

Path Dependence and Urban History: Is a Marriage Possible?

Martin V. Melosi
Department of History, University of Houston
Houston, Texas USA

The impact of a variety of technologies and infrastructures on the growth of cities is a central concern of urban environmental history. The implementation of new urban technologies, however, was not automatic, coincidental, nor inadvertent, but an intentional effort by decision makers to confront existing problems faced by cities as they extended upward and outward in the nineteenth and twentieth centuries.

Path dependence is an important approach for exploring the role of decision making on the development and impact of specific technologies or technical systems. The theory focuses attention on the means by which choices are made, the connection of those choices to future options and sequences of events, and to outcomes. The use of path dependence reinforces the idea that a variety of externalities influence the adoption of technologies. It can help historians turn from concentrating so heavily on a singularly past-centered perspective to a present-centered perspective that devotes significant attention to results as well as constraints on outcomes. This is especially useful if historians are interested in the policy implications of their work.

Social scientists, especially economists, began exploring path-dependence theory in the mid-1980s. Although definitions vary, simply put, path dependence exists ‘when the present state of a system is constrained by its history.’ The theory has been applied to a variety of technologies, institutions, and policies. In a larger context, path dependency has challenged neoclassical economics by stressing the importance of institutions (institutional economics) and through the suggestion that historical events affect present choices (evolutionary economics). Economic historian Paul A. David has argued that ‘the future of economics as an intellectually exciting discipline lies in its becoming an historical social science.’ Given that economics, and other social sciences, have been dominated by a strong behaviorist philosophy built upon quantitative methodologies, some saw the notion that *history matters* as a radical departure. From David’s perspective ‘[H]ow could there be anything new or radical in the idea that particular sequences of events in the past have had enduring effects upon current conditions?’ For historians, path dependence is quite reasonable, given our own sense of causation and the importance of sequencing events to determine change over time. The radicalism of path dependency, however, lies not so much in its fundamental claims, but in its challenge to social science orthodoxy in the wake of the cliometric revolution.

The debate over path dependency is interesting in its own right. That debate has also

been useful in helping to explore the intrinsic value of the theory for historians, including urban historians. A central question--and an ironic one--is: why borrow such an idea from colleagues in the social sciences, who borrowed it from us in the first place? This paper explores the scope of path dependence as developed by its advocates and criticized by its detractors, and reflects upon its value to the study of urban history. Paul David's 1985 article, 'Clio and the Economics of QWERTY,' brought widespread attention to path dependency. David illustrated the theory through a case study on the adoption of the QWERTY standard English language typewriter keyboard in the 1870s. The QWERTY had been designed to reduce the mechanical jamming of the keys and was quickly adopted by many office managers. Other keyboards, notably the Dvorak Simplified Keyboard introduced in the late 1930s, appeared to be faster and more efficient, but the QWERTY had long since dominated the market. In David's view, a small--or accidental--historical event had 'locked-in' the QWERTY technology and essentially eliminated its competitors. While the article garnered substantial attention and stimulated additional study of path dependence, defenders of neoclassical economic theory were unconvinced by David's argument and questioned the QWERTY case in particular and the path dependency theory in general. But as Douglas J. Puffert—a student of David's—perceptively noted, 'David defined path dependence as a dynamic feature of an allocation process, whether or not the resulting allocation is efficient. Many readers of his article, however, interpreted path dependence primarily as a source of market failure through lock-in to a suboptimal technology.' In essence, supporters and critics were often debating different issues.

In a recent article, and in response to critics, David defined the concept of path dependence as 'a property of contingent, non-reversible dynamical processes, including a wide array of biological and social processes that can properly be described as "evolutionary."' He added that 'the policy implications of the existence of path dependence are shown to be more subtle and, as a rule, quite different from those which have been presumed by critics of the concept.' These alterations in his definition were meant to suggest that *history matters* in economic processes, but not always in the same way. In addition, the concept of historical *lock-in* should not be taken too literally, but viewed as 'a vivid way to describe the entry of a system into a trapping region—the basin of attraction that surrounds a locally (or globally) stable equilibrium.' Thus *lock-in* is not rigidly inflexible, but the result of making choices in the past that constrain options in the present or future.

