"Technologies and World-Systems: innovation, de-novation, and diffusion as core problems for the social sciences."

Peter J. Hugill

Department of Geography & Bush School International Affairs Program

Texas A&M University, College Station, TX 77843-3147. E-mail: pjhugill@tamu.edu.

Abstract

In 1913 the anthropologist Goldenweiser proposed his "principle of limited possibilities," noting that once a line of cultural development has begun it develops increasingly massive inertia and becomes very hard to reverse. Despite claims by such scholars as Wallerstein and Taylor that a reversal is on the horizon what we have come to call, on the basis of Wallerstein's pioneering work, the Modern World-System, a form of societal self-organization based initially on capitalist agriculture, now possesses massive, probably irreversible inertia. In the late 1930s the economist Schumpeter, analysing Marx's failure to predict the demise of capitalism, suggested that capitalism periodically renewed itself by "the process of creative destruction." In 1988 the geographer Hägerstrand proposed the idea of de-novation as a logical corollary to the idea of innovation, suggesting that innovation was only possible in the presence of de-novation. I have argued that innovatory technologies, especially in transportation and communication, have driven successive waves of economic and political development for the past several hundred years of the World-System. If we are to successfully analyze, not just describe, the World-System, two core questions that must be answered by historical macro-social science are where, how, and why de-novation and innovation occur and along what pathways and with what success

such forces diffuse. Significant elements of these questions are inherently subject to geographic analysis.

Introduction

In volume three of *Das Kapital* Marx predicted, in his "Law of the Tendency of the Rate of Profit to Fall" (henceforth "Law") what to him seemed the inevitable demise of capitalism (Marx 1959, pp. 211-31). Marx suggested several ways in which capitalism could postpone the inevitable, most of which have been tried, but it fell to Schumpeter in the 1930s to accurately analyse the true reason why capitalism failed to decline, or, rather, why it showed a clear, regular, cyclical pattern of declining followed by rising profits first identified by the Russian economist Kondratiev. Schumpeter was the first to realise that the interests of capitalist investors were not necessarily the same as capitalist entrepreneurs and that all such capitalist interests were linked intimately but differently to technologies. Periods of declining profits in an ageing technology subject to Marx's "Law" were followed by what Schumpeter described as a "process of creative destruction" and the re-investment of capital in new, more profitable technologies (Schumpeter 1976, p. 83). Marx, unable to distinguish between investor and entrepreneur, failed to see that investors had no emotional commitment to a given technology: that their primary, perhaps their only interest, was in the profits that technology returned. Entrepreneurs who had grown up and prospered investing in a given technology, could not always "see" the declining returns on their investment, failed to disinvest, and drove the cyclical crises of capitalism identified by Kondratiev. Schumpeter thus "supplied the missing Marxian connection between the theory of the capitalist cycle and the theory of capitalist crisis, and made the distinction he believed Marx had failed to make, between the capitalist and the entrepreneur" (Hall & Preston 1988, p. 14). Simply put, disinvestment in old and reinvestment in new technologies is the motor of capitalism (Hugill 2003).

In 1913 the anthropologist Goldenweiser proposed his "Principle of Limited Opportunities" (henceforth "Principle"), suggesting that once a culture had embarked on a specific line of development other possible lines of development were choked off and either abandoned or seriously reduced in importance. Cultures thus develop a structural resistance to change. The capitalist world-economy, as described first by Wallerstein (1974), was a new macro-cultural World-System that replaced the first World-System seen on this planet, the world-empire. Tribute-taking world-empires were the over-arching human politico-socio-economic organizational system from their initial development in Mesopotamia until very recently: the former Soviet Union had all the hallmarks of a classic world-empire. As many authors have pointed out, world-empires were inherently unstable structures, prone to serious over-extension and collapse. Although some lasted significant amounts of time, the length of time was fundamentally dictated by the inherent slowness with which any such world-empire could expand when the only land transportation systems were animal or human powered. The most recent attempts at world-empires have fallen as quickly as they expanded.

Feudal Europe was, of course, not a world-empire, and the "crisis of feudalism," severe by 1450, was, as Wallerstein notes "a conjuncture of secular trends, an immediate cyclical crisis, and climatological decline." Out of this complex crisis, part economic, part environmental, came the second macro-cultural World-System, the capitalist world-economy. Wallerstein argues that "three things were essential to the establishment of such a capitalist world-economy: an expansion of the geographical size of the world in question, the development of variegated methods of labor control for different products and different zones of the world-economy, and the creation of relatively strong state machineries in what would become the core-states of this capitalist world-economy. The second and third aspects were dependent in large part on the

success of the first" (Wallerstein 1974, pp. 37-38). No geographical expansion, no capitalist world-economy.

