the accumulation of capital on a global scale by redrawing the world map of surplus-value production.

A final way in which advances in logistics have bolstered corporate profits is by improving capital's access to new consumer markets, labor pools, and sources of raw materials and energy, helping to fuel the geographically expansionary dynamic at the heart of capitalism. This observation shifts the analysis from the sites where value is produced to

the spaces where it is realized and appropriated via extraeconomic means. A long line of Marxian thinkers beginning with Rosa Luxemburg (2003) have argued that the ongoing reproduction of capitalism depends on predatory relations with a noncapitalist "outside" in order to absorb surpluses, secure cheap natural resources, and generally lend stability to the system. But that self-enlarging impulse need not be enacted through direct military force or formal colonial rule (though these continue to matter a great deal); it may instead be legitimated through the rhetoric of "economic opportunity" and "emerging markets" and actualized through the geographical extension of corporate distribution networks. Today this process is on full display in Cuba, where hundreds of multinational companies have applied to establish production and logistics operations in the Mariel Special Development Zone, a 465 km^2 free-trade area under construction next to a new deepwater container port (Miroff, 2013). Foreign interest in Mariel has been motivated in no small part by the desire to establish a foothold in the Cuban market in advance of a possible easing of US trade restrictions on the island nation. Similar expansionary tendencies are at play in Walmart's protracted battle to establish a retail presence in Vermont (LeCavalier, 2010) and in the recent construction of a transshipment port in the Canary Islands, off the north coast of Africa (García Herrera and Sabaté Bel, 2009). Bernes (2013) likens such incursions to the offensive arm of global commerce: logistics, he writes, is "war by other means, war by means of trade." Following this analogy, the architects of corporate supply chains operate like military strategists, establishing outposts at key locations in order to conquer neighboring territories in the name of capital. By opening up new extraction zones and by saturating regions with products, the logistics revolution has promoted the penetration of the commodity form into new areas, the dispossession of communal resources, and the dissolution of noncapitalist modes of life. The industry forms a key part of the sociotechnical apparatus that enables the expansion of "commodity frontiers" (Moore, 2015: 53) through processes of appropriation that, in tandem with the exploitation of labor power, are necessary to the continued accumulation of capital.

To recap, the growth and transformation of the logistics industry over the past half century have played a vital role in reshaping the spaces of production, consumption, and appropriation, promoting the accumulation of capital in three specific ways. First, the logistics revolution has encouraged the diversion of underutilized capital into the built environment through the construction of new transportation and communication infrastructures. Second, it has made possible the growth of globally integrated production networks characterized by a high degree of spatial and organizational flexibility and the dense interdigitation of the spaces of production and circulation. Finally, it has facilitated the expansion of capitalism's geographical orbit by improving companies' access to raw

materials, labor sources, and consumer markets that previously lay beyond the frontiers of commodification. In these ways, through the production of new landscapes and spatial relationships, capital's logistical fix has helped to fashion a geographical framework to undergird the reproduction of capitalist social relations into the 21st century.

Conclusion

This paper has characterized the logistics revolution as a period of wide-ranging and discontinuous change in capitalist methods of producing, moving, and selling commodities. This reorganization has facilitated the accumulation of capital by equipping businesses with a range of new strategies for both annihilating and producing space, thereby ushering in an era of unprecedented flexibility in the distribution practices of firms and the geographical organization of production networks. In the sphere of circulation, retailers and manufacturers, driven by the structural imperative to promote the smooth flow of value, have made considerable improvements to the speed, cost-efficiency, throughput, reliability, and flexibility of commodity flows. This new circulatory regime, in turn, has helped to reshape the geographies of production, consumption, and dispossession on a global scale. By encouraging large-scale investments in transportation and communication infrastructures, by making possible the spatial diffusion of manufacturing, and by expanding the geographical frontiers of the accumulation process, the ascension of logistics has played a vital role in forging the geographical configurations that have helped to underwrite the reproduction of capitalism since the 1970s.

The revolution in logistics has been intimately bound up, as both cause and effect, with processes of economic globalization over the past half century. Advances in the industry were a necessary condition of the spatial fix offered by global economic restructuring: in their absence, it is unlikely that globalization would have unfolded as it did. The rise of logistics has transformed not only methods of circulating goods but also the spatial organization of economic activity as a whole, deepening global economic interdependencies and helping to forge uneven geographies of wealth and poverty. By bringing far-flung sites of extraction, production, and consumption into profitable new combinations, the rise of logistics has remade global economic space in ways that promote the ongoing accumulation of capital. Of course, these two processes are mutually reinforcing: as the world economy has become increasingly integrated, so too has the logistics industry continued to change and grow.

While these are powerful forces of change, they are neither unyielding nor inexorable. Logistics remains an inexact science, ridden with tensions and vulnerabilities that can be

leveraged to create new openings for emancipatory political projects. If, as Lefebvre contended, it is through the production of space that capitalism has managed to survive, then anticapitalist critique and praxis have much to gain by directing their attention to the tools by which capital effects its spatial fix. The global logistics apparatus, as a vital instrument in the reproduction of capitalist sociospatial relations, merits close attention from those seeking to challenge contemporary structures of exploitation and dispossession. By highlighting the interconnections between changes in the spheres of production, circulation, consumption, and appropriation, a geographical critique of logistics can help to establish a common basis for social struggles located at diverse sites within the circuits of capital.

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