David utilized path dependence theory to question economic orthodoxy. 'Indeed, for too long,' he stated, 'it has seemingly been our collective educational purpose to extirpate from the minds of neophyte economists all but the most fundamental human intuitions about the role of the past in present (economic) affairs.' 'Path dependence, at least to my way of thinking,' he also stated, 'is therefore about much more than the processes of technological change, or institutional evolution, or hysteresis effects and unit roots in macroeconomic growth. The concepts associated with this term have implications for epistemology, for the sociology of knowledge, and cognitive science as well.' While David set a foundation for path dependence and attracted an initial firestorm of criticism, others have attempted to refine the theory and broaden its applicability within the field of

economics as well as in the other social sciences. Particularly noteworthy is the work of W. Brian Arthur, Douglass C. North, and Paul Pierson. Among his contributions to refining path dependency, Arthur has been particularly noteworthy in the area of increasing returns economics, by demonstrating how small historical events can be amplified by positive feedbacks. This approach stands in opposition to conventional economic theory that emphasizes diminishing returns, that is, economic actions that produce negative feedbacks resulting in a state of equilibrium for prices and market shares resulting in stabilizing the economy. Arthur and others found this latter approach to defy reality in several cases. Under increasing returns, multiple outcomes are possible. As a consequence, tracing the way in which small events accrue to cause a particular system to move to one particular outcome instead of another becomes important. In examining choices made among technologies, Arthur noted that ‘modern, complex technologies often display increasing returns to adoption in that the more they are adopted, the more experience is gained with them, and the more they are improved.’ When technologies compete for a market, therefore, ‘insignificant events’ may give one an initial advantage for adoption. The technology may then improve more than the others, and thus appeal to a wider group of adopters, and so on. In this scenario the technology that by chance gained an early lead may ‘corner the market’ of adopters, and other technologies may become ‘locked-out.’ Such an approach highlights two new properties in the adoption process: *historical lock-in* of a given technology (inflexibility) and path dependence (non-ergodicity). Arthur admitted that not all technologies enjoyed increasing returns with adoption, but he believes that it might be useful to determine to what degree the actual economy might be locked-in to inferior technology paths. This perspective, of course, is in direct opposition to the concept of diminishing returns, where small events cannot determine outcomes and where a *laissez-faire* approach leads to the success of a superior technology. Arthur’s increasing returns approach challenges those assumptions.

Arthur’s focus on modern technologies, however, does not take ample account of an institutional context for path dependence. Nobel laureate Douglass North clearly added that dimension to the theory: ‘History matters. It matters not just because we can learn from the past, but because the present and the future are connected to the past by the continuity of a society’s institutions.’ North regards institutions as ‘the rules of the game in a society or, more formerly, are the humanly devised constraints that shape human interaction.’ His concern is that there is no analytical framework to integrate institutional analysis into economics or economic history. North is particularly sensitive to the gulf between neoclassical theory and its concern over ‘the allocation of resources at a moment of time,’ and how much of ‘a devastatingly limiting feature’ that is to historians ‘whose central question is to account for change over time.’ ‘Moreover,’ he adds, ‘the allocation was assumed to occur in a frictionless world, that is, one in which institutions either did not exist or did not matter.’ North made clear that institutional analysis could make the U.S. economic history (in this case) ‘a truly historical story,’ and much of that history he believed was path dependent—‘simply by nature of constraints from the past imposing limits on current choices and therefore making the current choice set intelligible.’ Focusing on the process of economic growth, he postulated that the primary source of economic

growth is 'the institutional/organizational structure of a political economy;' and that economic growth is dependent on 'stable political/economic institutions. Furthermore, the 'belief systems of societies and the way they evolve' that is the 'underlying determinant of institutions and their evolution.' Understanding the nature of path dependence, he concluded, 'is the key to understanding the success or failure of economies in altering their competitive positions.' North also observed the ability of several actors to influence outcomes within an 'institutional matrix' through, among other things, a variety of increasing returns, through inducing incremental change, and through informal constraints such as the transmission of values. A theory of institutional change incorporating path dependence, he concluded, can become a central feature in understanding economic growth.

