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Assessing Core-Monopolization and the Possibilities for the Semi-Periphery in the World-System Today

A Case Study of the Semiconductors Industry

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Abstract

Drawing upon both classic and more contemporary world-systems analysis, along with oft-forgotten sections of Arghiri Emmanuel's work on technology, this paper studies, through a quantitative and qualitative comparative method, the history and development of the global semiconductors industry, its selective spatial re-organization/peripheralization over time, and the logic of technology transfers within the context of core-monopolization of high profit industries. The paper then draws comparisons between semiconductors and prior core-monopolized industries like the automobile industry, and analyzes attempts at entry into core-like production by the large semi-peripheries such as China and India and the difficulties faced by them not only by the structural limitations of the world-system but also due to opposition from the core nations (like the U.S.-China Trade War). Resultingly, the analysis concludes that significant upward mobility for the large semi-peripheries through entry into core industries is, within the current capitalist world-system, largely unfeasible.

Keywords: Semiconductors, Semi-Periphery, World-Systems Analysis, East Asian Development, Peripheralization, Technology Transfers, Core Monopolization

> "Semiconductors—small computer chips the size of a fingerprint that power everything from cell phones to automobiles and so much more. These chips were invented in America. Let's get that straight: They were invented in America. And we used to make 40 percent of the world's chips. In the last several decades, we lost our edge. We're down to only producing 10 percent…. We're going to make sure the supply chain for America begins in America—the supply chain begins in America."
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> Joe Biden, President of the United States
> State of the Union Address, February 7th, 2023

The idea that semiconductors and the chip industry hold, in some ways, the key to the future of industry, defense, and technology is not new. The U.S. government realized this fact as far back as the 1960s, when it was practically the sole purchaser and bankroller for the fledgling industry—an era when computing power allowed for little more than a simple calculator. Today, more than half a century later, these chips are a key component in nearly every modern product, from phones, fridges, and vehicles to military drones. Consequently, control over the design, supply, and manufacture of semiconductors has become a matter of prime national importance for states across the globe, and especially so within the context of the tense rivalry between the United States and China in recent years.

This paper analyzes the history and development of the semiconductor industry through the lens of the world-system, with a particular focus on the pattern of its spatial re-organization, the development of its value-chains, the transfer (or non-transfer) of technology, and the industry's role in perpetuating core-peripheral separation. The analysis will then focus on the events of the last two decades to look at the wider trends of this industry and its role in the world-system today alongside the tensions and conflict implicit to a declining hegemon (the United States), its allied core-states (Europe, Japan, South Korea, and Taiwan) and the rising semi-periphery, eager to move into core-like production (China, India). Resultingly, this paper hopes to not only showcase the role of the semiconductor industry as the key monopolized core good in the twenty-first century, but through comparative-historical analysis, highlight the limitations and difficulties for the semi-periphery to enter core-sections of a monopolized industry such as semiconductors, and thereby move into the core itself through such an entry. Finally, the paper also raises doubts over the possibility of upward mobility for the large semi-peripheries in the world-system today.

The Early Development of the Semiconductor Industry

Computing, and the demand for it, arose primarily from the needs of war. The World Wars saw many nations, like the nascent Soviet Union, Britain, United States, and Germany, all push for upgraded and newer weapon arsenals, and they looked towards computation to enable new frontiers in the development of their respective military technologies. Computation, it became clear, could bring about a new terrain of warfare; from guided missiles to satellites, sonars to spacecrafts. The semiconductors industry then began, as many high-tech inventions of this era did, in the Silicon Valley in the early 1960s, propped up by Stanford and Berkeley and funded almost entirely by the U.S. government to ensure its lead in cutting-edge military tech development. Initially, the immensely high cost of production meant that chips were seen as solely military hardware—crucial to develop defense systems in the context of the Cold War. The firm that first produced them, Fairchild, dominated in this period, rapidly multiplying the number of transistors they could place per chip. It was Fairchild co-founder Gordon Moore who observed that the rate at which the number of transistors could be fit per chip seemed to be doubling annually—aptly named Moore's Law, which has remained more-or-less accurate up to the present day. It was Moore, too, who envisioned semiconductors as being something more than simply a military good, and imagined the personal computer and mobile phone as early as the 1960s, leading Fairchild to cut costs and move into the civilian market; and by 1968, the private computer industry was as big a purchaser of chips as the military. By the time the moon landing occurred—guided by Fairchild-powered computers—venture capital funding was flowing rapidly into the industry as new firms emerged, and the industry began to grow rapidly and at an unprecedented rate. (Braun and MacDonald 1978; Lécuyer 2006; Miller 2022)

Before we can continue to discuss the evolution of semiconductor production globally, we must look, if only briefly, at the various specific steps in the process of chip manufacturing—the first, and in many ways, most important stage is the design stage. The process of designing a new generation of chips is one that has squarely remained in the offices of Silicon Valley even as the latter stages of manufacturing and assembly have long been offshored to East Asia—as an example, Apple plays no direct part in the long-winded production process for every new iteration of its phones except the designing of their signature high-power chips, and of course, the software. This design stage requires the input of highly-qualified researchers, engineers, scientists, and technicians, and is therefore almost always done "in-house." Importantly, the design stage includes all of the most R&D heavy sections—core IP; chip design; electronic design automation; advanced machinery. The next stage, that of fabrication or manufacturing of chips, is by-far the most capital-intensive stage. Machinery to fabricate and produce these intricate chips have always cost ludicrously large sums—even as far back as 1982, a single electron-beam etching machine cost upwards of a million dollars. Today, setting up an advanced fabrication plant costs upwards of the tens of billions of dollars (*Reuters* 2017). Once the chips have been fabricated, components have to be assembled and packaged. Initially this was a largely manual process, done by hand by assembly-line workers, though automation has permeated in various forms in this sector in the years since. The final aspect, that of testing, also requires specialized machinery to subject products to proper testing, and is relatively more capital intensive than assembly.

Two primary factors made semiconductor production especially viable for globalized production—The extremely high value-to-weight ratio, which made cross-oceanic transport of semiconductors economically feasible, as well as the presence of clearly separatable steps of production, each of which have wholly different infrastructural and labor requirements. Unsurprisingly, then, the semiconductor industry was among the very first to become truly global in nature, with offshoring beginning well before the generally accepted dates of the "dawn of neoliberalism," and its accompanying global restructuring of labor, usually placed somewhere in the 1970s (Harvey 2005). Until the early 1960s, assembly and testing tasks were done primarily by American women, who worked for lower wages than men, and were considered overall more suitable for the labor required. As the industry rapidly grew, however, so did the need for labor—cheap labor, the type that one simply couldn't find in a core nation like the United States. By as early as 1963, Fairchild realized the potential in offshoring these labor-intensive tasks and began operating out of Hong Kong, where low wages meant they could hire qualified engineers to run assembly lines, something unthinkable in the United States; and in its first year of operations, their Hong Kong facility produced about 120 million devices. This trend was quickly adopted by all the major players in Silicon Valley, and assembly lines were opened up across Asia, with Taiwan, Malaysia, Singapore, and South Korea being the most important ones. Semiconductor production had been well and truly globalized (Braun and MacDonald 1978; Flamm and Grunwald 1985; Miller 2022).