This geographical expansion of the late 1400s was technologically driven at the hardware and software levels: the hardware technology of wind-driven ships capable of open-ocean voyaging, as opposed to the human powered ships used by most world-empires, would not have been successful without the software technologies of reliable systems of navigation and increasingly reliable maps (Hugill 1993). As Wallerstein notes, the emphasis of the world-economy was, from it's beginning, on the movement of bulk agricultural goods and not of preciosities (Wallerstein 1974, p. 41). By Wallerstein's definition, and with apologies to Abu-Lughod (1989) and Chase-Dunn & Hall (1997), the only World-System before the late 1400s took the form of a multiplicity, over historical time, of failed world-empires. In Wallerstein's reading, the massive innovation of the capitalist world-economy could only emerge out of the "crisis of feudalism." Only Sanderson has attempted to address what many scholars have claimed is an argument for European exceptionalism. Sanderson dismisses the claims by many scholars that China was en route to capitalism around 1000 AD but argues that Japan was "essentially capitalist" before 1853 (Sanderson 1999, p. 176). In the event, Japan's indigenous capitalist development was halted when the capitalist World-System that had developed in Europe diffused into Japan after 1853.

The new technologies of open-ocean navigation and shipping made it possible for trade-based systems to start to displace tribute-based systems. New polities began to emerge as some governing elites switched from tribute taking and a tendency to want to themselves monopolise the trades in preciosities to taxing trade and providing transportation infrastructure and military protection for traders. As income from taxes replaced income from tribute this engendered more

and more willingness on the part of governmental elites to encourage a larger and larger merchant class to seek out and develop trading opportunities with decreasing levels of governmental interference.

Trade versus Tribute based Polities

As Tilly has demonstrated there are considerable differences between polities based on trade and those based on tribute. Most of these differences come down to communication technologies. Trade based polities need to manage production at a distance and from very different cultural regions, but are unable to use high levels of coercion because of the difficulty of power projection over space before land transportation systems moved beyond the animate. Trade based polities thus have to depend on rapid and accurate communication, capitalist managerial rather than coercive systems, and co-operative behavior between what are often culturally very different elites (Tilly 1990). Wallerstein notes that capitalist agriculture historically organized labor systems by region within the World-System: whether they were in the core, semi-periphery, or periphery (Wallerstein 1974). Taylor notes that elites practiced trans-regional co-operation, while imposing different labor management systems on different regions (Taylor 1993). The most innovatory software technology of the World-System in its formative period was the shift from co-erced labor systems in the core to free, waged labor.

The history of the World-System over the past five hundred years or so has been the history of the ascendancy of trade as opposed to tribute-based polities. Sanderson's argument about the indigenous development of capitalism in Japan before 1853—and his dismissal of the claims for an earlier, Chinese development—is that "capitalism was born of class struggle. However, it was not, as the Marxists would have it, a struggle between landlords and peasants. Rather, it was the struggle between the landlord class and the merchants" (Sanderson 1999, pp.

175-76). The ascendancy of trade not only saw the ascendancy of the merchant class, but also an ever-increasing emphasis on the transportation of goods and the communication of information and ideas. This has played out in the development of new forms of transportation, initially sea-based, but from the railroad on bringing the advantages of cheap bulk goods movement to land transport.

At the conclusion of his 1974 book in which he introduced the idea of the Modern World-System, Wallerstein suggested that the only alternative to the capitalist world-economy "that could maintain a high level of productivity and change the system of distribution…would [be]…a socialist world government" (Wallerstein 1974, p. 348). Many scholars who have followed Wallerstein have made similar arguments, usually without substance. Taylor, however, argues persuasively that the World-System is now suffering from a building crisis of over-consumption and that the planet simply does not have the resources, especially in energy, for human societies to continue to consume more and more (Taylor 1996). Taylor's preferred solution is the collapse of the capitalist World-System and its replacement by a socialist one. An alternative would be the emergence of technologies of sustainable development.

The Role of Technologies in World-System Change

World-System theory as put forward by Wallerstein is, essentially, descriptive and atheoretical. It has no predictive power since it regards each instance of hegemony as, essentially, unique and Wallerstein gives us no mechanism to drive the shifts of hegemonic power in the World-System that he identifies. In an article Wallerstein does provide a definition of hegemony: the brief overlapping of massive superiority in agro-industrial production, commerce, and finance, but he provides no mechanisms by which such superiority might be achieved (Wallerstein 1984). Kondratiev long-wave theory as adapted by Schumpeter indicates

that technological change drives Kondratiev waves in the world economy, but such waves are only of fifty to fifty-five years in duration. In 1978 Modelski pointed out, if one projects Kondratiev cycles back to the start of the European expansions in the late 1400s, there is a pattern of two Kondratiev cycles combining to create a world leadership cycle (Modelski 1978). In later work he and Thompson suggested that such cycles were marked, if not driven, by the achievement of the hegemon of massive naval superiority (Modelski & Thompson 1988). In 1993 I suggested that Modelski's world-leadership cycles were better understood as driven by the emergence of new technologies of transportation, and in 1999, building on work by Hall & Preston (1988), I deepened that argument to suggest that technologies of communications, especially telecommunications, have been even more important in driving hegemonic shifts because they have operated in a specifically geopolitical context (Hugill 1993, 1999).