Political scientist Paul Pierson has been influential in utilizing path dependence to analyze politics, political institutions, and decision making. In a recent article, he explored path dependence as a social process 'grounded in a dynamic of "increasing returns."' Like Arthur and others, he argued that increasing returns processes 'are likely to be prevalent' and can provide a strong framework for developing the study of historical institutionalism. He is particularly interested in developing path dependence theory with more rigour and beyond the 'loose and not very helpful assertion' that *history matters*. Utilization of an increasing returns process to elaborate path dependency is especially important because in this process 'the probability of further steps along the same path increases with each move down that path.' In addition, he is interested in exploring a narrow conception of path dependence (social processes that exhibit increasing returns is one approach) so that the theory does not suffer 'concept stretching' in which different types of temporally linked sequences are identified under a single banner. Pierson is aware that applying tools of economic analysis to politics can be 'treacherous' unless applied carefully and systematically. He believes that doing so produces salutary outcomes because 'The political world is unusually prone to increasing returns.' He is particularly concerned that in identifying initial causes influencing future patterns, the object of study needs to become the critical juncture or 'triggering events' which set development along a certain path. In addition, he cautioned that path dependent analyses need not presume that a particular alternative is permanently locked-in. With these caveats, he strongly asserts that increasing returns arguments may produce exciting results in political science. Skeptics of path dependency have challenged vigorously this analytical tool and, in turn, questioned the heightened assaults on neoclassical theory. For those interested in applying path dependence to a variety of historical problems, the critiques are valuable for an array of pertinent issues requiring further consideration. The best-known criticism of path dependence comes from economists Stan J. Liebowitz and Stephen E. Margolis. The primary thrust of their argument is that path dependence merely presents a false claim of market failure. They suggest that economists have found imperfections in free markets, and that improvement was difficult, but also that alleged market imperfections may prove later not to exist at all. Moreover, there may not be realistic means to overcome supposed market imperfections and ways may be found to improve upon independent decision making (by firms and individuals) which is how resources are allocated in a free market.