World-Systems, Technology Transfers and Core Monopolization

The development of a global supply chain allows here proper the introduction of a world-systems analysis. The question remains however—what makes the world-systems approach specifically useful in studying the semiconductor industry? The popular and mainstream capture in wider academia and other institutions (like the IMF or World Bank) of supply-chains based analysis has meant that most analysis in this method is routinely devoid of critical engagement with the basis of global stratification, the history as well as the patterns of surplus extraction, and reproduction of economic inequality innate to global supply-chain systems, especially in the twenty-first century, despite its origins lying in the work of scholars whose works are unquestionably critical and mindful of the same (see Grinberg 2016). The analysis that follows seeks to hold true to the radical anti-capitalist critique that world systems analysis and global value-chain analysis originated with, which has begun to regain traction in recent years (see Smith 2016; Suwandi 2019; Ricci 2021).

The world-systems perspective separates the capitalist world-system into two broad categories; the core and the periphery. These are defined by an economic relation: "Core activities are those that command a large share of the total surplus produced within a commodity chain and peripheral activities are those that command little or no such surplus" (Arrighi and Drangel 1986: 11–12). Furthermore, as Wallerstein puts it, supply chains result in "'core' processes in 'core' areas—and more and more of the processes that require less skilled and more extensive manpower that is easiest to keep at a low-income level in other areas – 'peripheral' processes in 'peripheral' areas" (Wallerstein 1984: 5). From this follows the logic of early offshoring of the United States' semiconductor industry. Assembly of the chips, the step of production with the highest pure manpower requirement, and also the lowest demand for skilled labor or capital investment, was perfect for offshoring to then peripheral East Asia, which had a large, cheap, and suitably trained labor pool; and, importantly, had governments in place that were close allies of the United States, and resultingly readily agreed to subsidies and agreements with American corporations that guaranteed "well-disciplined" cheap labor and steady profits and benefits for all involved. (Arrighi, Hui, and Hung 2003)

In the overview so-far of the historical development of semiconductor production, one important nation has been missing—Japan. It is in many ways Japan's attempt in challenging the United States that led to this early offshoring of production. In the world of electronics, Japan, from as early as the 1950s, emerged as an important player, mainly producing simple transistors for the domestic market—though Japanese producers such as Sony had to license the rights to produce them from American corporations. In this early period, a symbiotic relationship emerged; Japan essentially produced creative, low-end accessible consumer goods using simpler chips while America produced the very cutting-edge, and this relationship was strongly endorsed by both governments across the pacific (Miller 2022).

By the 1980s, however, this balance began to break, and Japanese firms quickly emerged as a direct rival—and not just a friendly co-operator—to American semiconductor production. Dynamic Random Access Memory (DRAM) chips, now a crucial component of a varied number of devices, saw Japanese firms producing chip hardware that rivalled, and in many ways, outdid, American capabilities. The transfer of technology and knowledge to a strategic ally that began as a policy decision in the days of post-war military occupation had, less than 40 years later, led to the emergence of a direct rival. What explains this process?

In his work on technology and underdevelopment Arghiri Emmanuel (1982) highlights a few central conceptions; primarily, that the most capital-intensive processes utilize the most capital-intensive technologies (in Emmanuel's conception, "technologies" constitute everything from conception of a product, to knowledge and techniques of production, to the management systems that organize production, and is the way this paper will use the term as well) to in turn maximize the quantity of products that can possibly be produced and thereby provided to a country's populace, correlating directly to the standard of living in any particular nation. Clearly then, the highly developed technologies of the core are a crucial factor that maintain the hegemony of the core nations while the poorer nations of the world are left at an impasse—owing to the world-system and its inherent polarizing nature—and are simply unable to follow the historical and developmental trajectory of the core nations to achieve the same level of technological proficiency. Neither, however, can technologies simply be transferred and handed off to suddenly bring about a rapid development in the periphery: after all, building semiconductor fabrication plants in Afghanistan today would not do much, where would the engineers and technicians required to maintain and apply such technology come from? The application of a high-knowledge highly advanced technology to an underdeveloped area, argues Emmanuel (1982), is quite unlikely to lead to long-term technology transfer, and therefore will only prevent the proper domestication of these technologies.

The core, almost by necessity, must then seek to protect these technologies from reaching the periphery. History, however, paints a more nuanced and complicated picture. A great deal (importantly, however, not all) of technology has, in various forms, unquestionably migrated out from the core, especially so in the realm of semiconductor production. Emmanuel (1976) himself, writing in the context of the era of the market liberalization of the Communist Bloc, argues that the only realistic way for a peripheral nation to gain access to core technology is by attracting core capital investment (MNCs) through favorable national policies. In this remains an otherwise oft-forgotten Emmanuelian perspective: capital's logic is driven solely by the profit motive—capital thus can very well ignore political differences and ideologies in the pursuit of profit, and resultingly while nation-states might be outward opponents or allies of each other, their respective "capitals"[1] might seek outcomes that stand contradictory to their national political goals in the pursuit of the maximization of surplus.

In the case of the transfer of knowledge and technology to Japan, though, we see a clear explanation—the post war leadership of the United States, eager for allies against the Soviet Union and the larger tide of communism, sought to foster the state of Japan militarily, economically, and technologically, and resultingly allowed Japanese capital to access American technologies. In doing so, the United States unexpectedly enabled the creation of its biggest economic rival. Firms operating in Japan, crucially, were eased into their technology transfers. Japan's rise and challenge to American production in the 1980s remained squarely in the domain of the more low-end segment of the semiconductor market (memory chips such as DRAMs)—which have relatively lower skill requirements, unlike microprocessors or ASICs (Application-Specific Integrated Circuits)—where productivity gains were witnessed from technology innovation. Here the larger productivity gains were witnessed from improvement in process technology, creation of economies of scale, and from the process of shop-floor improvements as well as learning and trial-and-error (Cho et al. 1998; Ernst 1998, as quoted in Grinberg 2016). By 1986, Japan had the largest market share in the global semiconductor market, and Japanese producers were under constant intellectual property lawsuits from American corporations, largely to no avail (Cho et al. 1998; Miller 2022). This dramatic rise of Japan in the industry, however, was short-lived. By as early as 1993, Japanese domination was already seemingly over, with challenges from above and below—American firms regained their domination of the high-end sectors of the industry while South Korea had begun to rapidly capture Japan's role as a leading DRAM producer.