Innovation and De-Novation

If new technologies save us from the malignant operation of Marx's "Law" and drive the successive waves of economic and political change in the capitalist World-System, then where, how and why new technologies develop is obviously of central importance to our society. Failure to innovate would, in this model, be the surest way to break through the inertia of the current World-System and bring us to some new and, *pace* Wallerstein *et al*, not necessarily better, over-arching politico-socio-economic organizational system. In 1988 Hägerstrand suggested that innovation could, because of the working of Goldenweiser's "Principle" and the need to break through the inertia found in all operating macro-cultural systems, only occur in the presence of some significant level of de-novation. Once the processes of de-novation and innovation have operated it then becomes important to look at the process of diffusion. Along

what pathways do new technologies and ideas move and by whom and with what success are they adopted?

Although there is a vast academic literature on diffusion there is comparatively little on the nature of innovatory environments and almost none on de-novation. The academic literature on innovation is somewhat contradictory in that the two main theories are more concerned with diffusion than with innovation, they conflict, and neither are well supported by the evidence. One theory, propounded by the *kulturekreis*—culture circles—school, held people to be generally uninventive, innovation to be rare, and diffusion easy, even epidemic in nature. The other, the utopian theory of culture change, held people to be innately and uniformly innovative. Yet diffusion is not epidemic in nature, as Hägerstrand and his students have routinely shown, and innovations cluster in time and, most particularly, in space (Hugill 2003).

Some of the most sophisticated work on where innovation occurs has come from Peter Hall's work on "The City as Innovative Milieu" (Hall 1998, pp. 289-500). Most innovations, especially in the technologies that have driven hegemonic shifts in the World-System, have come from a very small number of city-regions. Hall focuses on six cities and six sets of technologies:

(1) Manchester/cotton textiles

(2) Glasgow/shipbuilding

(3) Berlin/telegraphy, electrical power generation

(4) Detroit/automobiles

(5) Silicon Valley/solid state electronics, computers

(6) Keihin (Tokyo-Kanagawa)/consumer electronics, solid state electronics

Of these, only Manchester's cotton textile technology is not clearly related to transportation or communication technologies. Out of these case studies and a long introductory journey through location theory, "a rather obscure sub-science, existing at the borderline of human geography and economics" (Hall 1998, p. 291) Hall develops two models of innovation, "the freewheeling laissez-faire one…and the state-guided centralized one" (Hall 1998, p. 497). For Hall, neither answers the crucial question of how we might model Kondratiev shifts that depends on "a chain of continuing innovation over decades and even centuries" (Hall 1998, p. 499). The historical record shows that both models have both succeeded and failed at different times and in different places.

I argue elsewhere that Hall shows too much concern here with hardware, material production technologies, and not enough with the software and cultural production technologies that are becoming increasingly important to the profitability of the capitalist World-System (Hugill 2003). Hall does, however, treat cultural innovation somewhat tentatively—"theory almost fails us"—in another section, identifying two more great innovatory centers: Los Angeles for movies and Memphis for rock and roll (Hall 1998, pp. 503-608, quote p. 504). Here communications are again central. What theory Hall does find here emerges not from economics, but from the theory of communications propounded by Harold Innis, that there are space-binding cultures and time-binding cultures and that these are largely a product of interaction between their communications media and their macro-cultural goals (Innis 1950, 1951). In terms of more recent intellectual discourse these roughly approximate the trading states and territorial states proposed in rudimentary form by Mackinder (1919), more completely by Fox (1970) and most thoroughly by Tilly (1990). Although Hall fails to make the connection

the link between technology and state type through communication is both inherent in the work of Innis and inescapable (Hugill 1999).

We thus need a more complete theory if innovation, one that includes at least cultural and material production and hardware and software technologies. Hall's theory of the innovative milieu is an excellent place to start, if incomplete because it signally fails to merge cultural and material production in a single model. Hall approaches, but does not quite solve the problem, when he argues that the innovative milieu of the six industrial cities he examines was often formed in small workshops rather than great factories. The great factories of Arkwright in the first industrial revolution and Ford in the second were primarily solutions to the inherently geographic problems posed by inadequate transportation systems: the geographic complexity of the putting-out system before 1770 and the physical impossibility of overseeing small units of labor at many dispersed sites of production; and the impossibility, given the transportation infrastructure and technology of the 1920s of implementing "just-in-time" production as Ford wanted to—his Highland Park factory had worked well that way, but the scale jump to real mass production in his Dearborn plant rendered it impossible.