In defining path dependence, Liebowitz and Margolis assume that the theory

‘spilled over’ to economics from other fields or disciplines—in physics and mathematics in the form of chaos theory (a non-linear model ‘with sensitive dependence on initial conditions’) and from biology via contingency (‘the irreversible character of natural selection’). In comparing chaos theory and path dependence, they suggest that in chaos theory ‘small events or perturbations tend to cause a system to evolve in very different ways but the system never settles down in any repeatable path or fixed equilibrium.’ In the case of path dependence in economics, the view that minor initial perturbations are important is imported from chaos theory, ‘but has grafted this on to a theory where there are a finite number of perfectly stable alternative states, one of which will arise based on the particular initial conditions.’ Perpetual disequilibrium is thus missing from path dependence. Defense of traditional market mechanisms led Liebowitz and Margolis to dismiss David’s claims of path dependence as demonstrated in his various case studies, including the QWERTY example. Liebowitz and Margolis assert that David’s evidence is shaky, especially the notion that QWERTY became the standard because of the lack of sufficient challengers. They question the assumptions that the Dvorak keyboard was inherently superior, and that the sustaining influence of the QWERTY clearly indicated a market failure. Their critique challenges David’s historical data and also his drift away from neoclassical theory to make the case for market failure. They conclude that ‘what credence can possibly be given to a keyboard that has nothing to accredit it but the trials of a group of mechanics and its adoption by millions of typists? If we use only sterilized models of markets, or ignore the vitality of the rivalry that confronts institutions, we should not be surprised that the historical interpretations that result are not graced with truth.’ In a rather clever condemnation of path dependence--again relying heavily on an unwavering reliance on neoclassical economics--Liebowitz and Margolis developed taxonomy of path dependence. A minimal form—or first-degree path dependence—is an element of ‘persistence or durability’ in a decision with no apparent harm done at a later time. In second-degree path dependence, past conditions lead to outcomes that are ‘regrettable and costly to change,’ but where an individual failed to predict the future perfectly because of imperfect information. Third-degree path dependence—the strongest form—suggests that known feasible and preferable alternatives exist at the time the initial decision was made and thus an error that arises was avoidable. Their conclusion is that first and second-degree path dependence are common, have always been a part of economic thought, and that traditional theories of neoclassical economics can explain them. Third-degree path dependence—the kind associated with the critics of neoclassical theory—does not exist in the real world. Such argumentation effectively dismisses path dependence. In the concluding chapter of their recent book, Winners, Losers & Microsoft, Liebowitz and Margolis conclude ‘our message is simple: Good products win. Whether they are lowly mousetraps or high-tech networks, better products prevail in the marketplace. People choose what they want, and what they want survives, at least for a while. Surviving products are imitated and become the norm... Eventually, when something decidedly better comes along, there is a transition to the new product.’ And as Liebowitz was quoted as saying in a 1998 email exchange: ‘Finally... there is the claim that path dependence enhances the value of economic history. We think not.’

To a large extent, Liebowitz and Margolis are defending methods of neoclassical economic theory against an interloper. It is quite acceptable that path dependence (and economic history in general) be used as a tool for understanding some past actions, but when it is also used as a way of explaining and influencing the present, critics—especially in economics—fall back on disciplinary orthodoxy. As Puffert suggested, ‘[M]any neoclassical economists view history as little more than a source of data for testing theories. At the most, they restrict the role of history to determining the fundamental, *a priori*, “exogenous” parameters that presumably then determine a unique equilibrium—such parameters as institutions, technology, factor endowments, tastes, and information.’ To be fair, of course, it must be added that economists and historians do not always ask the same questions, although they may have, as economic historian G.R. Hawke stated, ‘overlapping rather than identical interests.’ He perceptively noted, ‘historians frequently use expressions like “understanding the past in its own terms,” while economists want to employ concepts developed more recently in their studies of past societies. The point might be described as a conflict between “past centred” and “present centred” studies.’ Hawke points out that the difference is one of degree, but the difference often exists nonetheless. Since his 1985 article, David has explained and refined his views on path dependence on several occasions. Ultimately, he has promoted some basic precepts of causation that historians should find easily compatible with their own views: ‘effects follow causes in temporal succession’ and ‘there are outcomes which simply cannot be achieved—or, are extremely unlikely to arise—except through some particular dynamic of intervening events.’ In many respects, path dependence puts a different name—and at times a different perspective—on a process that is basic to historical inquiry. Indeed, it is a concept originally borrowed from the discipline of history itself. What appears most useful about path dependence for historians, however, is not just the reconfirmation of historical causation, but a shift in focus from past to present, that is, greater attention to outcomes of past events rather than simply tracking change over time, which often emphasizes the look back as opposed to the look ahead or the impact of choices made. In this sense, critiques like that of Liebowitz and Margolis are valuable in forcing proponents of path dependence to provide more precise definitions of the theory. As economic historians Lars Magnusson and Jan Ottosson have argued that ‘...Liebowitz and Margolis are certainly right in that if “path dependency” is to serve as anything more than a catchword for sweeping criticism of neo-classical economics, it is important that we try to be more specific regarding its theoretical status.’ For the purposes of historians, Liebowitz’s and Margolis’s argument too narrowly focus on market failure, inefficiency, and good and bad (mistaken) technical choices. In some respect, the argument makes *a priori* judgment, not necessarily questioning that choices lead to particular paths, but that results that produce inferior outcomes do not correspond to actual market forces. ‘Better products prevail in the marketplace.’ They seem to accept a distinction made by others that choices can be *past dependent*, rather than *path dependent*. In other words, they question the sequencing of events that lead to what they argue are improbable outcomes. Yet, how can any outcome that is either *past* or *path* dependent not be influenced by what came before? Specifically, with respect to superior/inferior technologies, Liebowitz and Margolis seem to miss the point that what Arthur and others