The relationship between the United States and Japan and in-turn Japan and South Korea studied through the lens of technology transfers and the peripheralization of production provides various insights into the possibilities of development of nation-states within the world-system. The United States, as described earlier, enabled the rapid industrialization and core-like production for which Japan became prominent by the 1980s. A central requirement to move into comparatively capital-intensive core-like production is to have a skilled enough workforce, and additionally and importantly, to dismantle in some form the prior dominant labor-intensive production generally widespread in peripheral zones of the world-system. As early as the 1960s, the Japanese Ministry of International Trade realized that for Japan to truly develop would require not only an outward expansion but also a complete restructure of the domestic economy and resultingly in 1965, Japan and Korea reached an agreement as part of the Japan-Korea Normalization Pact—Japan would

[1] Emmanuel actually argues that national and foreign capital are no different from each other, see Emmanuel (1976)

subcontract to South Korea its labor-intensive, lower value-added export-oriented processing industries (Castley 2016).

In addition to this restructuring, the United States' tariff war against Japan in the 1970s meant that a significant market was closed off to Japanese producers. It was this requirement for a strong market, one that could purchase Japanese goods in addition to being the site of off-shored Japanese production, along with historical closeness of national elites and geographical proximities, that led to Japan's policy of enabling South Korea's rapid industrialization—fueled by Japanese capital goods (see Chibber 2003; Castley 2016).

What follows is a process emblematic of the peripheralization of core production. Japan, first, moved into industries such as car manufacturing by the 1960s—an industry prior monopolized by the core—and offshored its textile production to South Korea, enabling rapidly rising wages and core entry for itself. Then, in the following decades, Japan moved the majority of its heavy manufacturing industries (now, too, peripheral and uncompetitive owing to those aforementioned rising wages as well as global shifts in production) to South Korea. The Japanese, who saw no threat from Korean industry owing to this "exit-and-relocate" strategy, quickly enabled technology transfer at astonishing levels—in 1974, Japan accounted for almost 85 percent of technology supplied to the Korean electronics industry (Castley 2016). Additionally, the favorable linguistic affinity and geographic closeness meant that Japanese technicians and engineers were taking major roles in assisting Korean firms in setting up new manufacturing centers and factories. This meant, then, that Korea had little need for domestic R&D and, through direct technology transfers, it was able to penetrate into higher-value commodities like semiconductors that otherwise would have remained an impossibility for what was earlier, by practically all metrics, the less-developed of the two Koreas.

In Taiwan, much like in Korea, an overall similar pattern occurred. Both these nations began at the low-value assembly side of semiconductor production and through direct technology transfer and a multi-decade upskilling in the labor force, were able to move up in the global division of labor, and primarily through their entries into ever-higher value sections of the electronics industry, these nations were able to secure for themselves overall higher wages and thereby entry into the core. Taiwan has gone on to become a leader in chip fabrication, gaining major dominance in that section of production from the 1990s onwards. Nonetheless, contrary to the mainstream position held that these nations became rich through ingenious state-led developmentalist efforts, I hold that these are merely cases of "promotion by invitation" not too dissimilar to how Wallerstein (1979) first described it, where a prior semi-peripheral or peripheral state, through favorable geopolitical conditions, is allowed to enter core-like production.

Importantly, the rise of the "Asian Tigers" that occurred in the twentieth century did little to disrupt or change dramatically the larger world-system. The world-system, and the relation central to the core-periphery model implies, in comparative terms, that it is a zero-sum game. After all, the core-periphery dichotomy exists only in relation to the other, and therefore the more that a particular zone or state becomes core-like, the more the other becomes peripheral (Wallerstein 1985). The reason the dramatic rise of these nations made little change to the grander functioning of the capitalist world-system is explained by the following: first, they are all small nation-states, with relatively small populations, whose rise into the core could be absorbed easily by the periphery; and second, they posed no challenge to the overall hegemony of the dominant core state, the United States, and are on the contrary its junior partners. It is with this context that the escalation of geopolitical tension in the last decade will be examined now.

The Semiconductor Industry of the Early Twenty-First Century

In the early 2000s, we notice broadly a few trends in the semiconductor industry. First, the "fabless" model—where chip companies don't produce or fabricate their own chips—became an industry standard, something which just a decade prior had been considered almost blasphemous. These companies often ignore entirely the fabrication stage and stick solely to R&D, design, sales, and software, and include names like Apple or Nvidia, the latter of which began with this fabless model in mind. Pertinent to my analysis here is the fact that since the dawn of this fabless trend in the industry, it is largely American corporations that have the privilege of being fabless—in 2004 nine out of the ten biggest fabless companies were based in the United States, and in 2020 seven of the top ten remain American (Brown et al. 2005; Trendforce 2021). U.S.-based corporations still hold a significant monopoly in the design side of the industry through intellectual property protections, electronic design automation and so on—the most profitable and capital-intensive section of semiconductor production (Abrams 2013; Varas et al. 2021). Consequently, this led to a drastic shift in the global structuring of the industry at the end of the twentieth century. East Asia has become the location of the majority of fabrication processes, dramatically investing and specializing in cutting-edge fabrication. Lastly, we see the entry of China as a growing center for the remaining steps: assembly and testing.

From a world-systems perspective, China and the East Asian phenomena prior have both been studied and analyzed by a wide range of authors (see Arrighi 2007; Hung 2009; Li 2009, 2021; etc.) that cover everything from the entry of China into the capitalist world-economy, to its practices and methods of participation in it, and each scholar has put forward their own thesis on what China's rapid growth within the world-system means for capitalism's future. For my analysis here, however, I work with the following basic premise: that China entered the modern world-system as a largely peripheral nation, and today, despite its massive economic growth and increasingly exploitative relationship with large parts of the periphery, China is still only semi-peripheral, with significant unequal exchange with the core (Li 2021). Unquestionably, though, the Chinese state and bourgeoisie maintain strong ambitions of entry to the core.