It was left to Toyota to reintroduce "just-in-time" production and take credit for it and for companies such as Wal-Mart to bring it into the sales arena. The main structural advantage of a "just-in-time" system is that it maximizes two sorts of scale advantage. On the one hand it supports the economies of scale only large factory units enjoy. On the other it allows, in the workshops that support the large factories, the maximum number of innovatory experiments. Workshops are, however, sites of artisanal as well as industrial production, and artisanal production has a strong link to modes of cultural production: it is not merely about the mass production of the largest number of units at the lowest price, but also about artistic design and

pride of workmanship. It thrives best in sites of artistic production. Although Hall treats Los Angeles almost entirely as a center of movie production it is important to remember that Los Angeles has always made a larger contribution to automobile design than has Detroit. Harley Earl, later to head up General Motors' design team and create annual model changes based purely on appearance, started out customizing cars for movie stars in the teens and twenties. The traditional hot rodding of the 1940s on, no less than today's "tuner car" culture, is a quintessentially Angeleno phenomenon, developed in hundreds of independent workshops, the products of which meet weekly on the formal race tracks and nightly on the streets of Los Angeles, and which massively influence the broader American car culture. Many major car companies keep Los Angeles area design bureaus to tap into the constant flow of stylistic as well as technical innovation the region produces. Such synergy between cultural and material production must be part of a broader model of innovation.

But what of innovation's darker side, de-novation? Capitalist polities have been most reluctant to embrace Schumpeter's "process of creative destruction." Thus far only Thatcherite Britain and Reaganite America seem to have accepted that the destruction of jobs is as important as the creation of new ones, since new ones are unlikely to appear without massive disinvestment in old and reinvestment in new technologies, and even they have scarcely been purist, as witness the current American government's shoring up of textile and steel industries. Other capitalist polities, perhaps with worse memories of the consequences of the economic collapse of the 1930s, have maintained high levels of state spending on old technologies apparently regardless of costs. Clearly de-novation must be at least not demonized, if not actively encouraged. Clearly there must also be a societal "safety net:" re-education programs for those who wish to embrace new technologies; some level of welfare for those who cannot be re-educated.

If I return to Hall's central question of where something happens, where de-novation occurs is a much harder problem than where innovation occurs. Some cases are clear, but not necessarily helpful. Oldham, Lancashire, was once the greatest cotton textile weaving city on the planet for most of the 1800s and early 1900s: today, the square mile of "weaver's triangle" where nearly all those weaving sheds stood is open parkland. With few exceptions, nearly all of Detroit's pioneering automobile plants have been razed along with vast acreages of the housing for their workers. If Manchester (or Oldham) and Detroit once represented innovation and industrialization on a truly heroic scale they now represent de-novation and deindustrialization on the same truly heroic scale. Scale must count for something here. De-novation perhaps works well only at the workshop level, where comparatively few people are involved, disinvestments costs are low, and a rapid shift to an innovatory technologies is easier.

Diffusion

Finally I turn briefly to diffusion, not because it is of any less interest or importance than innovation and de-novation, but because it is academic ground well turned and cultivated. From the point of view of what matters most to the continued health of the capitalist World-System, however, the diffusion of technology is far less important than innovation or de-novation. Neither the *kulturekreis* model of epidemic diffusion nor the utopian model of universal innovation where diffusion would be irrelevant works in practice. A simple question, "where does innovation occur?" gives a simple answer: "only in rather special innovation milieus." For this reason diffusion of innovations is important. Our very considerable literature on diffusion suggests that it works well within a given culture, or between cultures with certain common values, but with great difficulty or not at all between markedly unlike cultures. Hardware technologies diffuse with relative ease, although the technologies needed to replicate

technologies may not. Software technologies often diffuse with great difficulty. For example, hardware technologies based on such technologies as internal combustion engines, electricity, and organic chemicals diffused rapidly within the core of the capitalist World-System as it existed in 1900. By the end of the first German War, America, Britain, Germany, and Japan were all capable of building massive battleships, automotive tanks, airplanes, wireless communications systems, and manufacturing dyestuffs and explosives based on organic chemistry. The American software revolution of more efficient production pioneered by such as Ford, Gilbreth, and Taylor diffused only very slowly and with great difficulty, yet it was to prove the compelling advantage in terms of organizing industrial production for the second German War, and one of the principal reasons for American hegemony thereafter. Yet no one sought to hide what was happening. Ford welcomed visitors to his assembly plants and exported whole plants to Britain, France, Germany, Japan, and the Soviet Union in the inter-war period. Gilbreth (1911) and Taylor (1911) both published extensively on their management technologies and actively promoted them outside as well as inside America. Yet only after the German Wars were over did the rest of the world fully embrace the software revolutions pioneered in America before the first of those wars.

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