are talking about are *characteristics* of technologies rather than simply technologies themselves.

It is not the point of this paper—nor is it within the expertise of the writer—to enter the rather extensive and detailed debate over the value of path dependence within the field of economics, or whether path dependence undermines neoclassical economics and offers a major epistemological breakthrough in the field. This discussion hardly does justice to a thorough discussion of market forces, network effects, diminishing returns, increasing returns, and so forth. More simply, rather than taking on that large task or even questioning the more narrow notion of whether an inferior technology could succeed in a market economy, for example, it is argued here that path dependence may be useful for historians in addressing questions from a slightly different vantage point. What are the constraints placed on a current generation because of choices made in the past? What are the limits of a chosen path, as opposed to what is or is not changeable? What are the implications of particular choices and potential lock-ins on practice and policy? What kinds of impacts are possible with path-dependent actions? In many respects, these are qualitative issues, but the kinds of issues that complement traditional uses of historical causation in understanding technologies, institutions, and politics, useful to urban historians. Again, ‘market failure’ seems to be a very narrow way to judge the value of path dependence. Historians tend to think in degrees of change, rather than absolutes. It seems that a major virtue of path dependence is to determine how future choices are constrained or limited rather than how they are precluded. *Lock-in* need not be a permanent condition, nor is it the best issue for historians to track. Choices are made, what are their consequences? Is there a substantial impact on the sequencing of events because of initial choices? These seem to be more useful question for historians rather than debating whether initial choices grow out of ‘insignificant’ or ‘small’ events or even random actions. ‘Insignificant,’ ‘small,’ or ‘random’ have to be evaluated and based on outcomes. Something is hardly insignificant if it produces a significant outcome. To repeat what was stated earlier, path dependence can help historians turn from concentrating so heavily on a singularly past-centered perspective to a present-centered perspective that devote significant attention to results as well as constraints on outcomes. This is especially useful if historians are interested in the policy implications of their work.

In my recent book, *The Sanitary City*, I attempt to use path dependency to help explain why choices made in American cities about water supply, waste-water, and solid waste systems in the early- to mid-nineteenth century constrained choices available in the late-twentieth century. (Some reviews rightly noted that my use of path dependence for solid waste systems was less convincing than for the other two.) Among other things, I argued that decisions to seek city-wide water supply and waste-water systems in the nineteenth century were influenced by several factors, including a growing desire by major cities to gain increasing control over revenues and services in the name of *home rule*; dissatisfaction with private approaches to service delivery that either failed to live up to expectations or weakened the ability of cities to control their own affairs; rapid population growth that produced a scale of demand for such services that no longer could be adequately provided by individuals themselves; for water supply in particular, the fear of

fire; and an abiding dread of epidemic disease that could affect the whole city and its hinterland. In the wake of these converging issues in the nineteenth century, city leaders sought to provide water supply and waste-water services (However, these services did not appear simultaneously—water supply had the greatest priority). Strongly informing choice was the ‘sanitary idea’ that had migrated from England in the 1840s. The notion that disease was caused by filth—or miasmas and smells emanating from putrefying waste—held sway in the United States until the bacteriological revolution became widely accepted in the twentieth century, purporting that disease was contagious and was caused by microscopic agents—or bacteria—and not from environmental causes like miasmas and putrefaction. The miasmatic theory of disease led to the conclusion that disease could be reduced and indeed eliminated through environmental sanitation. This meant, in the case of water supply, developing a technical system that carried *clean* water (determined largely through the senses) through pipes to home and businesses throughout the city. For effluents originating in the home or in businesses, pipes could likewise evacuate and deposit liquid wastes elsewhere—most typically into nearby rivers and streams or into the ocean. In essence, these early technologies of sanitation were nothing more than elaborated transportation systems for water and waste-water, but conformed to the thinking about disease eradication prevalent at the time.