China's foray into semiconductors production, then, began in truth before the market reforms of the post-Mao era. In the 1960s, China developed indigenous though comparatively technologically primitive semiconductors, and its industrial output of advanced electronics as a whole remained miniscule compared to its American, Japanese, or even Taiwanese counterparts; as Chinese semiconductors were designed, developed, and produced independently of much of the global market. The market reforms throughout the tail-end of the twentieth century didn't see significant improvement either. China's domestic production could do little to compete with the cheap imported chips that flooded Chinese markets after the opening-up of the economy, and during this era Chinese semiconductor firms continually failed to make a mark even domestically. Moreover, a majority of production lines were dependent on technology that had to be acquired from the West, and delays and blocks in these acquisitions meant that Chinese production remained far behind the capabilities of American (and U.S.-allied) corporations, which faced far less trouble accessing cutting-edge technology. Despite the rapid growth of China's overall economy and its definite establishment as "the world's factory," it had failed entirely to become the world's factory for semiconductors, owing both to the aforementioned technology acquisition blocks as well as the lack of skilled engineers or technicians. Throughout this period the sustained growth in domestic demand for semiconductors in China was placated through imports, with domestic production having minimal importance (He 2021).

By the turn of the century, however, Chinese policy makers realized the importance of a capable domestic semiconductor industry—both economically and militarily—as well as the weaknesses of its own heavy dependence on foreign imports for what was increasingly becoming an industry as important as steel or oil. China's tenth five-year plan (2001–2005) designated semiconductors as a "pillar industry," and delineated investments of nearly $20 billion into the industry over this period, with state officials stating their goal of surpassing Taiwan as the world's hub for semiconductors. Additionally, beyond the government investment into manufacturing infrastructure for the industry, cost incentives meant that labor costs were between an eighth to a tenth of those in Taiwan, water supply was 60 percent less expensive, and gas 30 percent less. Tax incentives allowed semiconductor firms to avoid tariffs, and additionally pay merely a 3–4 percent value-added tax in comparison to the 17 percent tax on imported semiconductors (Klaus 2003). During this period, then, we see finally the emergence of competent domestic firms in China, most notable being the state-owned Semiconductor Manufacturing International Corporation (SMIC), a pure-play fabricator (a firm that only takes part in the fabrication of chips) which was China's own version of the Taiwan Semiconductor Manufacturing Company **(**TSMC), already by then the world's largest pure-play fabricator. This comparison is not merely one for ease of understanding—SMIC was sued for IP and patent theft by TSMC and lost. This rapid growth in the first decade of the 2000s, however, did little to enable China to catch up with the rest of East Asia or the United States. China's domestic firms remained firmly in the low-end of its domestic semiconductor market, and China's reliance on foreign imports only continued to grow (He 2021). Despite significant state-led efforts as well as otherwise favorable conditions, China remained in lower end fabrication and other low-value sections peripheral sections such as assembly and testing throughout this period.

Peripheralization of Core-Industries: Semiconductors and Automobiles

In the prior section, we have seen the story of China's attempts to enter the semiconductor industry, and the significant challenges it faced in moving beyond the low-value sections of semiconductor production. As shown earlier, more than 50 years after the industry's birth, semiconductors still remained squarely a core industry with little space for entry except by invitation. Yet, the peripheralization of core industries is a natural, almost unavoidable process of the capitalist world-system. Core production, by its innate properties, generally exists as a quasi-monopoly; and in concrete terms this quasi-monopoly is held through the gatekeeping of technology, intellectual property laws, and access to the requisite skilled labor necessary for cutting edge production. Peripheral production, on the other hand, is, in Wallerstein's description, that which is "truly competitive" (Wallerstein 2004: 28). This dynamic between monopolized and peripheralized sections of production (which correspond respectively to highly profitable and barely profitable sections) in addition to other dynamics like core-peripheral wage differentiation is among the chief mechanisms of the flow of surplus value across the world-system. Once the quasi-monopoly is broken, and other producers across the global market begin to compete and undercut profit margins, there is usually a spatial relocation of this declining (in terms of profitability) ex-core industry into the semi-periphery and eventually possibly even the periphery, by which time that particular product is now wholly a peripheral one.

I have established already, in various forms, that semiconductors remain today a highly monopolized industry with only a select few corporations from a select few nations capable of participating in its supply chains, especially in the higher value-added processes such as design and fabrication. The degree of monopolization in the highest value-added sections is even more staggering—the very cutting-edge chips today are largely produced almost entirely by one corporation, TSMC, based in Taiwan. In fact, TSMC's operations in Taiwan account for 92 percent of the world's most advanced chip production (Varas et al. 2021). TSMC, however, is, as discussed earlier, purely a fabricator—it does not design chips but rather provides manufacturing services for "fabless" tech companies such as AMD, Apple, and so on. The design and overall pre-manufacturing stages are deeply monopolized too, with U.S. and European firms holding a 94 percent share of all electronic design automation and Core IP (Varas et al. 2021). In other words, the most capital-intensive, technology-intensive, high value-added sections of semiconductor production have already been neatly divided up by the core corporations and states. It is unsurprising then that the section with the largest non-core presence is the assembly, packaging, and testing section, the least profitable and value-added step; though the combined presence of all non-core non-China regions still amounts to a mere 12 percent share, with China's share being 38 percent. (Varas et al. 2021)

Before I analyze further this present state-of-affairs and predict future trends in the industry, we can compare the historical trajectory of semiconductors to prior core industries. The automobile industry, in many ways the vehicle upon which American hegemony took hold globally, is a useful comparison. The first mass-produced vehicle ever was the Ford Model T in the very early twentieth century, the production of which pioneered what is commonly referred to as the "Fordist" assembly line practices, and it brought automobiles to the wider public through the production of a staggering 15 million units throughout its production cycle (Williams et al. 1992). Ford, much like Fairchild, was a pioneering American corporation that birthed an entire industry. By 1921, Ford's Model T had a 60 percent market share in the global automobile industry, a significant monopoly (Bharadwaj 2018). By the end of the 1920s, Chrysler and General Motors, both American as well, entered the picture and together with Ford they dominated the automobile industry for decades, collectively referred to as the "Big Three." This early era of American dominance was built on petrol-engine based vehicles. The development of the diesel engine, then, in the 1930s, came as a major game-changer over time, with its early adoption by many up-and-coming competitors such as Citroen in France, Mercedes-Benz in Germany, Fiat in Italy, and Rover and Austin in the UK over the following decades (Bharadwaj 2018). The simple adoption of this new technology was alone insufficient, though, in immediately breaking the hegemony of the American Big Three, which continued through to the 1960s.

Much like the semiconductors industry, automobiles too were in many ways globalized early, initially primarily through licensing with local companies in other countries to enable ease of sales to customers there. Ford, for instance, entered the British market with a wholly-owned subsidiary as early as 1911 (Sturgeon and Florida 2000). In the following decades another major motivation for the globalization of production arose—transportation costs as well as tariffs on completed vehicles. The urge to reduce transportation costs as well as avoid heavy tariffs on complete vehicles led to the development of CKD (completely knocked down) kits, which contained most parts required for a complete vehicle, and were produced at "home" before then being sent for assembly to factories near or in the location of sale. This meant, then, that Model Ts in England and the United States were the exact same—both had parts manufactured in the same factory in Detroit—except when assembled in England, it was adapted to right hand drive, as is common there (Sturgeon and Florida 2000). This process of offshore assembly continues up to the modern day.

Major historical events were responsible in many ways for the weakening of the American Big Three. The Second World War allowed for the development of domestic automobile industries in much of Europe and Japan. In Nazi Germany, the state's *Motorisierung* policy meant that the Volkswagen began to mass-produce vehicles for the common man; and similarly in Japan, where Ford and GM dominated prior, the Imperial Japanese government passed various laws that by the onset of World War II had forced American firms out of Japan, enabling Toyota, Nissan, and others to step in and fulfil domestic demands. Post-World War II damages and restrictions (in varying degrees in Europe and Japan) meant that in the first two decades of the post-war era, American hegemony only strengthened globally, and producers across Europe were left to manufacture for—at best—their own domestic markets. It was the dramatic spike in the cost of petrol and the Oil Crises of the 1970s, along with rising public awareness regarding environmentalism that caused a sudden rise in the demand for smaller, diesel-powered, fuel-efficient vehicles that were being built in Europe and Japan (Bharadwaj 2018). In addition, invitations by governments in the semi-periphery such as Brazil, Argentina, South Africa, Mexico, and so on to set-up both integrated production of older models as well as CKD assembly factories were taken up by European and Japanese competition following in the footsteps of the earlier offshoring practices of the American Big Three (who actually offshored to fellow core nations initially). These shifts, combined with a massive wage-differentiation between the highly unionized American workers and the relatively low-wage labor in countries like Japan meant that non-U.S. manufactured vehicles were much cheaper to produce and purchase. By the end of the 1970s, the era of United States' sole dominance was over (Sturgeon and Florida 2000).

The next dramatic shift in the automobile industry, then, came at the turn of the century. In 1997, the core nations of Europe, the United States, and Japan produced over 75 percent of the world's automobiles. By 2009, this had fallen to half (Bharadwaj 2018). As of 2019, Asia (minus Japan) outproduces Europe, the United States, and Japan combined (OICA 2019). China alone produces over a quarter of the world's automobiles as of 2019, when two decades earlier it was far outside even the top five producers (OICA 1999). It is not just China that has so dramatically entered the world stage in the automobile industry; nations such as India, Mexico, Brazil, and Thailand find themselves among the top producers of automobiles globally today. The manufacturing of automobiles, once the crown-jewel of America's golden post-war years, is now done by much of the poorer nations of the world. The production and assembly of simple mass-manufactured vehicles had simply ceased to be profitable enough in the core, and low-wages, automation, reduction in skill requirements and favorable state policies all meant that general production and assembly could viably be off-shored (Humphrey 2003). The core nations now focus on R&D and other "knowledge" based or capital-intensive sections, as well as high-end luxury vehicles, and offshore the less profitable sections of production. Regardless of this spatial restructuring of production, the ten largest automobile companies continue to be from the core though their production processes largely remain in the semi-periphery or integrated peripheries. Work on analyzing the automobile industry through a world-systems/global value chains lens has been done by a myriad of scholars (see Mordue and Sweeney 2019 for an overview), who correlate levels of foreign ownership of automobile production, the absence or presence of domestic automakers, as well as the rate of cost of production in order to separate countries into the automobile core, semi-periphery, and periphery. The result, crucially, that scholars working on the automobile semi-periphery draw is that it is highly unlikely that the semi-periphery can ever shift from the labor-intensive manufacturing to high-technology knowledge-intensive sections that are characteristic of core or core-adjacent automobile industries (Mordue and Sweeney 2019).

In sum, the automobile industry and the semiconductor industry have some important similarities. Both were world changing industries—before the dawn of the automobile, transport was primarily on foot or on horseback, and before semiconductors the smartphone or the personal computer didn't exist. Both industries began in the core (specifically the United States), both saw an extended period of American dominance following which other core nations managed to enter various leading positions in production, and even today the majority of technology, production, and ownership in both industries is in the hands of a handful of core corporations headquartered in core nations. There are significant differences as well, however. The semiconductors industry, relative to the automobile industry, is a *much* more capital-intensive industry, and this is demonstrated by the magnitudes higher ratio of R&D investment made by firms in the first compared to the latter. The cost of entry for the fabrication of semiconductors is prohibitively higher than the setting up of practically all steps of the production of automobiles. Another major difference is the importance of the economy of scale in productivity as well as the staggering difference in the rate and speed of the development of newer and newer models built on similarly newer and newer equipment and technology. A car manufacturing facility with only minimal upgrades can function for much longer producing top-end vehicles, whereas each new generation of ever-smaller chips requires dramatic machinery and wafer upgrades and replacements. IP protections in addition to these costs makes the entry of poorer nations and their corporations into any stage of the semiconductor industry aside from assembly and testing extremely difficult. In automobile production, however, over the last two decades, we have seen the entry of multi-national corporations based in nations such as China and India, like Geely or Mahindra respectively, that are participating in relatively higher value-added sections of the automobile industry and are able to export production, processing, as well as finished products to more peripheral markets in Asia and Africa. In addition, they are able to pay wages domestically that far outweigh the wages of those engaged in other peripheral production (though they employ only a miniscule percentage of the total workforce), a key mark of a relative core-like practice, especially within the semi-periphery. Automobile manufacturing, today, is generally a much more common sight in the semi-periphery than the core, while semiconductors at every stage of production remain still a crucial core-monopoly. The automobile industry has been described as dynamic, with frequent spatial reorganization (Mordue and Sweeney 2019), whereas the semiconductor industry has only further entrenched the status quo of its spatial organization throughout the twenty-first century. Will semiconductors ever witness such dramatic spatial reorganization? The question of the possibilities of the peripheralization and spatial re-organization of semiconductors will be dealt with in the next sections.