Through these practices, several forms of epidemic diseases showed sharp declines, due in part to these closed systems. But diseases itself was not eradicated; in some cases displaced from one location to another or not confronted at all. Yet bad science had led to relatively effective technology—at least within the context of the nineteenth century. Future additions to the systems—filters, treatment facilities, chlorination equipment—emerged in the wake of the bacteriological revolution and took careful account of the communicable nature of epidemic diseases and placed increasingly less reliance on environmental sanitation. Despite the significant breakthrough in the understanding of diseases, the basic systems changed little from their origins in the nineteenth century in the sense that they were highly centralized, capital intensive systems focusing on access to *pure* water supplies and contending with forms of point pollution. In the later years of the twentieth century, however, pollution problems became increasingly complex—more pollution from run-off (non-point pollution) and ground-water contamination. These forms of pollution were not easily addressed with large-scale fixed systems that were incapable of capturing run-off from a variety of sources and directly addressing groundwater sources of pollution. This change in context—along with a growing sensitivity to a range of ecological perspectives which made our understanding of the environment more sophisticated, but more complex as well—indicated that our technologies of sanitation derived from the nineteenth century were not up to the task of protecting cities from current health hazards as they were believed to be years before. Choices made earlier in the path clearly constrained future options for no other reason than the existing infrastructure was too extensive, too costly to replace, or resistant to change.

The weakness of my assessment was not discussing viable alternatives to the existing systems or outlining carefully the available policy options. Frankly, this is something I intended to do in a series of articles after the book was written; believing that

the primary thrust of the study was to provide the historical underpinnings for some future discussion of these questions. In some respects, as well, the book did not deal explicitly with the theory of path dependence much after the introduction, since I assumed that the issues were implicit in the narrative. The possible weaknesses of my presentation with respect to path dependence theory, however, do not undermine the value of the theory to historical scholarship—in this case urban history. Path dependence theory focused my attention on the means by which choices are made by decision makers, the connection of those choices to future options and sequences of events, and to outcomes. The use of the theory clearly reinforces the idea that a variety of externalities influence the adoption of technologies, but I am not convinced that the proper way to frame the questions is to rely on the assumption that choices result essentially from *historical accidents* or *insignificant events*. Many decisions are made without the ability to predict outcomes or to appreciate potential alternatives. Context is extremely important. The miasmatic theory was not an historical accident or an insignificant event. It was made significant because of its timing and the related issues and concerns that produced the desire to develop new technologies of sanitation in the nineteenth century. It is no little comfort that some economic historians, economists, political scientists, and other social scientists believe that *history matters*. It is for historians to help demonstrate what the phrase actually means in practice. Employing path-dependence theory—or at least experimenting with it--can advance that effort.

A version appeared in Dieter Schott, et al., eds., *Resources of the City* (Hampshire, UK: Ashgate, 2005): 262-75.

P. A. Gorrigne, 'Path Dependence –Causes, Consequences and Policy,' in Grimes, Arthur, et al. eds. *Economics for Policy: Expanding the Boundaries: Essays by Peter Gorrigne* (Wellington, NZ 2001).