Semiconductors and a New "Cold War"

China has, through its economic reforms and embrace of capitalism, held two seemingly contradictory visions. It has, unquestionably throughout the last few decades, tried to invite foreign capital and investment into practically every sector of production in China. The Maoist period led to the presence of a relatively well-educated and skilled workforce, along with technological capability and low wages in a manner unseen in other peripheral or semi-peripheral states of the late twentieth century (Li 2009), which made China especially favorable for manufacturing and other labor-intensive low value-added processes when it entered the capitalist world-system proper. China's immense labor pool (larger in its totality than the core's entire labor pool) meant that such a spatial re-organization could be done without significant global wage inflation. These factors cumulatively meant that in China, and similarly—though at a smaller scale—in India and Indonesia, among others, foreign capital began to play a major role in "development." China, however, has held ambitions for much more than simply being the world's factory. Chinese policy makers, aware of the size and importance of not only their own labor pool but also its growing domestic market, have maintained strong regulations and restrictions for foreign capital in certain sections of the economy; usually those sections deemed of interest to national security, with software being a prime example. China has developed a domestic online ecosystem, with Weibo, WeChat, and Baidu replacing Facebook, WhatsApp, and Google for Chinese netizens. This policy of the suppression of foreign software corporations and the promotion of an independent Chinese-made online presence is, of course, part of the ambition for a counter-U.S. hegemonic project and a reduction in dependency to the West. All this software, however, must still run on hardware, and most cutting-edge electronics were and are still being produced by the United States and its allies.

China has, in many ways, attempted to break its dependency on the intellectual property held by the West. In 2001, the Chinese state funded the ARCA (Advanced RISC Computer Architecture) project, which was an attempt to produce a domestic Central Processing Unit (CPU) that could break Intel's dominance in the CPU market. Additionally, this CPU was designed to work with Linux, an open-source operating system, to evade Windows' hegemony in the operating system space. While the ARCA line of chips functioned perfectly well, the Linux operating system that came with it was completely incompatible with widely used Windows software products such as Microsoft Office. This led to a boycott of the CPUs by various government agencies and institutions, who complained about functionality as well as poor user experience (He 2021). This led to the ARCA project being abandoned, along with other similar indigenous development plans.

It comes as no surprise, then, that as Chinese firms now hope to compete globally in the realm of artificial intelligence, cloud computing, and other such high-tech sectors, the demand for semiconductors continues to grow. The issue of dependency remains, however, with Chinese data centers running on Intel and AMD's CPUs; and with no major Chinese Graphical Processing Unit (GPU) producer, this market too is dominated by AMD and Nvidia (Miller 2022), all of which are American corporations. The rapid growth in the demand for semiconductors in China today has made it the world's biggest market (China and the United States roughly account for a quarter each of global semiconductor sales), and China has resultingly restated, repeatedly, self-sufficiency in semiconductors to be a primary goal (Varas et al. 2021).

In the last decade, China has followed a policy of enabling technology transfers and international acquisitions to enable entry into cutting-edge semiconductor production. In 2014, the National Integrated Circuit Industry Investment Fund and the Outline of the Program for National Integrated Circuit Industry Development by the State Council marked a new era of state endorsement for the industry. The program included, importantly, the goal of achieving an advanced level at each and every step of semiconductor production, from design and core IP to fabrication to assembly and testing. Through equity investment the fund put most (63 percent) of its capital in memory chips fabrication, with the remaining distributed among the other steps of production such as design and testing. On top of this domestic expenditure, the fund enabled acquisition of foreign firms, such as China-based JCET acquiring Singaporean STATS ChipPAC, one of the world's biggest chip packaging firms (He 2021). In addition to this, China attempted to gain access to core technologies through deals with competitors of industry-leaders that would see them exchange technology for increased market access. IBM, once a close partner of the U.S. military, announced in 2015 that it would open its chip technology to Chinese partners, and in exchange for this technology transfer it was given increased market access in an area otherwise dominated by Intel. In another case, AMD, seeking a quick profit, controversially finalized a deal with a Chinese consortium in 2016 to license the production of its chips for the Chinese market. The deal was highly controversial in Washington, where competitor Intel along with many in Congress and Pentagon saw the deal as dangerous to U.S. interests, though at the time there existed no mechanisms to stop the deal (Miller 2022). These instances of technology transfers are evocative of Emmanuel's (1976, 1982) analysis discussed earlier, where capital was induced to act against "national interest" in the pursuit of profit. Nonetheless, most technologies acquired through technology transfers or acquisition in the mid-2010s remained generations behind the cutting-edge, especially so in chip fabrication. The outline set a goal of 16/14nm fabrication by 2020, which was still a few generations behind Taiwan's TSMC, and by 2020 mass-production capability of 14nm chips was still not achieved (He 2021).

China isn't the only large semi-peripheral nation that has its eyes set on developing advanced domestic semiconductor capabilities. On the first of February, 2023, in its annual budget the Indian government announced a Rs 3000 crore (US$365 million) total allocation for silicon-based semiconductor fabs, which was heralded by some as the first step in many to make India the next hardware powerhouse, with the Chairman of the Vedanta Group—who had partnered with Taiwanese firm Foxconn, the world's largest contract electronics manufacturer, in a $20 billion bid to set up a semiconductor manufacturing plant in India—stating this,

> …we must lead on the hardware side too. Building a strong base in the electronics manufacturing value chain is very important. Currently only 4 countries manufacture semiconductors and glass display. India is in leading position to become (the) 5th country after (the) government announced policies in both sectors (Agarwal 2023).

This project was given heavy state-support, with capital, water, power, and land subsidies guaranteed by the government (Ministry of Electronics & IT 2022). Two other proposals were also in the pipeline, with an international consortium, ISMC, proposing a $3 billion dollar investment for a fabrication plant in India in 2022 (Vengattil 2022). The Vedanta-Foxconn proposal states the goal of manufacturing 12-inch wafers that carry 28nm chips. TSMC, however, was producing chips of this type in 2011, and since 2020 has utilized the 5nm process, with plans to begin 3nm production, an exponentially superior and more advanced level of chip fabrication (TSMC 2022). Thus, in the case of both India and China, where the method was the acquisition of firms or technology from core corporations in the case of China or through state-sponsored joint ventures with core firms in the case of India, an important common factor is that the ambition of these efforts still lags a few generations behind the cutting-edge core production in the industry, and even those unlofty targets have only seen delays and failure, for reasons aplenty.

The attempt by the semi-periphery (more specifically here, China) to break apart from U.S.-led hegemony in this industry has been met with very heavy resistance. There is no doubt in the minds of policymakers everywhere that semiconductors are now possibly *the* chief economic and military good. The most advanced military weapons today are built using cutting-edge semiconductors, and the explosion in AI, machine learning, and other chip-dependent sectors has made semiconductors a matter of national importance for core nations outside of its already significant role in civilian industry. In response to China's ambitions towards developing its own advanced semiconductor capabilities and ending what Chinese officials have called the United States' "tech hegemony," the United States passed the Export Control Reform Act (ECRA) in 2018, which allows for the reclassification of various semiconductors related technologies to fall under the United States' Controlled Commodity List (CCL), thereby requiring export licenses from the state to sell or transfer such technology outside of its borders; which in essence means that any and all cutting edge technology deemed of national interest by the United States will be denied a license. This led to a dramatic halt in the acquisitions of U.S. tech-related companies by Chinese entities (Capri 2020), which was among the chief techniques used to enable technology transfers out of the core and into China.

Moreover, as part of the larger U.S.-China trade war, the United States has placed sanctions and a strew of restrictions on various Chinese tech firms such as SMIC, Huawei, HikVision, and ZTE among others, all important players in the electronics industry in China, again on the pretense of national security (Shepardson 2021). Initially, in the case of Huawei for instance, export restrictions were placed for technology related to 5G and other more cutting-edge technologies, but licenses were still given for older technology—Qualcomm was given licenses in 2020 to sell 4G smartphone chips to Huawei. However, the United States has only further tightened restrictions in 2022 and 2023, and drafted new formal policies that denied the export of items that now includes lower-end technology as well, such as 4G, Wi-Fi 6 and 7, and general AI and cloud computing related items. These restrictions have considerably lowered the revenue of these firms, with Huawei losing a third of its sales since the onslaught of trade restrictions (Freifeld, Alper, and Nellis 2023). In October 2022, the U.S. Commerce Department's Bureau of Industry and Security announced significant *worldwide* restrictions on China's ability to specifically import advanced finished semiconductors as well as advanced fabrication technology, targeting AI chips, chipmaking tools, and supercomputing (Bureau of Industry and Security 2022). The effect of these harsh restrictions has been felt immediately in China, with China's chip imports falling 26.5 percent in the first two months of 2023 compared to the same period a year earlier. SMIC has blamed the difficulty in procuring equipment since the onset of restrictions for delays in production at its planned cutting edge $7.6 billion fabrication plant in Beijing (Cao 2023).

The United States through these policies aims primarily to suffocate China's capacity to compete with or even enter the cutting-edge sections of the semiconductors industry through these actions, which make technology transfer to China practically impossible. The United States isn't alone—it is acting together with its core partners, such as Japan and the Netherlands (itself a major producer of the most advanced machinery for fabrication processes), who have both agreed to various restrictive legislations as well, with the goal being to contain the transfer of technology and production capabilities to China (Sterling, Freifeld, and Alper 2023). The Netherlands announced new regulations that will enforce a licensing requirement on the ASML, the leading European semiconductor equipment company, specifically on its second-highest tier of machinery—the deep ultra violet (DUV) line of equipment. Their highest-tier of machinery, the extreme ultraviolet (EUV) lithography machines, are already restricted by the government, and have never been exported to China, but have been exported to other U.S.-allied states. Perhaps the biggest showcase of the United States' strongarm handling of this "chip war" is through an upcoming rule, which will allow the United States to restrict the export of *foreign equipment* with even a miniscule percentage of U.S. parts to major semiconductor facilities in China. This rule would mean that companies like the ASML, whose equipment includes U.S. components in them, could face further restrictions on exports to China, most likely on the export of older equipment lines (Freifeld 2023). Similarly, in the case of AI chips, upcoming updates to rules are only tightening restrictions, which will set limits to the computing power that chips exported to China can have, which will prevent the development of AI technology in China (Nellis and Freifeld 2023).

In India, the highly publicized, state-supported plans for a "Make in India" semiconductors sector have now either stalled or collapsed. On July 10th, 2023, a little over a year after Vedanta and Foxconn became partners in their $20 billion joint venture to develop India's first semiconductor production plant, the joint venture collapsed, with Foxconn withdrawing from the project with no formal explanation, leaving the plan in limbo, with no real progress to show for it (Blanchard, Vengattil, and Kalra 2023). The other bids that the government received for manufacturing semiconductors, such as from ISMC, have stalled too, with the deputy IT Minister of India explaining that they "had to drop out," with no elaboration (Vengattil et al. 2023). The common problem that persists across the various bids for manufacturing in India is the difficulty in accessing technology, which requires partners from the core to be on board with such a project in India. Among the major difficulties faced by the Vedanta-Foxconn joint venture was to find a technology partner ready to transfer technology and provide licensing sufficient for their requirements, a situation that the same IT Minister described as a "struggle." The joint venture, after many months, managed to get STMicro, the largest European semiconductor manufacturing and design company, to license its technology, yet the deal collapsed, as the Indian government wanted the corporation to be more involved and to take on a stake in the partnership, something that STMicro was not keen on (Vengattil et al. 2023). The relegation of India to low-end sections of the semiconductors industry seems likely despite the government's clear focus on promoting the manufacturing and design of chips. Just weeks before the collapse of the Vedanta-Foxconn joint venture, India approved a $2.7 billion plan for a semiconductor assembly, packaging and testing unit for U.S.-based company Micron (Ahmed, Hunnicutt, and Kalra 2023), retrenching its position in the periphery of global semiconductor production.

While China's access is being suffocated and others like India are unable to attract foreign capital and technology, the United States has itself begun to invest heavily into redeveloping its own domestic semiconductor manufacturing capabilities, with the CHIPS and Science Act of 2022 providing almost $280 billion of funding to jumpstart this process. The massive subsidies that this provides to semiconductor firms are meant to reduce the otherwise increased costs of production in the United States as compared to its Asian competitors, with a clear aim to make the United

States a more favorable location for manufacturing semiconductors once again. Some fear that this will lead to a process of the de-coupling of the deeply integrated global commodity chains of the semiconductor industry, though this is an impossibility. Much more probable is a drastic increase in the protection and monopolization of cutting-edge technology by the core, and a push for independence from non-allied states in these sections of semiconductor production.

What It Means for the Semi-Periphery Today

There is no question about the importance of the semiconductors industry in the modern world-system—it is the key manufacturing industry of the twenty-first century, and is now the world's fourth most traded product (Varas et al. 2021). It remains deeply monopolized by the core nations, who make up over 87 percent of the total value-added processes in the entire value chain, with the United States alone taking up a 38 percent share, going up to 75 percent of value-added share in the Core IP section (Varas et al. 2021). The exorbitant cost of entry in either the design and R&D side or cutting-edge fabrication side has meant that non-core nations have so far only managed entry into the relatively low-value added sections of lagging-edge fabrication, assembly, and packaging. Despite these restrictions, nations such as China and India have repeatedly made attempts to break into the industry, but how possible is such an entry realistically?