See D. J. Puffert, 'Path Dependence in Economic History,' November, 1999, Internet www.vwl.uni-muenchen.de/ls_komlos/pathe.pdf, based on 'Pfadabhängigkeit in der Wirtschaftsgeschichte,' in Herrmann-Pillath, Karsten, Lehmann-Waffenschmidt, and Marco, eds, *Handbuch zur evolutiven Ökonomik* (forthcoming). See also L. Magnusson and J. Ottosson, eds., *Evolutionary Economics and Path Dependence* (Cheltenham, UK, 1997), 1-2.

P. A. David, 'Path-Dependence: Putting the Past into the Future of Economics,' Technical Report No. 533 (Stanford, CA Dec. 1988): abstract.

Ibid., 6.

The name of the keyboard was derived from the first six letters on the top row of the keys.

P. A. David, 'Clio and the Economics of QWERTY,' *American Economic Review*, 75, May, 1985, 332-37. See also David, 'Understanding the Economics of QWERTY: The Necessity of History,' in W.N. Parker, ed., *Economic History and the Modern Economist* (New York 1986); David, 'Path Dependence and the Quest for Historical Economics: One More Chorus of the Ballad of QWERTY,' University of Oxford Discussion Papers in Economics and Social History, No. 20, 1997; David, 'Path-dependence and Predictability in Dynamic Systems with Local Network Externalities: A Paradigm for Historical Economics,' in D. Foray and C. Freeman, eds., *Technology and the Wealth of Nations: The Dynamics of Constructed Advantage* (London, 1993).

A well-known rebuttal is S. J. Liebowitz and S. E. Margolis, 'The Fable of the Keys,' *Journal of Law and Economics*, 33, 1990, 1-25.

Puffert, 'Path Dependence in Economic History,' 2.

P. A. David, 'Path Dependence, Its Critics and the Quest for "Historical Economics,"' 1, Internet, www-

econ.stanford.edu/faculty/workp/swp00011.pdf.

Ibid., 10.

David, 'Path-Dependence: Putting the Past into the Future of Economics,' 9.

David, 'Path Dependence, Its Critics and the Quest for "Historical Economics,"' 16.

W. B. Arthur, *Increasing Returns and Path Dependence in the Economy* (Ann Arbor 1994), 1.

Ibid., 28.

W. B. Arthur, 'Competing Technologies, Increasing Returns, and Lock-In by Historical Events,' *Economic Journal*, 99, March, 1989, 116.

Ibid., 117, 123, 126-28. See also Arthur, 'Competing Technologies and Economic Prediction,' *Options*, (Laxenburg, Austria 1984), 10-13; Arthur, 'Self-reinforcing Mechanisms in Economics,' in P.W. Anderson, K.J. Arrow and D. Pines, eds., *The Economy as an Evolving Complex System* (Redwood City, CA 1988); Arthur, 'Path Dependence, Self-reinforcement, and Human Learning,' *American Economic Review*, 81, 1991, 133-58; Arthur, 'Competing Technologies: An Overview,' in G. Dosi, C. Freeman, R. Nelson, G. Silverberg, and L. Soete, eds., *Technical Change and Economic Theory* (London 1988), 590-607; Arthur, 'Positive Feedbacks in the Economy,' *Scientific American*, 262, 1990, 92-99.

D. C. North, *Institutions, Institutional Change and Economic Performance* (Cambridge, 1990), vii.

Ibid., 3.

Ibid., 131.

D. C. North, 'Some Fundamental Puzzles in Economic History/Development,' in W. B. Arthur, S. N. Durlauf, and D. A. Lane, eds., *The Economy as an Evolving Complex System II* (Reading, MA 1997), 224-25.

Ibid., 228.

North, *Institutions, Institutional Change and Economic Performance*, 137-38.

P. Pierson, 'Increasing Returns, Path Dependence, and the Study of Politics,' *American Political Science Review*, June 2000, 1. See also 'Not Just What, but When: Timing and Sequence in Political Processes,' *Studies in American Political Development*, 14, 2000, 72-92; S. E. Robinson, 'You Can't Get There from Here: Path Dependence, Evolutionary Economics, and Public Agencies,' (Paper presented at the Scientific Study of the Bureaucracy Conference, College Station, Texas, February 2-3, 2001), 2.