The first hurdle remains the monopolization of technology. The nature of technology transfers is two-fold, as established earlier in the discussion on Emmanuel. The logic of capital to seek profit maximization should frequently enable technology transfer out of the core, but the interstate system can often create hurdles to this otherwise seemingly natural process. In the cases of Korea or Taiwan, I have established how "promotion by invitation" enabled their acceleration from periphery to the core through technology transfers and access to coveted markets. In the case of China, however, we see the obstruction of technology transfers owing to inter-state rivalry within the world-system. These trade restrictions are, from purely the logic of capital, disastrous for both sides, and industry research groups have repeatedly restated this (see Capri 2020; Varas and Varadarajan 2020). While U.S. officials justify these restrictions on the basis of "national security," there is little doubt that these measures are part of attempts by the United States to stifle China's growing role in the world-system and refusal to be directly politically subservient to American dominance. The question remains then—can the semi-periphery, despite these hurdles, move into the core?

It is abundantly clear that the hurdles that have to be overcome are tremendous. The core-monopolized sections of the semiconductor industry have little space or possibility for the "peaceful" entry of non-core states—and this is true of the semiconductor or automobile industry as well as any other industry generally. In the world-economy's system of global value chains, spatial reorganization constitutes only the peripheralization of relatively low value-added sections; and this peripheralization of production, though it has enabled entry into the semi-periphery for many prior peripheral states, has generally had its "hard limit." For instance, the outsourcing of low-value added highly labor-intensive sections of IT services and processes to India, or automobile production to Thailand, have led to the creation of a relatively wealthy comprador domestic worker elite that captures higher wages than their poorer domestic counterparts, but these have done little to change the overall character of their national economies, and especially little to improve the quality of life of the poorer sections of these nations who have captured practically none of the growth. Moreover, the dramatic cost of entry, requirements of highly-skilled experts, and the ever-growing gap between latecomers and the cutting-edge makes an independent entry into such core industry nigh-impossible regardless of geopolitical interference and pressure. China, despite favorable conditions and significant state support is still generations behind the core in every step of the semiconductor production chain, not to speak of the outdated chips possibly soon-to-be produced in "ambitious" states like India. It would take the discovery of entirely new technology in the non-core, something extremely unlikely owing to staggering differences in R&D expenditure, or global epoch-defining wars, crisis, or revolutions leading to a fundamental restructuring to open avenues for entry into high-value core production.

Even if we were to presume that these hurdles could be crossed, there remain other aspects of the capitalist world-economy that restrict core movement (see Wallerstein 1979). I discussed earlier the major reasons why core entry for Taiwan and Korea, among others did not disrupt the world-system. Can the same be said for the hypothetical entry of China or India? The answer here remains a firm *no.* The reasons for this are multi-fold. First, the rise in wages for a hypothetical core-like India and China across its entirety (as opposed to the small labour aristocracy present in both countries today) to core-like levels would have drastic, unsustainable effects on the capitalist world-system. A significant factor for stratification in the world-system is the process of unequal exchange that occurs through the international trade of unequal quantities of labor, embodied in commodities. This inequality in the terms of labor trade is itself dependent primarily on wage levels, which through various historical factors remain vastly different across national borders, while capital remains a constant in its functions globally (Emmanuel 1975). Resultingly, commodities produced by high wage nations are "overpriced" internationally, and those by low wage nations are "under-priced," a key factor in enabling unequal exchange in the twenty-first century today (see Ricci 2019; Hickel, Sullivan, and Zoomkawala 2021). Throughout the history of the capitalist world-system, regardless of the hegemon, only a minority percentage of the world population has maintained core standards of living; with the percentage of population in the core never having exceeded 20 percent, and some scholars showcasing this to have been in the range of 13–14 percent (Karatasli 2017; Li 2021). A change in the placement of the large semi-peripheral states such as India and China, which combined make up nearly 40 percent of global population, unlike the cases of South Korea or Taiwan who combined make up less than 1 percent of global population, into the high-wage domain of the present core would then require, first, a drastic reduction in the wage-levels and resultingly consumption levels and standard of living of not just the core bourgeoisie but also much of the "labor aristocratic" working classes of the core; or second, dramatically heightened exploitation (to a level unseen before in human history) of the remaining peripheries of Africa and Asia to maintain surplus extraction sufficient for such a large core population. Third, in both cases there would occur the complete and utter drain of the Earth's natural resources within a few years—resources which are already being consumed beyond a sustainable level by the present core (Hickel 2020). It is clear then that even if the large semi-peripheries were somehow able to enter core-like production through high-value added sections of industries such as the semiconductor industry, it would do little to allow overall core-entry for the country itself. Much more likely in this scenario is the development of a small highly-skilled section of labor aristocracy—employed in semiconductor production—that enjoys not only substantially improved wages and standard of living, but also a highly exploitative relationship with other low-paid laborers in their own countries, not too dissimilar from already-present worker elites in these nations (see Dunaway and Clelland 2016).

Therefore, despite what appears to be tremendous economic growth year-after-year in countries like India or China, the global hierarchy of wealth has largely remained unchanged; and the future of the semi-periphery appears in reality to be gloomy, for whom progress and ambition for actual entry into the core through industries such as semiconductors is not only against the interests of the core, but who additionally face structural limitations owing to the world-system having reached its geographical as well as ecological limit. The rosy picture of development within global capitalism has begun to reach a point of exhaustion worldwide, leading to widespread discontent in recent years, and there is little doubt that the current world-system as we know it is rapidly reaching either its demise or faces major restructuring (see Silver and Payne 2020). The question for the masses of the large semi-periphery remains: will they continue to believe in the developmentalist rhetoric of their ruling classes, or will they take matters into their own hands, and move the oppressed majority of the world towards a planet free from the unequal and endless accumulation of capital.

Conclusion

We have looked at the trajectory of the global semiconductor industry from its origins to the modern day, and through it have drawn an analysis from a critical world-systems lens. The semiconductor industry is the key industry of the twenty-first century—semiconductors are a required part of almost every modern invention. This industry, however, is deeply monopolized by a handful of core nations, who have cornered the rights and the technological capacity to design and manufacture the most advanced and modern chips. Attempts at entry by non-core nations have only been successful in a few cases, which have been cases of "promotion by invitation," and since then the industry has remained impenetrable except in the lowest value-added sections. The interference of the core nations, who wish to maintain their hegemony, along with the extreme requirements to enter and compete with the core without direct technology transfers, coupled with the structural limitations of the world-system, all cumulatively mean that core entry for the totality of the large semi-peripheries such as India and China remain an impossible task, who at best can have a small worker elite that engages in some degree of relative core-like production. Resultingly, I conclude that the lofty ambitions of the ruling classes of the semi-periphery to join the core through industries such as these is untenable within the current capitalist world-system.

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