Ibid., 3.

Ibid., 18.

Ibid., 19, 22-23. Others have made a distinction between *trajectories* and *turning points*. The former are "interlocked and interdependent sequences of events" whereas the latter are 'events that have the potential to redirect trajectories along new paths.' Trajectories are inertial, but turning points can switch trajectories to new paths. See L. A. and D. Harrison, 'Technological Trajectories and Path Dependence,' 4., Internet www.bath.ac.uk/imp/pdf/18_AraujoHarrison.pdf.

S. J. Liebowitz and S. E. Margolis, *Winners, Losers & Microsoft: Competition and Antitrust in High Technology* (Oakland, CA., 1999), 1.

S. E. Margolis and S. J. Liebowitz, 'Path Dependence,' May 28, 2001, 1, Internet, HYPERLINK "http://

www.pub.utdallas.edu/~liebowitz/palgrave/palpd.html" www.pub.utdallas.edu/~liebowitz/palgrave/palpd.html. See also Liebowitz and Margolis, 'Path Dependence, Lock-In, and History,' Internet, HYPERLINK "http://www.utdallas.edu/~liebowitz/paths.html" www.utdallas.edu/~liebowitz/paths.html .

Liebowitz and Margolis, *Winners, Losers & Microsoft*, 39.

Ibid., 49-56.

Ibid., 235.

Email, John Conover, December 14, 1998, Internet HYPERLINK "http://www.johncon.com/john/correspondence/981214003911.12734.html" www.johncon.com/john/correspondence/981214003911.12734.html. Others support Liebowitz and Margolis with similarly strong language. In a review of *Winners, Losers & Microsoft* appearing in *Regulation*, 23,----- emeritus professor of mineral economics Richard L. Gordon noted: 'Liebowitz and Margolis are overly polite is dealing with the fundamental problem of the path-dependence model: its reliance on a long chain of improbable assumptions to prove that markets can sustain bad choices.'

Puffert, 'Path Dependence in Economic History,' 1.

G.R. Hawke, *Economics for Historians* (Cambridge 1980), 3.

Ibid., 12-13. Causation is central to historians' thinking, so much so that, as one study suggests, 'historians continuously use causal language. In fact, they are the only cognitive discipline in which it is correct to emphasize the types of causation present in ordinary, undisciplined, common-sense discourse.' See P. K. Conkin and R. N. Stromberg, *Heritage and Challenge: The History and Theory of History* (Arlington Heights, IL, 1989), 170. For more on historical causation and conceptions of time, see 171-91; A. J. Lichtman and V. French, *Historians and the Living Past: The Theory and Practice of Historical Study* (Arlington Heights, IL 1978), 44-72, 249-54; R. F. Berhofer, Jr., *A Behavioral Approach to Historical Analysis* (New York 1969), 211-69; D. H. Fischer, *Historians' Fallacies: Toward a Logic of Historical Thought* (New York 1970), 164-86.

Magnusson and Ottosson, *Evolutionary Economics and Path Dependence*, 3.

Something may be *past dependent*, the argument goes, if events within a specific system can be predicted on the basis of the state of the system at a later time, independent of how the system arrived at that time. See Araujo and Harrison, 'Technological Trajectories and Path Dependence,' 2.

Pierson, 'Increasing Returns, Path Dependence, and the Study of Politics,' 8.

However, it might be useful at some future date to consider the impact of path dependence theory on the Kuhnian notion of paradigms. Path dependence suggests evolutionary change, while Thomas Kuhn made a case for paradigm shifts in science—an idea that has been broadly applied to many fields. See Thomas Kuhn, *The Structure of Scientific Revolutions* (Chicago 1962).

The Sanitary City: Urban Infrastructure in America from Colonial Times to the Present (Baltimore 2000).

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